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Managing the Transition of the European Automotive Supply Chain

Electrification, Risks, Global Competition

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Abstract

The European automotive industry is currently in the middle of a radical transformation from internal combustion engine vehicles to electric vehicles. This change represents a structural challenge for the automotive industry because it affects both the product architecture and it also puts under stress a very complex supply chain, that developed itself around ICE vehicles. The aim of the thesis is to analyse how the European automotive supply chain is responding to this change and how suppliers can strategically choose the best ways to remain in the market and be competitive.

The European Union's 2035 phase-out of new ICE vehicles triggered and accelerated the electrification process even if it has been softened in latest revisions. The regulatory pressure imposed to the automotive stakeholders is shifting value creation from traditional mechanical components toward batteries, power electronics, semiconductors and software systems. This redistribution challenges incumbent suppliers specialized in ICE-related technologies while creating opportunities for firms with high levels of investments capabilities and financing.

This research examines also emerging supply chain risks, like the dependence on critical raw materials and geographic concentration of battery production. By relying on supply chain resilience theory, the study identifies possible strategic responses such as diversification, vertical integration, evaluations of firm mergers and acquisition.

The thesis highlights the importance for suppliers to adapt to the changes that the OEMs are requesting them, through strategic long-term decisions and a proper reading of the industry evolution. The electrification roadmaps that OEMs and European policymakers are following are putting under stress the firms: in order to remain central, the European supply chain must evolve to ensure long term competitiveness and resilience.

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Chapter 1

Introduction

1.1 Background and Context

European industry sector is extremely developed on multiple complex types of industry. One of those industries is certainly the Automotive sector. Since the end of the nineteenth century in European countries, the Automobile development started its own process to arrive to the current status. Automakers and OEMs represent the heritage and the core of this sector. One of the main strengths of the European automaker is the vast and fully integrated supply chain, that built and developed itself alongside their main customers. During the years, the supply chain specialized in the production of multi-purpose components: from interiors parts to chassis or engine/transmission parts. In relation to this last category, the development saw as a technical boundary the necessity of producing parts needed for internal combustion engine cars, for long times the only choice for users.

Since automakers rely a lot on their supplier bases, there has been a strong economical leverage for supplier to develop new materials and technology, in order to lower cost while maintain quality, or to increase efficiencies of production. From these strong inputs, the derivation is that many parts or materials or processes developed specifically for the automotive sector have been adopted also from other industrials sectors: as clear examples we can take also the airplane industry or the bicycle industry.

The strong push toward the industrialization of supplier related to the automotive sector has been driven beyond by the strength and the importance of the automotive sector in Europe.

In recent years, the raising attention related to the global emission levels created a sort of disruption in the direction of the automotive sector: The internal combustion engine has been appointed of being one of the "easiest" way to decarbonize the industry. Policymakers started very soon to create statal incentives in order to steer the development before, and the consumers after, toward the electric car. This strong intervention done by Governments all across Europe created a huge misalignment between the fast changing needs of the automotive sector and a supply base that was still running for very complex ICE car production. This change carries many attention points, from the financial stability to the development capabilities of the sector.

1.2 Industrial Transformation and Supply Chain Implications

The automotive supply chain has historically represented one of the most complex and advanced industrial systems in Europe. It is characterized by a multi-tier structure, strong interdependencies between original equipment manufacturers (OEMs) and suppliers, and a high degree of technological specialization.

The automotive supply chain represents since many decades one of the most complex and advanced industries in Europe. This is due to fact that there are multiple layers of supply, from tier 1 to tier-N level. It is interesting also to highlight how the level of the single supply company characterizes also the capability of both operational and development activities. This kind of specialization plays a fundamental role in sustaining the competitiveness of the value chain, affecting in the end the competitiveness and the quality of the products delivered to the OEMs.

The recent switch toward electrification challenges the core structure of the industry and blackmails the way in which it has been built during time. The EV drivetrains are by design less complex and much more "homologated" in the way of production and in relation to the materials. Batteries, power electronics and software are taking the strategical lead in the choices of carmakers and they directly affect the value distribution along the supply chain.

These components cannot no more be handled by medium or small local entities, but instead must be handled by much more capital intensive and financially capable companies. This triggers a huge change in the types of materials and components, but it also affects hugely the owners of the final earned value.

This matrix of change in complexity, number of components and capital needs are occurring in an environment already marked by additional sources of stress. Energy price volatility, rising raw material costs, geopolitical disruptions, and tighter financial conditions are creating huge strategic concerns and financial risks across the supply chain.

Any subtle movement in this delicate pattern amplifies every financial vulnerability of companies and exposes the strong dependency of the supply chain on the pre-electric era way of producing cars. As a consequence, the ability of the supply chain to absorb shocks and adapt to structural change becomes a critical determinant of industrial sustainability.

1.3 The European Automotive Industrial Model

The European automotive industry has historically developed in a very specific pattern: the stakeholder are mainly the OEMs and their suppliers. This scheme developed through the decades and created a strong connection and interdependency between the two main actors. Taking in consideration the main car manufacturers (without the ultra-luxury specific carmakers), the Europe's competitiveness has relied less on large-scale vertical integration and more on a distributed ecosystem of very specialized suppliers operating multiple layers of the supply chain.

This model has enabled European OEMs to achieve high levels of product quality, while maintaining a conspicuous rate of car sales. The high level of technological requirements and process reliability has been kept at high standards thanks to the co-development activities carried out by Tier-1 and Tier-2 alongside OEMs. This pattern triggered a strong enhancement in the creation of new engineering solutions and production know-how. In countries like Germany, this collaborative structure has been reinforced by long-term relationships among the stakeholders. Therefore, skilled and specialized workforce and strong regional industrial clusters became more and more vital for the sector.

However, the same characteristics that historically represented a strength may become weak spots during periods of fast technological transition. High levels of specialization and big capital-intensive investments with long break-even times can limit the adaptability of the industry.

Nowadays the industry is facing a demand shift toward electrification. This change challenges the historical industrial structure by reducing demand for traditional components while requiring significant investments in new technologies and production capabilities. Suppliers and OEMs that are unable to keep the pace of the transition are risking to be kept out from future investments, and so kept out also from the market.

1.4 Policy Ambition and Industrial Feasibility in the Electrification Transition

As of today, the electrification of the automotive sector in Europe is not driven by the common result of a consumer preferences change; it is caused mainly by the outcomes of green policies adopted by the governments. The policymakers saw the Automotive sector as one of the first industries that could achieve the new environmental targets to reach a low carbon economy. The distortions arose when the EU governments decided, alongside the quantitative targets, also the timing targets for the industrial evolution. The Green Agenda established the 2035 as non-negotiable year in which ICE cars could not anymore be sold in the market. This fixed and tight schedule provided a medium-long term direction with very challenging investment and development commitments by the carmakers, that started developing and investing in the new technologies useful for the scope. For suppliers, this rapid shift created a very tense situation: from one side the risk of remaining out of the market, on the other the complex questions regarding industrial feasibility and implementation.

All the investments needed to meet the renewed industrial requirement must be made under conditions of uncertainty, while existing assets risk becoming obsolete. This situation affects all the supplier base but in particular the small/medium sized companies with limited financial capabilities. One additional component of stress on the value chain is the complexity of modifications in capital allocation, workforce planning and long-term innovation strategies.

As a result, policy-driven transition dynamics impacted directly the stability and exposed the limited resilience of the automotive supply chain.

1.5 Supplier Distress

In recent years, an increasing number of Automotive suppliers are undergoing restructuring processes, filing for insolvency or are facing financial distress. Specifically, within the German supplier base, many companies that were considered solid and stable are now less financially reliable. There are many specific reasons for each single firm, but the growing frequency suggests the possibility of a systemic distress.

The analysis that will be carried over with this thesis will observe the supplier distresses, while trying to understand if they are the result only of managerial shortcomings or isolated strategic errors.

If not, the critical situation can be understood as a signal of structural pressure generated by the interaction between electrification, labor and energy cost increases and global competition.

Supplier operating in the ICE segment are already facing declines in volumes and decreases in profitability, lengthening the return on investments and simultaneously being required by the

new market necessities to expose money in new capabilities. The positioning of supplier in the value chain creates an additional issue for industrial choices that they need to do. Compared to OEMs, they have more limited bargain power and room for negotiations, limited access to capital and a restricted flexibility in shifting from one technology to another.
As a consequence, the ability of suppliers to absorb shocks and reshape themselves for the adaptation to the new structural change becomes a key determinant of the overall resilience of the automotive supply chain.

1.6 Risk, Resilience and Structural Adjustment

The automotive supply chain is facing extremely disrupting challenges that cannot be fully understood without considering two main concepts: risk management and resilience. The electrification of the cars and therefore of the supply chain, introduces new forms of risks, like technological uncertainty, demand volatility, and the dependency on supply sources located mainly outside of the European continent.
While facing these new forms of risks, standard industrial concerns are still present: cost fluctuations, supply disruptions and financial constraints continue to threaten the stability of the sector.
The keyword of the context is “resilience”. It refers to the ability of supply chain stakeholders to understand the market in advance, absorb the inevitable impacts and recover from disruptions while maintaining the production. In the specific case of automotive suppliers, resilience is intended also beyond operational continuity because it includes also the strategic adaptability of the firm’s choices. Companies must decide if they have to invest in new technologies while diversifying with possible new industries, try to consolidate the capitalization trough mergers or acquisitions. In the last chance they can also evaluate the possibility to exit declining and less profitable segments even with decreases in turnover.
Understanding why some suppliers have been able to adapt while others are struggling or went already bankrupt requires a high level vison that includes both industry structural trends and practices of risk management. This is particularly relevant in a period characterized by rapid change and limited margins for strategic error.

1.7 Global Competitive Pressure and Emerging Automotive Ecosystems

The transformation of the European automotive supply chain is happening in parallel to a new global competitive environment. While Europe has been an historical leader in the field of automotive engineering, in other continents, countries like China and India have strengthened their industrial presence and capabilities in the last twenty years. Thanks to big statal and directed investments, in China are born many new carmakers, mostly specialized in electrical cars. The magnitude of the speed and precision of the engineering capabilities developed by the Chinese have been the core of the industrial policy and corporate strategy, supported by the statal control over critical upstream resources. India instead followed the strategy of cost competitiveness compared to European countries, while enhancing its engineering capabilities and selecting strong industrial policies to strengthen the sector.

For European ecosystem of carmakers and suppliers, this global context adds an additional source of competitive pressure. For an ultra-developed continent like the EU, that is facing higher production costs, stricter regulatory requirements and fragmented industrial structures compared to international competitors, these elements may contribute to the loss of the leadership in the automotive sector.

If not accompanied by effective adaptation strategies, competitiveness becomes closely linked to the ability of the supply chain to manage risks deriving from the transition and reposition itself within emerging global value networks.

1.8 Research Gap and Contribution

There are extensive researches on the topic of the electric mobility and supply chain resilience, but several gaps remain.

Current existing studies are focusing mainly on the technological aspects of electrification or on the resilience frameworks with less effort in trying to interpret these perspectives within a concrete industrial context.

Typically, supplier financial distress is frequently analyzed at the single firm level, with limited attention to the implications for industrial nearby ecosystem.

The interpretation of supplier bankruptcies and restructuring processes maybe can be a possible indicator of the structural transformation.

This thesis tries to assess if the links between electrification, risk management and global competitiveness can be interpreted to have a status of the system, with a specific focus on the automotive supply chain.

By doing this, the study aims to contribute to the understanding from an analytical point of view and from a managerial decision-making perspective automotive the heath of the supply chain, using supplier distress as an analytical lens.

1.9 Objectives of the Thesis

The objective of this thesis is the analysis of the ongoing transformation of the European automotive supply chain by taking in consideration the electrification transition with a specific focus on supplier stability, risk exposure and global competitiveness.

The analysis will be carried out by considering the automotive supply chain like an integrated industrial system, instead of considering each single firm as a standalone company.

In this framework, supplier financial distresses and restructuring processes are interpreted as indicators of possible structural pressure, generated by many sources like the technological shift, the policy constraints and the renew global competition.

The main objectives are:

- The analysis of the impact of the electrification on the structure of the European automotive supply chain, focusing on the decreased component complexity, the different value distribution and the main stakeholders
- The examination of the stress at both financial and operational level, with a particular attention to the relationship between electrification, cost dynamics and increasing instances of supplier distress
- An assessment of the supply chain resilience mechanisms
- An evaluation of the competitiveness of the European automotive supply chain in a global context with an analysis comparing it with emerging automotive ecosystems, in particular China and India

In the end, this thesis focuses on the industrial and supply chain implications of the electrification transition, combining qualitative insights and quantitative evidence.

Chapter 2

Literature review

2.1 Electrification and Industrial Transformation: The 2035 EU Agenda

The electrification of the European automotive sector that is currently ongoing, cannot be seen only as a technological substitution of internal combustion engine cars with electric ones: it is a fundamental structural and technological transformation of an entire industry.

This is forcedly driven by many factors, such as: regulatory intervention, geopolitical pressures, technological advance and the needs of having a newly-configurated chain of value.

The European Union's 2035 phase-out of new ICE vehicle sales is the turnkey point of the most challenging commitment taken by European governments in order to decarbonize road transport, involving a total reshape of the industry. According to the Eurofound's research, "the transport sector accounts for 27 % of total carbon dioxide (CO2) emissions in the EU": this is the main reason why Policymakers are targeting the Automotive sector in the European Green Deal. Within this document, manufacturers are forced to transition to zero-emission vehicles by 2035, effectively declaring the end of the ICE technology in passenger cars.

Interpreting the 2035 Agenda only as a climate regulation document can be misleading and underestimates the range of the effects on the industrial dimension.

According to the Organisation for Economic Co-operation and Development, OECD, one main challenge of the green policies is to be able to strengthen the levels of competitiveness, securitization of energy supply and strategic autonomy.

In the "Green industrial policies for the net zero transition 2023" paper by OECD highlights how the governments need anyway to use industrial policies to pursue multiple objectives beyond decarbonization. Value chain resilience, domestic manufacturing capacity, labor levels and industrial capabilities remain key features for EU policymakers.

Even though the main priorities for Governments remain the ones states previously, the EU approach to decarbonization reflects the logic of redirecting capital allocation, innovation trajectories and supply chain development through regulatory standards.

2.1.1 Industrial Policy and Structural Reconfiguration

The automotive sector is pivotal in the EU industrial pattern, accounting for "over 7% of the EU GDP14, which totaled around EUR 936 billion in 2020" (European Parliament, 2021). This highlights how every possible decision taken regarding the sector is directly impacting the GDP of the Eurozone. The electrification process undertaken is therefore occurring under very delicate conditions and it is under stress by the global rising competitiveness from Chinese companies. Since the industry after nearly 100 years of lead in the development, now it's being challenged by external and mainly new companies, the European commission is pushing, among the others, on "Industrial alliances for the developments of key technologies, such as on batteries". Although the effort in this direction is appreciable, the environment is very exposed to strategic vulnerabilities.

Let's take in consideration the example of Battery production.

Currently the EU accounts only for the 7% of the World's battery production capacity and the target is to reach 25% of the global production by 2030 (Eurofound, 2025). By taking in account the China has a 76% share, this is a clear strategic vulnerability issue. Even if the 2030 target of production is achieved, still there are structural gaps hard to be filled with a short-term implementation. This raises big question in relation to the strategic autonomy of the sector and the clear raw material decencies on China.

A similar situation is occurring on the remaining value chain: in general, electric vehicles are involving completely different technical parts, mostly never used before. "Batteries, electric motors, converters, inverters, new cooling systems and recharging interfaces" are the new main elements of a car supply chain, letting off the mechanical components.

This clearly implies the obsolescence of entire segments of the currently existing supply chain and the need of creation and expansion od new technological domains more afferent to the needs of the market.

2.1.2 Incumbent Strategies and Path Dependency

The shape that the transformation of the sector is taking is driven by two main agents: the regulations imposed by policymakers and the subsequent reaction of incumbents involved.

In 2015 Wesseling et al. in "Business strategies of incumbents in the market for electric vehicles: Opportunities and incentives for sustainable innovation "Highlight how incumbents reacts differently in relation to their incentive to innovate and opportunity to innovate. These two factor can be synthetized respectively in "net Income" and "EV assets already available". In the analysis, Eu manufacturer are mainly in a neutral position or in a place I which there are incentives to remain within a laggard strategy, with few integration of EV cars.
European OEMs adopted a gradual strategy in relation the EV cars, relying more on electrified ICE cars, like plug-in hybrid technologies instead of a full commitment to EVs.
Obviously, tightening regulatory scheme of the EU boosted a more effective shift towards electrification.
From a study of the European Union (The Future of the EU Automotive Sector, 2021) the local OEMs are accelerating the process of enhancing the electrification of cars offer but they're still far in case we consider only the BEV cars. In this case, China and US are leading the sector and the lag of the EU is clearly visible. One of the main reason of this gap is for sure the reliance on batteries and rare materials nearly unavailable in Europe, or, if available, not exploitable due to ecological reasons.
On top of that, electrification means also digitalization. The role of software and electronics in the lifetime of the vehicle is more and more relevant and central: this, alongside the lower mechanical complexity, triggers the possibility to have new entrants in the market from other industries (i.e. Electronic).
This additional dynamic lowers the entry barriers and creates an additional point to be addressed by the "historical" OEMs, that must protect themselves also from this new external competitive factor.

2.1.3 Employment, Skills, and Regional Impacts

The automotive industry impacts part of the European labor market and so electrification affects directly the workforce distribution. The overall automotive employment increased between 2011 and 2023 but in the same period there has been a clear modification on the geographical distribution. Actually, the Eurofound notes that "job losses have so far been particularly prevalent in countries where many of Europe's largest car manufacturers are headquartered". It is evident how western European countries that before were historically strong in powertrain production, now are instead exposed to market fluctuations.

The differences in workforce intensity involved in the production of BEVs differs substantially from ICE vehicles: less moving components require less work to manufacture.

In parallel, new opportunities have been opened by the new technologies needed for the EVs: "new skills requirements are emerging, particularly in relation to the greater digital connectedness of vehicles, calling for more software engineers, data analytics professionals, expertise in AI applications" (Eurofound, 2025). The European labor market is called to a shift toward digitalization and a new complete set of knowledge.

Emerging	Declining
8 % in 2018; 21 % in 2022	**41 % in 2018; 26 % in 2022**
Roles such as:	Roles such as:
data analytics professionals and scientists	assembly and factory workers
AI and machine learning specialists	data entry clerks
process automation specialists	client information and customer service workers
software and applications developers and analysts	accountants and auditors
innovation professionals	accounting, bookkeeping and payroll clerks
sales and marketing professionals	administrative and executive secretaries
service and solutions designers	transport attendants and conductors
product managers	material-recording and stock-keeping clerks
industrial and production engineers	general and operations managers
supply chain and logistics specialists	business services and administration managers

Source: World Economic Forum (2018).

1 Figure 2.1.3 Assessment for Emerging and declining jobs in the automotive industry (Eurofound, 2025)

Such kind of offsetting effect of knowledge of the people employed is difficult to obtain, even more under the time constraint given by the European policies that are currently in place.

2.1.4 Competitiveness and Supplier Vulnerability

In these general conditions of labor uncertainty and technology challenges, supplier among the industry are facing financial distresses and liquidity criticalities. In a recent document released by CLEPA - European Association of Automotive Suppliers and McKinsey, there is an indication of the current status of the firms among the supply chain: "Squeezed profitability: 75% of suppliers expect continued low profits, with 42% expecting to operate at break-even or face losses in 2025". The main structural issue is related to the schema of the automotive supply chain, where supplier anticipate many investments that only later in time a paid back by the OEMs. By doing so, suppliers are intermediaries and are functioning as shock absorbers in case of price fluctuations.

This market geometry carries a structural problem for the electrification: while the policymakers are pushing for the EV implementation, the industrial base is already under stress from a financial point of view.

Due to all these elements, there is a real risk of a deindustrialization of the sector if not managed in the correct way. The study commissioned by the European parliament - The Future of the EU Automotive Sector, 2021 – highlights how the automotive industry "will evolve more in the next decade than in the previous century": the ability of policymaker of not creating a market bubble and of the firms involved in leading the investment strategies are crucial to avoid the sector collapse.

2.1.5 Electrification as Geopolitical Strategy

The electrification of the automotive sector can also be seen as a geopolitical leverage to create a more autonomy industry. Nowadays, the battery supply chain is far more developed and competitive in China compared to EU. Chinese and Asia battery producers "enjoy major competitive advantages, notably the control of their supply chain for minerals and components" (Eurofound, 2025). Therefore, the major assets for them are the extraction capabilities of raw materials from the soil and the availability of these minerals in their territories. Alongside this, China has been able to fully develop an entire industrial sector specialized on this production.

Europe instead remains vulnerable on the battery production and minerals extraction. Another possible interpretation of the 2035 Agenda could be also the geopolitical leverage to fully develop and implement an internal chain for the production of automotive batteries: this can reduce dependencies on external countries and enhance the creation of a competitive EV ecosystem.

2.1.6 Risk of technical knowledge loss

The phase out of ICE vehicles represents not only a technological change for the industry but also a potential disruption in the industrial knowledge accumulated over the decades. The EU automotive industry has developed around mechanical processes and research with incremental innovation in combustion-related technologies. The forced shift toward EVs raises doubts about the technological capabilities remaining in the market.

From a literature point of view, “Technologies which are incompatible with the dominant technological regime are, however, locked out” (Klitkou et al.): this is a crucial concept that can be applied to the European automotive industry. In the case of ICE cars, the incumbent technologies were creating a clear lock-in effect: specialized labor market, ad-hoc regulatory standard and production facilities already developed. These elements created over the time a technological regime that favored the development and enhancement of the current technology over a radical disruption, like electrification.

Nowadays there is an asymmetry between the capabilities of the sector and the new requirements and needs requested. There are “some essential components of ICE vehicles, like fuel, transmission, exhaust, and cooling systems, do not exist in EVs.” (Jagani et al,2024) alongside an entire part of the supply chain specialized in core ICE systems. All the firms producing components like fuel injection systems, exhaust treatment and gearboxes risk to end out of the market if not able to modify their core businesses. There is a huge timing constraint deriving from the asymmetry: if suppliers are not able to restructure their production to meet OEMs needs there could be market gaps that are easily filled by external companies, like Chinese ones.

From an industrial policy perspective, the main challenge is the management of the exit from ICE cars without triggering excessive industrialization gaps and technical knowledge loss.

Ultimately, the transition from combustion engines to electric ones contains a paradox for European industry: the historical technological strengths created a very rigid market and ultra specialized firms that are now the most critical elements that are impeding an easier process. Whether the 2035 Agenda will result in a destruction of industrial capabilities or in a renewal of the market will depend solely on how the supplier base will respond and how effective the EU policymakers will be able to mitigate the lock-in affects.

2.2 Supply Chain Risk and Resilience

The electrification agenda fundamentally reshapes the technical range of the European automotive industry. However, in addition to that, the transition toward EVs triggers also systemic risks among the stakeholders involved in the supply chains. If before we discussed more on the technological and knowledge risks, now we face the financial, structural and operational risks. As vehicle production volumes are dropping in EU area and suppliers try to match the market needs, the management of risks becomes more critical than before to survive and maintain competitiveness.

2.2.1 Supply Chain Risk Management: Conceptual Foundations

Supply chain risk management (SCRM) is a field of study that in the recent decades has been increasingly object of interest. The definition of supply chain risk given by Elock in his “Supply Chain Risk Management: A Review of Thirteen Years of Research” is straightforward: “Supply risk is defined as the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring”. By considering this concept and applying it to the current market, it is possible to note how supply chains are increasingly exposed to complex and interconnected risks derived by globalization and technological interdependence. Similarly, Ghadge et al. are highlighting how “managing risks in the modern environment is becoming increasingly challenging (Christopher and Lee 2004), primarily because of uncertainties in supply and demand, global outsourcing and short product life cycles”. It’s evident how this definition can be useful to understand also the risks involved in the automotive supply chain during the shift toward electrification. Modern supply chains are characterized by vulnerability due to high complexity and reduced overlapping of resources. The main priority for many years has been only the efficiency over the robustness and resilience: this strategical choice until now has been the correct decision however nowadays this is increasing the exposure to disruptions.

The electrification intensifies and highlights the effect of these vulnerabilities:

a. It introduces new upstream dependencies: raw materials, batteries, semiconductors
b. It creates disruptions among existing suppliers
c. It overlaps with a decrease of production volumes in EU, amplifying financial distress

2.2.2 Financial Distress in Automotive Supply Chains

One of the most critical elements of risk for the supply chain that is facing a transition is the financial distress. In the automotive sector suppliers are operating with very low marginality and extremely asymmetric bargaining pure when negotiation with OEMs. As a consequence of that, during phases of disruption or uncertainty, financial risk propagates quickly in the supply chain and affect many stakeholders.

By its nature, the transition from ICE to EV platforms creates an evident disadvantage for suppliers specialized in all the components that are involved in the engine or related parts production (exhaust systems, fuel injection technologies, and mechanical transmissions).

In normal conditions, with a growing economy and good access to credit lines, financial risk can be often underestimated among the supply chain. In the current situation instead, in the context of electrification, suppliers are called to massively invest big capitals on new capabilities while facing uncertain demand trajectories. This dual source of stress – high capital expenditure and uncertain revenues – creates a huge vulnerability. In this context, there also smaller actor in the game, like small Tier 2 or Tier 3 suppliers that can have difficulty in accessing credit lines and few power in negotiating terms and conditions with upper tier suppliers.

The European supply chain is ever more strained by the global competition from Chinese manufacturers, who can exploit big economy of scale effects, extremely developed upper and lower vertical integration and state aid from the Government. As EU produced ICE cars are starting to decline and assets were already put in operations, there is the risk of having experiences of stranded assets. The main result is that actually the system is facing a simultaneous overcapacity for ICE components and undercapacity and non-competitiveness on battery related technologies.

2.2.3 Decreasing Quantities of EU-Produced Cars

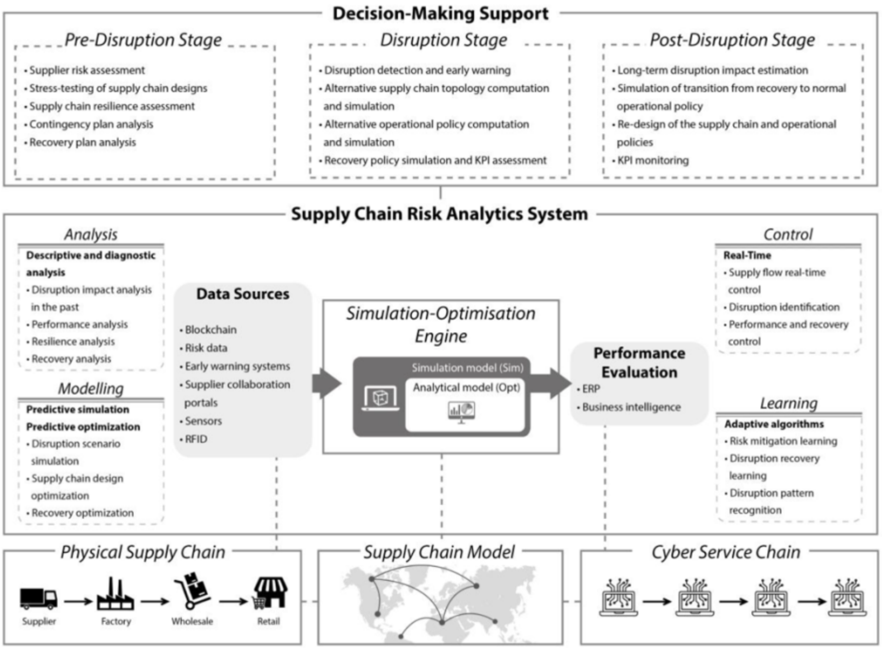
After 2020, EU car production never reached the pre COVID volumes. The supply chain was hit strongly and the financial consequences are still not solved among suppliers. All the risks on the supply chain are affected by this factor and on top of that there is the volume of EU production. According to the European Automobile Manufacturers' Association (ACEA), also "in the first half of 2025, new car registrations across the EU declined by 1.9% compared to the same period in 2024, reflecting the lingering impact of economic uncertainty and weaker consumer sentiment in several major markets". The transition to electric mobility adds on another layer of risks and complexity.

The production of batteries and key EV components is concentrating in regions were firms are incentivized to build gigafactories and able to extract raw materials, like China. This outsourcing of production externally creates another disadvantage for European incumbent suppliers: less volumes of components affect critically the ability to exploit economies of scale and thus lowering competitiveness.

The COVID-19 impacted temporarily the sector and demonstrated the fragility of the globalized supply chain for car manufacture but the electrification transition represents a permanent shift. Lower volumes of ICE cars and overestimated selling forecasts for EVs created a critical combination: suppliers are facing financial risk exposure due to lower turnover generated and in parallel are destroying their ability to exploit economy of scale and so they're more expensive than outside-EU competitors.

2.2.4 Digital Supply Chain Twins and Resilience

While the firms in the supply chain are more exposed to risks due to electrification and digitalization of the vehicles, the latter can be useful as a support in risk management decision making. Ivanov and Dolgui (2020) proposed a digital twin that is a "conceptual-technological framework of a generalized DSS – Decision Support System- for supply chain disruption management comprising data-driven disruption modeling in the SC and uncovering the interrelations of risk data, disruption modeling, and performance assessment". According to the authors, a digital twin can support firms in strategic risk decision making, by analyzing the historical data and the current elements available. In the context of electrification, digital twins



2 Figure 2.2.4 Generalized framework of a digital twin for supply chain disruption management (Ivanov & Dolgui, 2020)

can support OEMs and suppliers in the possible risk identification and management and can anticipate possible issues and bottlenecks in critical supply materials.

Ghadge et al. emphasize in “Supply Chain Risk Management: Present and Future Scope, 2020” how the proactive risk management can be beneficial to mitigate the effects of a disruption or a critical issue in the supply. Digital twin is perfectly aligned to this concept: trying to predict some possible vulnerabilities trough data-drive decision making and try to prevent the possible bad outcomes.

However, resilience is not only made from digital monitoring. It also relies on physical preventive actions like diversification of the business, redundancy of capabilities and strategic safety stocks. In a highly developed and specialized supply chain, it is difficult to create redundancy due to cost and investment pressures.

Electrification can be taken as a chance to better shape the industry trough modularity and flexibility: this requires redesign efforts from both OEMs and supplier, thus can be beneficial for everyone.

2.2.5 Transition risk and structural rebalancing

The combination of financial distress and volatile production volumes accentuates the broadest structural issue: managing the risks arising due to transition. In this specific case, transition risk refers mainly to the economic and financial exposures deriving from the industry shift toward low emissions vehicles. For firms producing automotive parts, the financial risk is created by capability obsolescence in the form of stranded assets, machinery outdatedness and mismatch in internal know-how.

Another contribution is also the geographic position of groups of interconnected suppliers: the inherent systemic risk is the carry-over of financial exposure from one supplier to another. Such problems are macro-level regional risks that secondarily will affect the labor market and public finances.

From a supply chain perspective, resilience of the stakeholders should be analyzed at differ levels:

1. Firm level
2. Network level
3. Regional level

The outcome of layered analysis should support the strategies to be taken at each level in order to enhance consolidation of the supply chain. In the past, the focus was mainly only on the cost and labor efficiency. This led the creation of a very specialized thus rigid supply chain, with difficulties in fast readaptation.

Strategic autonomy considerations are pointing toward a rebalance with more geographically clustered productions for some key elements – like batteries.

2.3 Suppliers' Adaptation to the New Automotive Industry Paradigm

In the previous chapters 2.1 and 2.2 the analysis concentrated on the 2035 Agenda and on the increasing exposure risks along the supply chain, both of these elements converge on a critical question: how are automotive suppliers adapting to the transformation? The transition in the direction of electric vehicles is not only changing the product architecture but it reshapes the entire supplier's footprint by redistributing earning, marginality and competitiveness along the chain.

The core spine of the transformation are automotive suppliers, called to win this challenge while facing simultaneous technological, financial and strategic pressures.

2.3.1 The Changing Role of Suppliers in the EV ecosystem

Although "most ICE vehicle supply chain elements can adapt to support the EV supply chain, around 25% of the EV supply chain will need to be rebuilt. [...] Therefore, some suppliers will need to explore diversifying into EV components sooner to survive." (Jagani et al., 2024).

Jagani et al. highlight the impact of the transition in terms of quantity of supplier that will need to readapt to the new EVs, but the components that are mostly needed are extremely raw materials intensive and require big investments and completely new plants. Historically, European automotive suppliers created competitive advantage thanks to mechanically complex components and high levels of specialized engineering excellence shared with OEMs. However, EVs ecosystem is characterized by interdependencies with other industrial sectors like digital, extractive and energy, increasing the complexity of the matter and modifying the competitive challenges.

It is already known by governments in EU that "the share of electronic components on the overall vehicle value in 2019 stood at 16% for ICE vehicles, and it is estimated to increase to 35% for BEVs by 2025. This percentage is expected to further rise to 50% by 2030." (European Parliament, 2021). This structural change challenges the current supplier hierarchy and introduces new competitive patterns. Suppliers must cope with the choice of shifting to productions needed in the EV market, although volumes and profitability are far from being reliable and stable.

Since most ICE-related components will be worthless in term of market value in few years, certain supplier segment will become niche or certainly compressed, while others -BEV relevant- will be in strong expansion. Suppliers that will be able to exploit the integration of software and digital elements in their production capabilities and components will be likely the ones that will lead the market.

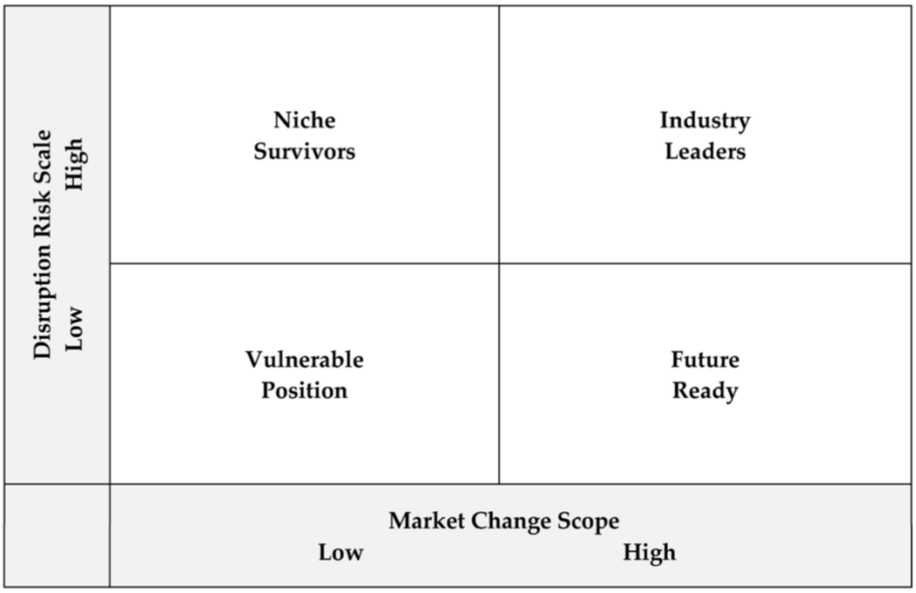
2.3.2 Strategic Pressure and Transformation capabilities

In the latest CLEPA survey, many firms involved in the supply chain were asked to answer questions related to the levels of profitability expected in current and next years. The outcomes are clear:

"1.A deepening sense of uncertainty: 63% of suppliers express a negative outlook, a significant decline in overall industry sentiment.

2.Squeezed profitability: 75% of suppliers expect continued low profits, with 42% expecting to operate at break-even or face losses in 2025." (CLEPA, 2025)

These findings strongly confirm that the industry change is happening under significant financial and structural distress. Firms involved need capital intensive investment, with relevant sunk costs derived from Research and Development expenses and physical building of new tools and machineries with high start-up costs. In addition to that, "57% report increasing pressure from Chinese component imports." (CLEPA, 2025) Chinese automotive firms are backed up by strong economic support by the Chinese Government, contributing to have unfair players inside the EU supply and manufacturing market.



3 Figure 2.3.2 Automotive Supplier Typology (Jagani et al., 2024)

In order to cope with all the challenges, suppliers must weight their strategies, basing on their adaptation abilities. The simplified scheme below, created by Jagani et al. synthetizes the possible positions of EU suppliers.

From the table it's evident that for the EU effort toward electrification, firms that are able to locate in the two sector on the right, the ones able to bear high market change scope can be beneficial. Industry leaders are firms with solid financials and high capabilities: these are the ones that can take the lead over production of new elements like batteries, chips and digital components. Future ready firms instead, could follow leaders, but they need to implement strong risk management strategies and maybe can be backed up by institutional warranties.

The new market will require also a shift in core competencies, already right now the EU industry is facing "a large demand for experienced and skilled workers. However, there is a shortage of suitably qualified staff in a number of areas, such as high-quality, high-volume, highly digital and technically complex production processes, chemical engineering" (Eurofound, 2025). Suppliers, in this context, must therefore develop capabilities and expertise in the cited sectors. The main strategic choices can be:

1. Diversification: investing in new EV relevant technologies like batteries, inverters or electric axles, while creating possibility of synergies also with other industries
2. Vertical integration or partnerships: acquire upstream sources and internalize key raw materials processes, or settle strategical agreements with firms already in that specific level of the chain

3. Consolidation or exit: typical for smaller firms, merging with other companies to create a more solid company able to invest or exit the market completely

Successful adaptation of the supply chain will derive from the optimal choices taken by the stakeholders involved.

2.3.3 Regional Clusters and Uneven Adaptation

As highlighted by the Eurofound, in the past decades, the automotive supply chain developed around different regional clusters:

1. **Core western/northern Europe** with strong automotive industries that are the headquarters of the largest OEMs
2. **Southern Europe** practically entirely controlled by companies from core countries.
3. **Eastern Europe** with significantly lower costs and large amounts of State aid

The electrification transition will impact each region in a different way. Not considering support policies that can be implemented by Governments, it is likely that only the first and third clusters will benefit from the green policy implementation. While investments in northern Europe will be supported by the presence of the major part of EOMs and western countries will be the “productive” region, the south of Europe will face more difficulties in participating to the game. As said before, innovation is extremely capital intensive, and labor cost remains a key factor in the production cost: in this scheme, southern countries show weaknesses for both the elements.

The uneven adaptation raises concerns about the regional distribution of the value within E_U. Without external support, some territories will face productivity erosion and firms exiting the market, reducing diversity and geographical resilience of the EU supply base.

2.3.4 Digitalization as an Enabler of Adaptation

As discussed in section 2.2, digitalization of the supply chain is beneficial to the transition. Industry 4.0 and digital twins, alongside advanced digital analytics can support the management of risks. The European Parliament highlights that “the overarching aim of most

OEMs and top tier suppliers is to increase the resilience of their regional and global supply chains, to which end digitalization is an essential tool. The implication for suppliers is that they have little choice other than going down the digitalization route" (European Parliament, 2021). Because of that, supplier capable of matching the integration of digital services to create a more efficient production may enjoy higher margins. A practical example could be predictive maintenance software or digital tools for the procurement of raw materials: these can represent hybrid proposals than can be effectively integrated also by medium or small sized firms. The latter represents a consistent portion of the supplier base and their turnover doesn't allow them to be the first investors in the digitalization. On top of that they remain the riskier part of the supply chain: they may struggle to adapt to the new paradigm, triggering a possible outbreak of firms exiting the automotive sector.

2.3.5 Strategic Autonomy and Ecosystem Reconfiguration

Supplier adaptation is integrated in a broader EU strategic – and green – industrial policy. The current situation sees a crucial rely of the EU EV sector on Chinese battery and raw materials supply: it's a clear fatal flow in case of geopolitical frictions between the continents. Battery manufacturing, semiconductors, rare earths are all non avoidable elements at the base of the new electric paradigm. EU parliament stated clearly that the "main threat to the development of electromobility in Europe is still the weak battery supply base" (European Parliament, 2021): large scale industrialization is needed to cope with it, backed up by public funding and solid internal investments. While in the past the ICE supply chain was more vertically developed, the new EV and digital architecture is more "horizontal": there are many spill-overs from different industries and different technologies that are in development that are involved.

Collaboration between different types of companies is crucial to exploit this knowledge horizontalization: energy providers, digital platforms, raw strategic materials manufacturers must put pursue the common objective of securitization of the EU supply.

2.3.6 From Adaptation to Transformation

The transformation of firms of the EU automotive sector is not incremental but structural. Electrification carries on the decrease of components and requires new technologies: the consequences can be the compression of certain segments, expansion of others while redistributing the value chain allocation. Financial distress and volatile production of EVs intensify the urgency of strategic choices that must be taken to shape the new supply trajectory. The key challenge relies on matching technological upgrading with short and long-term financial sustainability: if suppliers lack capital to invest, adaptation may stop, triggering bankruptcy or exit from the market. Conversely, a reliable access to investment capital alongside a coordinated industrial policy can boost dynamic upgrading.

In conclusion, supply chain adaptation constitutes the primary base for the European automotive transition. Through targeted investments, electrification and digitalization, technological requirements can be achieved while ad-hoc risk management can support the shift exposure.

2.4 Global Competitiveness and Industrial Policy Frameworks

The electrification transition analyzed in the previous sections unfolds in an increasingly complex global industrial framework. EU industry is not transforming while isolated from the rest of the world, but instead it is doing so in a context of intensifying geopolitical competition, technological challenge and strategic repositioning of production networks.

Electrification, supply chain risk and supplier adaptation must be analyzed also in the context of the global competitiveness.

2.4.1 Electrification as a Competitive Disruption

Europe has been historically the cradle of the automotive engineering and vehicles manufacturing, with many OEMs established since the 19th century. Now, the electrification transition is massively disrupting the competitive advantage. EU OEMs and the related supply chain possess a deep expertise in mechanical and industrial engineering, while external

competitors, like China, have developed in recent years massive know-how in batteries production and electronics. In addition, their territories are rich in rare heart materials needed for the electric mobility and technological infrastructure.
The European parliament underlines that "global competition is also intensifying. It is expected that 80% of growth in the global automotive industry will occur outside the EU." (European Parliament, 2021), so governments are aware of the world economic condition affecting the sector. Companies from the Asia region are the most likely to grow and take the engineering lead on the EV ecosystem.
With the ICE vehicles, the high levels of specialized qualification and R&D needs were creating huge barriers to entry for newcomers: Electrification lowers dramatically this impediment. As analyzed in paragraph 2.1.1, Europe accounts for only a residual part of Global battery production, while China leads with an ultra-verticalized supply chain and governments funds. The direct consequence of this asymmetry implies a reallocation of industrial power outside of the EU unless strategic countermeasures are taken.

2.4.2 Delocalization of Knowledge and Capability Erosion

A critical dimension of global competitiveness concerns not only the specific productive industrial capabilities but also knowledge and talents concentration. As mentioned in 2.1, the phase out of ICE combustion engines risks to erode decades of accumulated technical knowledge. On top of that there is the concrete risk of relocation and development of knowledge and know-how directly outside EU regions.
Global production networks are now being restructured to be able to cope with the EVs necessities and EU remains one of the main actors. However, when gigafactories and semiconductor hubs are locating outside EU, than in a matter of some years it's likely that also these places will be more attractive for talents and investors. This process is already happening for battery production, where EU has an overdependence on Chinese manufacturers.
If complex components like battery cells, chips and semiconductors are mainly produced outside EU, in the long-term European firms risk losing also the system integration with their own components.
Knowledge delocalization can happen through multiple channels:

1. Foreign direct investment patterns: investments in EU facilities may be led by non European firms, externalizing the development processes
2. Talent migration: engineers and researchers may relocate to regions with strong EV capabilities
3. Supply chain dependency: with components coming directly from outside EU, know-how and R&D remains in the region of production

As stated by OECD, the new green industrial policy should "strengthen national security and accelerate the energy transition": policymakers should coordinate state intervention in order to prevent structural dependencies on strategic competitors.

2.4.3 Increasing Ability of Non-EU Countries to Produce Complex Components

The landscape of global competition is conditioned also by the increasing ability of non-EU countries to manufacture technologically complex automotive components. Asian firms have advanced dramatically in battery cell chemistry, power electronics and EV platforms. As noted by Eurofound, "Chinese producers enjoy major competitive advantages, notably the control of their supply chain for minerals and components and also economies of scale thanks to the strength of their domestic market" (Eurofound, 2025). From this analysis it is important to note how for China strong internal domestic demand and supportive industrial policies have triggered an acceleration in learning curves. These advantages enable fast technological upgrading, competitiveness and cost reduction. In parallel, also in other economic regions like the United Stated, firms are advancing in autonomous driving technologies and by doing so, also developing deep knowledges on the field of EVs.

As highlighted in the previous section 2.1, the main source of pressure is from China and its manufacturers. While the new technology breaks the rules ad constraints of the old ICE paradigm, the increasing ability of non-EU firms of producing complex EV-related components erodes the remaining barriers to entry and compresses profitability of the incumbents.

The risk, by the way, is not merely only on price competition, but also on effective competitive abilities of the long-standing ICE components manufacturers: they were specialized in high mechanically complex systems and now the paradigm is made out few, mainly electronic intensive, components. If non-EU firms will be able to drive and consolidate their leadership on key components relevant for the EVs (batteries, semiconductors, integrated electronic), Europe's historical competitive advantage may no longer exists and fall behind.

2.4.4 Industrial Policy Responses: Between Regulation and Competitiveness

Before the EV breakout, the EU automotive sector was a free market with good level of competition among suppliers and technological barriers to entry for external newcomers. After the start of the electrification transition, EU governments have been called to action to enhance investments and give a clear direction to the development of the companies in the ecosystem. The Green Deal and the 2035 Agenda create a natural tension between the ecological targets and the industry growth in competitiveness. The European Industrial policy, in this case, is called to face two objectives: the climate targets and the economy strengthening.
Currently, "around three quarters of Member States offer purchase incentives -to buy EVs- to individuals. [...] There is also a trend towards reducing purchase incentives." (Eurofound, 2025): the European commission aim to boost the initial market needs for electric vehicles enhancing internal demand and subsequently implementing a reduction to reach the neutral status of the market back again. It is relevant to note that these incentives, in addition to the emission reduction standards for cars sold in the market, cannot secure supply-side capabilities and investments build-up.
For some strategic components like batteries, the European commission "also includes measures providing continued support to the EU battery industry, building on the European battery alliance initiative launched in 2017" (Eurofound, 2025). The target here conceals both the internalization of the supply chain and the development of new industry sector through direct subsidies.
Finally, an attention point involves the Small and Medium Size companies – SMEs: they are a relevant part of the supply ecosystem, but they are difficult to manage due to their dimensions. Some countries are trying to support the transition for SMEs trough subsidization of upskilling of the workforce (Spain) (Eurofound, 2025).

2.4.5 Strategic Autonomy vs Global Integration

A further challenge lies in balancing strategic autonomy and global integration of the automotive supply sector. Historically, the EU automotive sector has been export-oriented and open to cross-border supply chains, coming from the major global competitors and commercial partners. However, the current geopolitical situation involving wars, tariff uncertainty and global competition is contributing to mine the equilibrium established between EU and non-EU stakeholders.

Increasing protectionism in major markets like US and subsequent countermeasures set up by EU and China are complicating strategies for most of the European OEMs and suppliers. At the same time, inbound investments in EU placed production plant by non-EU firms may become a structural countersense: they're strengthening EU production capacity but increasing external ownership of key assets.

The industrial policy dilemma becomes multidimensional: from a final consumer point of view, the optimum is a completely open market, in which the price competitivity is totally fulfilled; while from a strategic vision, critical technologies a key assets must remain internal both in relation to the production and the know-how.

2.4.6 From Industrial Leadership to Industrial Transition Risk

Section 2.1 and 2.3 highlighted that electrification introduces erosion risks for manufacturing, production, development, margins and know-how of the automotive sector. These challenges share the path with the external pressures and competitive dynamics. If EU OEMs and the supply chain fail to adapt and production volumes continue to remain unstable, the historical industrial leadership could move irreversibly toward non-EU regions with more EV ready ecosystems.

The risk of a real deindustrialization is therefore not theoretical: economies of scale are not working in an efficient regime due to low volumes, weakened financial capabilities are shortening the supplier's ability to remain in the market and firm exits may eliminate the regional proximity efficiencies. Europe risks to change from a production leader to a technology importer.

In this context, there are still possible opportunities: digital twins, battery production enhancements and boost in development of advanced manufacturing for EV related components can reposition Europe as an industrial leader. The success will depend on how EU suppliers and OEMs will be able to effectively invest and ingrate risk management strategies within the green industrial policy framework.

Chapter 3

Methodology

This chapter describes the methodology used for the development of this thesis.

3.1 Research Design

This thesis tries to investigate how the European Automotive supply chain is adapting to the Electrification transformation: a mixed method of analysis involving qualitative and quantitative tools is used. The transition from ICE vehicles to EVs represents a structural industrial shift that impacts the supplier in all areas of business: financial strength, technological ability, market positioning and risk exposure.
Given the complexity of this structural change, a single method of evaluation would not be exhaustive and could miss some relevant information.

For this reason, the research integrates:

1. Qualitative insights from industry insiders: collected through interviews with professionals of the sector.
2. Secondary financial and industrial data: firm-level financial indicators obtained from corporate annual reports
3. Descriptive statistical analysis: growth comparisons and trend evaluation to assess financial resilience and exposure
4. Industry benchmarking: comparison of firms operating in the market in electrification-relevant fields of action
5. Multi-Criteria Decision Making (MCDM) modelling: as a structured framework to evaluate supplier by considering many firm specific inputs.

The aim of this multilayered framework is to connect the current theoretical structure with more realistic firm-level indicators. Although the effort to create a MCDM reliable structure is maximum, it is important to highlight that industry insiders feedback, given their access to firm specific data, will be considered as highly valuable.

3.2 Data Sources

Mainly four data sources have been considered. Given the intrinsic complexity of the matter and the number of possible variables, in order to keep the research lean, these 4 were selected:

1. On-filed information from industry insiders
2. Open financial databases
3. Industry reports and official institutional data
4. Evaluations for data-based comparison

On-Field Information from Industry Insiders

Qualitative hints and feedback from people working in the European Automotive industry are a key factor to carry on the analysis. Structured discussion and question times toward relevant persons involved touched every possible area of the Electrification process. Along all the departments available (Procurement, Project management, Quality, R&D, Risk management, Logistics, Sales) professionals have been questioned. Inside European OEMs and Supplier, interviews have been done with:

- Procurement managers
- Project managers
- Supply chain specialists
- Financial analysts
- Strategy consultants

As stated previously, the discussions have been focusing mainly on electrification-relevant topics:

- Investment priorities
- Supplier evaluation criteria
- Perceived risk exposure
- Capital allocation changes
- Regulatory adaptation

The scopes of the information collection from real-life involved people are mainly two:

- Validation of data emerging from quantitative analysis, to ensure that the suppositions made and the data collected are in line with the sentiment and the hints from industry insiders
- Exploitation of the information collected to calibrate the evaluation criteria and balance the weights of each parameter

Since all the contributions were firm-specific and provided sensible data, all the information collected have been anonymized and normalized.

Financial Data

To contribute to the robustness of the research, some actual firms involved in the Automotive supply chain have been analyzed. For this reason, firm-level financial data have been collected from official corporate disclosures and public financial information. Since these data are disclosed only by public companies, smaller size firms won't be taken in consideration from a quantitative point of view. Collected data from smaller firms have been considered only as qualitative feedback in order to protect company's secrecy.

Datasets considered contains mainly last decade data, to evaluate the pre-transition status and the post-policy introduction changes.

The main indicators extracted include:

- Revenue growth
- EBITDA & EBIT margin
- R&D expenditure (if available)
- Capital expenditures (CAPEX)
- Net financial position
- Return on invested capital (ROIC)
- Geographic revenue distribution

The variables listed above allow the evaluations of financial distress, capacity of innovation and if there are changes in the way of managing firm's economics.

Industry Reports and Institutional Data

To contextualize and to scale the analysis to a bigger European-wise perspective, macro-industrial data have been collected from the major EU contributors.

Documents collected come from:

- European Commission
- Industry associations
- International agencies
- Strategic consulting reports

The macro data collected are useful to provide indicators of the industrial context in which suppliers are in business.

Some of the main indicators extracted are:

- EV penetration rates
- Battery production capacity
- Trade flows for raw materials
- Employment rates related to ICE components production
- Industrial trends

Industry reports permit to have a broader vision of the industry-level modification and transformation dynamics.

Evaluations for data-based comparison

In this framework, some real case evaluations will be carried out to analyze multiple stakeholders comparatively. With the support of analytical tools, examples of firms will be taken in consideration in order to take a real-life picture of the market sentiment and trend. The comparison will take in consideration mainly different suppliers that are adapting or not with specific strategies to the market needs created by the electric transition.

3.3 Analytical Methods

Analytical methods used in this research have been chosen on the base of the typology of the data available.

Three analytical layers have been identified and integrated

1. Descriptive statistical analysis

2. Industry benchmarking
3. Multi-Criteria Decision Making (MCDM) modelling

Each method addresses a specific dimension of electrification-driven transformation.

Descriptive Statistical Analysis

Descriptive statistics has been used to identify possible patterns in supplier financial strategic choices.

The main drivers of the analysis are:

- Mean and median comparison
- Growth rate analysis
- Profitability
- Ratio analysis
- Trend comparison across time

This approach tries to identify the main systematic differences regarding:

- Investment intensity
- Profitability resilience
- Electrification exposure
- Geographic diversification

The principal objective is to find if structural divergences are existing among suppliers and if these can be linked to the exposure to risks related to electrification.

Industry Benchmarking

Industry benchmarking has been chosen because it integrates both qualitative and quantitative evidences. It assess supplier positioning and strategical paths undertaken by early investor suppliers or possible strategies available for latecomers.

Benchmarking focuses on:

- Technological capability
- Financial stability
- Electrification exposure
- Supply chain resilience
- Regulatory alignment

Many of these drivers have been taken from data extracted by industry insiders. They have been used to highlight the importance of long-term strategic positioning over short-term profitability.

A specific section (3.4) has been dedicated to the MCDM modelling proposed.

3.4 Multi-Criteria Decision Making (MCDM) Framework

In addition to the previous indicators, this research tries to implement a possible decision-making tool that can be used for single suppliers evaluation. The aim is to identify which companies are adapting (or not) their business models to the transition. The aggregate output of many analysis can be useful to evaluate the overall supply chain adaptation condition.

Rationale

Since the time of first globalization, the analysis of the supply chain has become more complex than before. Supplier base is more interconnected and some of the less profitable or specialistic businesses have been outsourced. As a consequence of that, "evolution included a more strategic focus on the buyer-supplier relationship where close collaboration was necessary and certain skills and capabilities were required" (Govindan et al., 2025). OEMs are still using evaluation criteria to rate suppliers, and this research wants to carry over the same scheme for the supply chain electric adaptation evaluation.

Traditional single financial based assessments are insufficient for providing effective feedbacks on supplier because they typically lacks of a more global evaluation. Electrification introduces new elements to be taken in consideration and to be converted in comparable values.

In this scenario, Multi-Criteria Decision Modelling can be used to structure a transparent evaluation of each supplier involved in the Automotive supply chain.

Given the complexity of electrification transition, MCDM provides:

- Integration of heterogeneous indicators
- Transparent weighting of strategic priorities
- Replicable ranking mechanism
- Reduction of subjective bias

Formal Model Definition

We summarize briefly the general mathematical basis used for the MCDM structure proposed.

Let:

$$A = \{A_1, A_2, ..., A_m\}$$

be the set of suppliers under evaluation.

Let:

$$C = \{C_1, C_2, ..., C_n\}$$

be the set of evaluation criteria.

Each supplier A_i is evaluated under specific criterion C_j , based on each index specificity, producing performance value:

$$x_{ij}$$

The decision matrix will be:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

Criteria Structure

The assessment for each criterion is divided into macro-dimensions:

1. Financial Strength
2. Innovation and Technological Capability
3. Electrification Exposure
4. Supply Chain Resilience
5. Strategic and Regulatory Alignment

Each macro-dimension can have different rating evaluation process, from quantitative data to qualitative rating evaluation.

Normalization

Since not all the criteria derives from the same scale and due to the fact that not all the drivers share the same unit of measure, normalization is needed to have coherent data.

To obtain an effective normalization, there's the need to divide two types of criteria:

- Benefit or positive performance criteria: the performance is positively influenced by increasing inputs. In this case the normalization formula is:

$$r_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)}$$

- Cost or negative performance criteria: the performance is negatively influenced by increasing inputs. In this case the rationalization formula is:

$$r_{ij} = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)}$$

By adopting these 2 rationalization formulas, normalized outputs can be confronted directly.
At this point, the normalized matrix is composed by the normalized values, coming from each performance value per each supplier:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

with:

$$0 \leq r_{ij} \leq 1$$

Weight Assignment

In general terms, we could take the assumption of having assigned to each criteria the same impact of weight.
In this case, since there could be some electrification relevant factors that could be more impacting than other, it can be possible to overweight some specific drivers. Following this approach, we must ensure that the overall "weights" are anyway within 1.
Considering w_i the weight assigned to a generic j criteria, we must ensure that:

$$\sum_{j=1}^{n} w_j = 1$$

With:

$$w_j \geq 0$$

Specific weights may be assigned thanks to expert judgment or benchmarking.

Composite Score

By considering what shown before, the calculation of the score S_i for the i-th supplier will be:

$$S_i = \sum_{j=1}^{n} w_j r_{ij}$$

Where supplier scoring will be better the higher the S_i value.

It's evident how higher values impacting the weights or the scoring for a single evaluation criteria will impact positively the overall supplier score.

Limitations

The methodology presented can be useful for the purpose of this research but it entails limitations:

- Dependence on publicly available data
- Potential subjectivity in weight assignment
- Absence of causal econometric testing
- Rapid technological evolution potentially outdating evaluation parameters

These flaws are limiting the results of the research but thanks to the multi-criteria evaluation adopted, at least a general understanding of supplier performances can be extracted. By considering the fact that evaluations criteria and weighting of each one will be derived from expert evaluations, the power of the tool can be more effective.

Chapter 4

Electrification

4.1 Industry Transformation Overview

The electrification of the EU automotive sector is one of the most impacting industrial transition that took place in the last decades. While in the literature review the regulatory and the geopolitical challenges have been underlined, the current implementation of electrification of the supply chain is visible trough measurable changes. The transformation is altering top-down supply chain organization, production architectures, distribution of the value along the chain and consequently also the financial stability of the firms involved.

Previous technological transition in the automotive industry were less organic, impacting only small portions of the architecture. Traditional vehicles with internal combustion engines rely on mechanically complex systems, including many moving parts and ad-hoc ancillaries, like: engine rotating components, fuel injection systems, transmissions and gearboxes and exhaust after-treatment systems. Electric vehicles, instead, require less mechanical components and systems but integrate higher levels of electronics, software capacity and chemical materials. The technological discontinuity created by a large unnecessary number of physical parts implies a declining demand for suppliers operating in the ICE segments. These suppliers will face a long-term declining demand while the new emerging technological domains will create space for new business opportunities.

The redistribution of value across different categories of the supply chain is already visible. Thanks to information received from industry insiders, nowadays OEMs are shifting some of their long-term development partnership from fully mechanical scope suppliers to firms that have knowledge and capabilities in the software integration, battery or EV relevant technologies.

It is clear that electrification is increasing the intrinsic value and importance of electronics, semiconductors, batteries and digital integration control systems. In the last decade, this value shift was broadly anticipated also by sector studies (European parliament, Eurofound). The electronic components are estimated to reach a share of the overall vehicle value from current 35% to 50% by 2030 (European Parliament, 2021). This shift naturally triggers a challenge to the current structure of the automotive supply chain on the competitiveness and capacity of production. Firms historically specialized in mechanical systems manufacturing must rapidly reallocate their core businesses toward new technological domains, even implying the complete rebuilt of the technical knowledge.

The current macro-industrial situation of the automotive sector is badly affected by unstable production levels and different trends between EVs and ICE cars. The overall production is declining and far to reach again the target of pre-2020 levels (15 millions in 2017 vs 11,4 millions in 2024). This decrease causes a cascade process, decreasing suppliers production volumes and making them to run in undercapacity conditions their production lines. In parallel to the overall decrease, there are increases in the market share of electric powered or assisted vehicles: this trend is beneficial to firms already involved the market sectors relevant for EV components, while worsening even more the financial conditions of ICE parts manufacturer. The current production pattern creates important vulnerability gaps for those firms that have not enough resources to invest in new electric capabilities or made strategically bad decisions when facing the choice of where to allocate development expenses.

In addition, as analyzed in the literature review, thanks to the high level of globalization achieved, suppliers must face the competition also from outside-EU companies, that started investing high quantities of money on the EV sector while strongly supported by their governments. The magnitude of this pressure is so strong that nearly 75% of suppliers are expecting low profits in next years, with the majority of them fearing of not reaching the break even financial point (CLEPA, 2025). These figures underline the fragile companies pattern in which many supplier are trying to navigate.

Thanks to feedbacks from interviewed people working in some European OEMs, a new trend is impacting suppliers: the shift of bargaining power towards OEMs.

The automotive supply chain has historically been characterized by a strong asymmetry in bargaining power: aside from rare cases, OEMs are the owner of the majority of the power, while suppliers detain only small negotiation spaces. Contracts set up between OEMs and suppliers were relying on stable production volumes and loyalty of relationship between the involved stakeholders. However, in recent years, lower selling volumes and lesser new cars are causing OEMs to struggle in keeping proper financial conditions. Insiders are confirming that there are increasing claims from suppliers to OEMs for missing production volumes but due to the huge asymmetry in contracts set up, suppliers can do nothing. Typically, huge penalties are charge to firms in the supply chain that are unable to deliver parts and still no volumes guarantees are present. In a standard contract between a supplier and OEM, payment flows are extremely delayed: from nomination date to payment date for tooling cost or development costs, the delay can last years, still with no guarantees on future volumes. Moreover, only in rare cases there are clauses related to raw material or energy increases, that in other way are directly and only covered by suppliers.

In these extremely complex conditions, suppliers must transition toward EV-relevant components. They must invest in new technologies even with uncertainty of the market and with a rapid evolution of the platform architectures. In parallel they must anticipate all the costs, creating a temporarily but long-lasting mismatch between cash outflow and inflow, menacing revenues and financial stability.

The increasing importance and relevance of previously overseen technologies: digital integration, semiconductors, software, etc., now creates also new space for new companies inside the automotive supply chain. This convergence of industries creates new pressure on automotive supplier incumbents, highlighting the risk of loss of technological dominance of internal firms.

As highlighted in previous chapters, the automotive industry is evolving toward a more interconnected industrial system, with new technological boundaries that broaden the borders of the electronic integration and restrict the region of mechanical moving parts. Battery production is surely one of the top industries that will face a strong demand and so, investments for productive capacity. Geographical sector rich in raw materials like lithium, nickel, cobalt and rare earths will be naturally favored for battery production and costs control over these minerals. Unfortunately, most of the global reserves are located outside EU, where there are poor regulatory basis for mining and refining of these materials. Countries rich in these minerals, like China, are now the main sources: the upstream dependency from them creates a strategical flaw in the supply.

In this context, electrification transition becomes a total systemic and globally impacting transformation. The supplier base, which before represented the strength of the automotive industry is now called to shift to a completely new paradigm while preserving an already fragile financial sustainability.

The next section therefore tries to focus on the financial dimension of the transformation, by taking in consideration selected European suppliers that are coming from different specialization sectors but have to anyway face the electric transition. By the examination of firm-level financial data, it becomes possible to understand and assess if suppliers are successfully adapting or not the electric transition or if they are already experiencing some kind of financial distresses.

4.2 Quantitative Analysis of Supplier Financial Exposure to Electrification

The transition towards electric mobility creates a significant financial pressure on the incumbent automotive suppliers that are already in the market and must face new entrants competition. The EV's components need changes drastically the cost structures of the production and development, thus capital intensity and investment requirements. As discussed before, ICE cars requires a high amount of complex mechanical components and systems while EVs require less components but very capital intensive from production and R&D point of view.

Suppliers that wants to remain in the market, therefore face the challenge of maintaining legacy product lines and a parallel investments in new technologies. This research took three major European suppliers, different for core competencies but strategical in the supply base of the EU industry.

These companies are:

- Forvia: founded by the merger of Faurecia and Hella in 2022, its core competences are: interiors systems, electronics, lighting and sustainable mobility
- Valeo: founded in 1923, long standing French supplier. Specialized in electrification technologies, thermal systems and driver assistance
- Eberspächer: active since 1865, established German supplier. Main production is: exhaust technology and thermal management systems. Currently they're adapting their portfolio toward EV relevant components.

These companies have been chosen because they are representative for different clusters of suppliers, specialized in specific core technologies and now facing the electric transition.

The analysis relies on publicly available financial data, like annal financial reports related to fiscal year 2024. The main purpose is the evaluation and comparison of some specific indexes that have been processed through MCDM methodology. Therefore, the objective is not to provide a full financial statement analysis of each company.

The main drivers relevant for the research are a set of indicators capable to capture some key elements relevant for the transition, like profitability, innovation effort, capital investment intensity and capital efficiency.

Four indicators were selected for the analysis:

- EBIT margin: reflects operational profitability and the capability of keeping costs under control
- R&D intensity: represents the commitment of the company on innovation and new technological investments
- CAPEX intensity: in a extremely capital intensive transition, this indicator is crucial to understand how capable firms are regarding to new investments
- Return on Invested Capital (ROIC): indicates the efficiency with which firms are deploying their capital with the target to generate operating returns. It's an important indicator for long-term strategic financial and operational sustainability.

All the indicators are "Benefit or positive performance criteria" so, as explained in Chapt.3, the performance is positively influenced by increasing inputs.

4.2.1 Financial Data Sources and indexes calculation

The automotive companies selected are European, public and private:

- Forvia and Valeo: Public, listed in Euronext Paris
- Eberspächer: Private

The financial data have been extracted from the publicly available financial reports for 2024, posted on the official company website (FORVIA Universal Registration Document 2024; Valeo Universal Registration Document 2024; Eberspächer Annual Report 2024).

These documents are providing official and audited financial information, therefore they represent a reliable data source.

These documents provide audited financial information and therefore represent reliable primary data sources.

EBIT Margin

EBIT margin measures operating profitability, recalling the formula:

$$EBIT\ Margin = \frac{EBIT}{Revenue}$$

Forvia reports operating income of approximately 1.400 Mio€ on revenues of 26.974 Mio€.

$$EBIT\ Margin_{Forvia} = \frac{1,400}{26,974}$$

$$= 5.19\%$$

Valeo reports operating income of 919 Mio€ on revenues of 21.492 Mio€.

$$EBIT\ Margin_{Valeo} = \frac{919}{21,492}$$

$$= 4.27\%$$

Eberspächer reports adjusted EBIT of 114.1 Mio€ on revenues of 2.731,7 Mio€.

$$EBIT\ Margin_{Eberspächer} = \frac{114.1}{2,731.7}$$

$$= 4.17\%$$

The results points out that Forvia has currently the highest operating profitability. The other suppliers share a similar result.

R&D Intensity

R&D intensity measures the amount of revenue invested in research and development activities compared to Revenues.

$$R\&D\ Intensity = \frac{R\&D}{Revenue}$$

Valeo reports R&D expenditure of 2.127 Mio€, corresponding to 9.9% of sales, reflecting the company's strong focus on electrification and advanced mobility technologies.

$$R\&D\ Intensity_{Valeo} = \frac{2,127}{21,492}$$

$$= 9.89\%$$

Forvia reports R&D expenses of 934,8 Mio€.

$$R\&D\ Intensity_{Forvia} = \frac{934.8}{26,974}$$

$$= 3.46\%$$

Eberspächer reports R&D investments of 40,2 Mio€.

$$R\&D\ Intensity_{Eberspächer} = \frac{40.2}{2,731.7}$$

$$= 1.47\%$$

In this case, the comparison highlights strong differences among the 3 suppliers. Valeo clearly entails a very aggressive R&D strategy, in line with the transition requirements, while Eberspächer lacks in innovation capabilities and has a more conservative approach.
Forvia sits in the middle, expectedly with an average index, confirming the pattern of a balanced production portfolio between traditional components and EV relevant ones.

CAPEX Intensity

Capital expenditure intensity measures the scale of investment in physical and technological assets in relation to revenue.

$$CAPEX\ Intensity = \frac{CAPEX}{Revenue}$$

Valeo reports capital expenditures of 1.138 Mio€.

$$CAPEX\ Intensity_{Valeo} = \frac{1,138}{21,492}$$

$$= 5.29\%$$

Eberspächer reports investments of 102.4 Mio€.

$$CAPEX\ Intensity_{Eberspächer} = \frac{102.4}{2,731.7}$$

$$= 3.75\%$$

Forvia reports capital expenditures of approximately 1.000 Mio€, corresponding to roughly 3.7% of revenue.

$$CAPEX\ Intensity_{Forvia} = \frac{1,000}{26,974}$$

$$= 3.71\%$$

Again, these figures suggest that Valeo detains the highest level of capital investment capabilities in relation to its size.

Return on Invested Capital (ROIC)

ROIC measures the efficiency of conversion of investments into operating profit in its business. This index is weighted on the tax level of each company, in fact the profit considered is the Net Operating Profit After Taxes (NOPAT).

$$ROIC = \frac{NOPAT}{Invested\, Capital}$$

In which:

$$NOPAT = EBIT \times (1 - Tax\ Rate)$$

And Invested capital equals:

$$Equity + Net\ Debt$$

For Forvia, the corporate tax rate reported in the financial statements is approximately 25.83%. Thus,

$$NOPAT_{Forvia} = 1,400 \times (1 - 0.2583)$$
$$= 1,038\, million$$

Invested capital is approximated as:

Forvia:

$$9.6 + 6.6 = 16.2\, billion$$

$$ROIC_{Forvia} = \frac{1,038}{16,200} = 6.4\%$$

For Valeo, the effective tax rate is 31%, as calculated from their annual report and available in the Euronext Valeo specific data. (https://live.euronext.com/en/products/equities/company-news/2025-02-27-valeo-2024-results).

$$NOPAT_{Valeo} = 919 \times (1 - 0.31)$$
$$= 634\, million$$

Invested capital:

$$4,515 + 3,813 = 8,328$$

$$ROIC_{Valeo} = \frac{634}{8,328} = 7.6\%$$

For Eberspächer, a private company, the effective tax rate is not officially disclosed in the financial annual report. Therefore, as a reliable reference, the German combined statutory corporate tax rate has been considered. The value is 30.06% and it is an annual index reported by KPMG per each European country. (https://kpmg.com/dk/en/services/tax/corporate-tax/corporate-tax-rates-table.html).

$$NOPAT_{Eberspächer} = 114.1 \times (1 - 0.3006)$$
$$= 79.8\ million$$

Assuming invested capital of approximately 1.400 Mio€, the resulting ROIC is:

$$ROIC_{Eberspächer} = \frac{79.8}{1,400} = 5.7\%$$

4.2.2 Decision Matrix & Aggregate scoring

The financial indexes calculate din the previous section represents the input dataset for Multi-Criteria Decision Making (MCDM) analysis. The main objective of this section is to organize the raw data into decision matrixes, useful for suppliers systematic evaluations and comparison.
The decision matrix includes the four indexes calculated per each supplier. These indexes aim to capture complementary aspects of supplier financial capabilities and competitiveness.
As declared before, all the indexes are "Benefit criteria": also the derivate indexes will carry on this property.
The resulting decision matrix is presented below.

1 Table 4.2.2A Decision Matrix

Supplier	*EBIT Margin*	*R&D Intensity*	*CAPEX intensity*	*ROIC*
Forvia	5,19%	3,46%	3,70%	6,40%
Valeo	4,27%	9,90%	5,29%	7,60%
Eberspächer	4,17%	1,47%	3,75%	5,70%

This matrix is the starting base layer for the MCDM analysis. However, the scale of the input used for these indicators are extremely different: to have a more effective comparison, a normalization of the data is useful.

Normalization of the Decision Matrix

As said before, to have a better understanding of the data it is useful to convert them in comparable values. Since the criteria shares the benefit property, a classical min-max normalization is applied. In this way, the results will consider the span of values between the best performing and the worst performing supplier.

As shown in Chap.3 the normalization formula is defined as:

$$r_{ij} = \frac{x_{ij} - min(x_j)}{max(x_j) - min(x_j)}$$

where:

- xij represents the original value of index j for supplier i
- min(xj) and max(xj) are respectively the minimum and maximum values of the index j among the possible suppliers

This transformation rescales the values between 0 and 1, where:

- 0 represents the weakest performance
- 1 represents the best performance

Applying this normalization procedure to the decision matrix produces the following normalized matrix.

2 Table 4.2.2B Normalized Decision Matrix

Supplier	*EBIT Margin*	*R&D Intensity*	*CAPEX intensity*	*ROIC*
Forvia	1.00	0.24	0.00	0.37
Valeo	0.10	1.00	1.00	1.00
Eberspächer	0.00	0.00	0.03	0.00

The normalized matrix permits an easy comparison of the data. All criteria per each supplier are now comparable without distortions.

Weighting of Criteria

After the normalization, each criteria must be assigned with a specific weight in order to reflect the importance of each one. In this case, equal weighting has been assigned to each criteria. This assumption reflects the confirmation by industry insiders that the importance of each criteria is the same. The indexes chosen are all crucial in evaluating a supplier in the chain due to the structural impacts on financials by the electrification transition.

Therefore, each criterion receives a weight of:

$$w = 0.25$$

The weighting scheme is summarized below.

3 Table 4.2.2C Criteria Weights

Criteria	***Weight***
EBIT margin	0,25
R&D Intensity	0,25
CAPEX Intensity	0,25
ROIC	0,25

Aggregate Score and Ranking

By aggregating the weighted indexes per each supplier, the final score overall supplier can be calculated.

The score for each supplier is calculated as:

$$Score_i = \sum w_j r_{ij}$$

where:

- w_j is the weight assigned to criterion j
- r_{ij} is the normalized value.

The resulting scores are shown below.

4 Table 4.2.2D Final MCDM Scores

Supplier	***Score***
Valeo	0,78
Fovia	0,40
Eberspächer	0,01

The ranking derived from the MCDM model is therefore:

1. Valeo
2. Forvia
3. Eberspächer

This ranking reflects the positioning of each supplier based on profitability, technological investment and capital efficiency

4.2.3 Interpretation of the Results

The result of the MCDM analysis underlines differences in the financial and strategic positioning of each supplier in the current context of electrification transition.

The supplier that better responds the financial requirements requested by the transition is certainly Valeo. In the model Valeo performs best, excelling particularly in levels of research and development investment and capital expenditure. These indexes highlight a strategic focus on strong innovation, namely on electrification technologies and mobility solutions. There is only one element in which Valeo is not best in class, the EBIT margin. In this case Valeo fully compensate this index trough strong balancing with the two drivers. Having a high level of ROIC represents that the high levels of R&D are being transformed effectively trough invested capital into profit.

Forvia ranks second in the analysis. The company data demonstrate high levels of operating efficiency in comparison to the other suppliers. By considering also the lower level of R&D and CAPEX intensity, the company tries to balance the improvements in the current production while still investing in new development and new productive capabilities. This balanced approach could be effective in the case of a slow industry transition, where the advancement speed allows gradual investments. In the context of electric transition, while in short-term this strategy could maintain a good financial stability, it could also delay the repositioning of the supplier in the market and thus impeding full supplier competitiveness.

Eberspächer ranks last in the analysis, mainly due to its significantly low R&D intensity and smaller investment capacity. The company spent decades in producing and developing ICE components like exhaust systems and thermal management technologies, that now are less requested by the market. Although the firm maintains a good operative profitability until now, it's the worst performing in nearly all the criteria and the lower level of innovation capability may limit critically the ability to reposition itself in the EV supply chain.

Overall, the analysis shows that financial resilience in a capital and R&D intensive context like the electric transition does not rely only on short term yearly profitability. The capacity to sustain high investment levels and to convert these into profit is crucial for long term business. The main key is that, in this fast-paced environment, suppliers must invest more aggressively in innovation and production capacity for new technologies or they will fail to remain in the market.

4.3 Case Insights on Strategic Adaptation: Bosch

The electrification transition is creating increasing divergence among supplier in the automotive sector: many companies are finding difficult to reposition themselves, others are trying to catch up to remain aligned to the market and there are also firms that started as early birds and now they're already exploiting good strategical choices taken in the past. To examine how successful adaptation can happen, in this section the research examines the firm Robert Bosch GmbH, one of the biggest European automotive supply company in the world.

This company is a peculiar case because it built its competitive advantage by producing parts needed for internal combustion engines. As the cleaner mobility started to be perceived as a likely direction for the European market, Bosch adopted a proactive strategy aimed to gain knowledge and set investments for the electric components. Rather than waiting for transition to happen and remaining only with the exploitation of already existing production assets, the company expanded capabilities in electrified powertrains, power electronics, battery management systems and digital mobility technologies. It is important to note how this path was started back in time, progressively increasing in magnitude until now.

Bosch's Historical Position in the ICE Supply Chain

Before the boost given to the electrification transition given by the European Union, Bosch was the undiscussed leader in the supply chain technologies for key components for the internal combustion engines. The most important technological legacy was the fuel injection systems: a critical element for enhance combustion efficiency and emission control. In short time, Bosch became the global leader in production and development of gasoline and diesel injection technologies, supplying high-pressure pumps, injectors and electronic control units to major automotive manufacturers.

Alongside the injection systems, Bosch developed advanced electronic devices for engine management. Those were control units capable of regulating ignition timing, fuel injection and emission control systems: all crucial elements in Europe, in which the emissions regulations were already starting to be very stringent to ensure a better air quality. For the same reason, Bosch developed also exhaust after-treatment technologies, including sensors and additional control units for catalytic converters and filters. This portfolio of components was strongly relying on the production of ICE cars and Bosch was efficiently exploiting the market needs. However, all these components on EVs are no more needed and so the company started very soon to move towards other productions.

Early Strategic Moves Toward Electrification

Bosch did the strategic move of starting to invest in electrified mobility technologies already before the large-scale diffusion of electric vehicles. A key point was 2009: Bosch entered a joint venture with Samsung SDI with the target of common development of batteries for automotive applications. Through this move, Bosch started acquiring expertise in the battery systems in large advance to the breakout of EVs.

Another relevant milestone occurred in 2011, where Bosch introduced its own first electric drive system, to be installed on Electric or hybrid vehicles. These early-stage development were conducted also in partnership with automotive manufacturers and allowed Bosch to gain on-field experience.

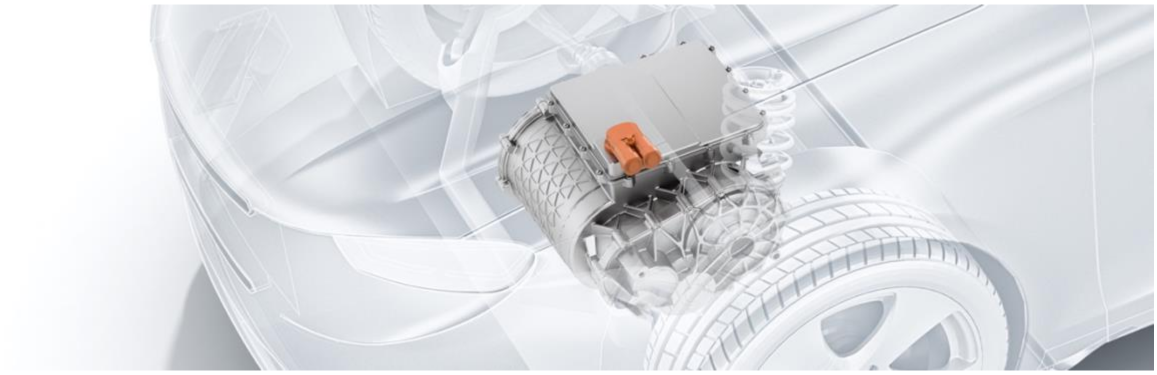
During the following decades, the company continued to expand its portfolio toward electric mobility. By 2018, the company was already strongly into the EV chain, the early investments allowed Bosch to strengthen its technological position before expansion of the EVs.

Expansion into Electrified Powertrain Technologies

Bosch strategic adaptation has been strongly supported by investments relying on a solid and financially stable company. From the annual report of 2024, the figures for the annual R&D investment volume are hugely impacting: 7 billions of euros were put in R&D, corresponding to the 9% of the total revenue. A growing share of these investment is being considered for electrification technologies and software defined vehicles architecture.

Electromobility has become one of the fastest-growing segments in Bosch portfolio: in 2023, the electromobility business generated around 5 billions€, in 2026 they're planning to reach around 10 billions of euros, as global EVs demands expands.

One of the core business elements that contributed to Bosch EV parts leadership is the electric axle (eAxle): this system integrates the electric motor and the transmission with the electronic controls ancillaries, in one single compact unit.



4 Figure 4.3 Bosch eAxle

This architecture dramatically lowers complexity of EV drivetrains, removing hardware specificity for each car model and creating a nearly off-the-shelf unit to be installed on different vehicles platforms.

Another strategic area of investment is represented by silicon carbide semiconductor technologies, relevant for power electronic devices that control the electric powertrain and vital to reduce energy dispersions and losses.

Strategic Partnerships with OEMs

Another interesting element of the Bosch case are the technological partnerships agreed with many European OEMs. As highlighted by some industry insiders, the company exploited its trustful relationship with OEMs and long-standing presence in the sector to gather the opportunity to establish development partnership with mostly every European car manufacturer. The scheme is simple but effective: OEMs R&D do not have full deep knowledge of electronic specific components, so instead of assigning only the production of parts to a supplier, they choose a supplier that carries on both the development and research and subsequently also the lifecycle production of parts. In this case, given the dominance that

Bosch created over time on electronic components, the company is strongly involved in the development and production of electrified vehicle platforms.

Bosch maintains strong cooperation agreements with Volkswagen Group (incl. Audi, Skoda, Seat, etc.) , supplying the development and production for EV technologies such as power electronics, electric motors and energy management systems used in electric vehicles. The company also has collaboration agreements with Daimler in the development of electrified and hydrogen-based powertrains for heavy-duty transport applications. By entering these development partnerships, Bosch ensured its leading role as a technological integrator among components within the electric mobility ecosystem.

Digital Capabilities and Technological Diversification

As previously stated, the electric transition is strictly linked to the ongoing digital transformation of the automotive industry. Modern cars are more and more relying on software systems for connectivity, energy management and automated driving. Bosch took the opportunity to join this industry and expanded its capabilities in it.

According to company Group Corporate Profile (2025) the workforce involved in development employs 86.600 associates, of which 48.000 are software engineers. These figures help to understand the development capacity of the company for future expanding EV related businesses.

At the same time, the company continues to maintain some degree of diversification in its technological portfolio, by investing in hydrogen mobility technologies: current those are considered as a complementary solution for the heavy-duty sector, where battery technology could face effective technical limitations.

Implications for Supplier Adaptation

The Bosch case highlights which are the factors that contribute to a successful supplier adaptation to the new paradigm. Firstly, Bosch has been an early investor in electrification technologies, beginning partnership already in 2009 to develop batteries for electromobility and continuing to invest up to current days. Secondly, the company took advantage of its consolidated expertise in ICE electronic technologies for leveraging development in new technological domains like eAxles and battery management systems. Third, Bosch enhanced its strategic position through strategic long-term partnerships with OEMs that allowed the company to have a competitive advantage over competitors and being crucial for car manufacturers not only from a production point of view but also from a system integration development point.

The rapid growth of Bosch business in electromobility certifies the interest of the company to maintain and strengthen its position as industry leader for EV transition.

Overall, Bosch is a positive example of how incumbent suppliers can remain competitive also during strong technological disruptions by anticipating the trends and perform strategic collaboration partnerships with OEMs.

Chapter 5

Risk Management and Resilience in Automotive Supply Chains

5.1 Risk Typologies and Mitigation Strategies

In the past decades, globalization has conditioned supply chains: they became increasingly complex, geographically jeopardized and technologically interconnected. These characteristics led to a significative improvement of operational efficiency but have simultaneously increased the exposure of stakeholders involved to possible disruptions and systemic risks. As production networks expands in multiple global regions and involve an increasing number of actors, issues or disruptions in a single node of the chain may lead to a vast propagation to other nodes.

This pattern is extremely relevant for the automotive industry: it relies on coordinated supply chain ecosystems, where multiple suppliers deliver components under quality and time constraints. Production logistic models like just-in-sequence (JIS) or just-in -time (JIT) schemes enabled extreme operational and cost efficiency thanks to the reductions on inventory needs and faster flows inside factories. However, these models entail additional operational risks in case of unexpected disruptions and lower ability of problem absorptions.

The ongoing electrification transition is further stressing the structure of the automotive components supply chain because of the intrinsic characteristics of the technologies needed. As seen in previous chapters, the transition requires the integration in the supply chain of new components and new raw materials like lithium, cobalt, nickel and rare earth elements: all resources mainly coming from outside EU and subject to geopolitical, economic, and logistic uncertainties.

In this industrial context, ensuring a resilient supply chain has become a central element to ensure stable production capacity and operational continuity. Resilience is "the capacity for an enterprise to survive, adapt and grow in the face of turbulent change" (Pettit, T. J. et al., 2019), so resilience is not only the ability to recover from operational interruptions but goes beyond, including the capability to adapt to changes affecting the market.

To adopt and develop efficient resilience strategies, the first step is to understand the main possible sources of risks for the supply chain. Since Supply chains are networked structures, disruption affect one single part of the system could spread widely, generating cascade effects along the entire network. As highlighted by Pettit, T. J. et al., there are several structural factors that contribute to supply chain vulnerability: globalization of production networks, centralized manufacturing facilities, increased outsourcing, reduced supplier bases and growing demand volatility. In the automotive industry these elements are particularly relevant due to high levels of specializations among supplier and the manufacturing interdependencies between vehicle component assemblies.

The electrification transition amplifies these vulnerabilities due to the introduction of new components that before were only marginal, or absent. For example, battery cells production is critical per EVs but it's concentrated in a small portion of regions and the mineral extraction and processing is mainly performed outside EU, relying on a global supply network. It is clear that small issues or disruption in the upstream value chain can cause critical consequences for the production of cars in OEMs plants.

From the current industry knowledge, traditional approaches to supply chain risk management has always been relying on identification and mitigation of risks trough assessment processes. However, the growing complexity of modern supply networks highlighted some criticalities an limitations of the traditional risk management frameworks. As highlighted by Pettit, T. J. et al., 2019: "traditional risk management techniques are lacking in their ability to assess the complexities of supply chains, evaluate the intricate interdependencies of threats, and prepare an enterprise for the unknowns of the future": since the direction of the automotive supply chain has the same characteristics, it becomes critical to find new possible evaluation schemes. Another flaw highlighted by Pettit, T. J. et al., 2019 is that there are additional issues in identifying low-probability but high-impact events and "the greatest weakness of risk management is its inability to adequately characterize low-probability, high-consequence (LP/HC) events". Scenarios like natural disasters, geopolitical conflicts, pandemics, or systemic technological failures are the ones that mostly are described by the LP/HC definition. Although it is difficult to predict the effective realization in the future of these risks, it can be possible to create some kind of preventative plans to be activated in case of such events. This is extremely relevant because the electrification transition raises the exposure risk, as the EVs production relies on new technologies, new stakeholders and new geographical distribution.

To synthetize the main sources of vulnerability along the supply chains, Pettit et al. identify seven general major categories of supply chain risks:

- Turbulence
- deliberate threats
- external pressures
- resource limits
- sensitivity
- connectivity
- supplier or customer disruptions

Here follows a brief description of each one, and the impact on the overall automotive supply chain.

Turbulence relates to the uncertainty in the system originated from unpredictable changes not controllable by the actor in the supply chain. Applied to the automotive industry it includes: technological innovation and uncertainty, regulatory changes and fluctuating volumes.

Deliberate threats are intentional actions with the target of interrupting the flow of the supply chain or to cause physical or financial damage. For the automotive industry risks of this typology could include cybersecurity attacks to gather information or steal not disclosed details.

External pressures entail all broader environmental factors that create limits or constraints to the supply chain. The electrification transition itself represents an external pressure on the automotive supply chain: the environmental policies are directing the development and also are creating a time-adoption constraint.

Resource limitations represent the availability of raw or refined production inputs, such materials or skilled labor. In the electrification context, these limitations are particularly visible for batteries or semiconductors.

Sensitivity is the degree of proportion between an input variation on the output. It is relevant in case minor disruption can generate bigger operational consequences. In EVs production typically the sensitivity is high due to the integrated electronic systems and advanced battery technologies.

Connectivity represents the level of interdependency in complex networks. How a disruption in a single point inside or outside of the supply chain can affect horizontally also other streams.

While interdependency enhances efficiency and coordination, it causes a risk of major propagation along the network.
In general terms, supply chains are intrinsically exposed to possible disruption coming directly from suppliers or due to errors from customers. Production problems, quality issues or legal contractual disputes affecting tier 2 or tier 3 suppliers may create a cascading effect on the overall supply chain and affect the continuity of final manufacturers.
In order to compensate and mitigate all the vulnerabilities shown before, companies can develop portfolios of actions aimed at strengthening the supply chain resilience. Pettit et al. define these capabilities as "attributes that enable an enterprise to anticipate and overcome disruptions" (Pettit et al., 2019): the pursue of these attributes is to prevent and reduce the impacts of possible disruptions and then also provide a fast recovery. In a manufacturing intensive supply chain, like automotive, examples of resilience capabilities are flexible sourcing strategies, supply chain visibility, collaborative relationships with upstream suppliers, development of back-ups for productive or logistic solutions. In this pattern, digital technologies play an important role in providing continuous control over risk detention and chain monitoring.
A factual consequence of the implementation of resilience frameworks is that it cannot be possible to anticipate all the possible sources of risk or prepare counter actions for each scenario, but the key is to find a balance between vulnerability exposure and capabilities. As Pettit et al. highlights, "supply chain resilience increases as capabilities increase and vulnerabilities decrease", however excessive concentration of investments in resilience attributes can reduce the efficiency of normal operation business.
Firms must develop a balanced portfolio of capabilities to address main vulnerabilities, by selecting the most critical trough careful ex-ante analysis.
In the context of the automotive electrification transition, risk management along the supply chain and resilient supplier networks are priority tasks to be addressed, also taking in consideration the newly complex system.
The following section therefore examines resilience practices among automotive suppliers in order to assess their preparedness to manage emerging supply chain risks.
Below is shown a table synthetizing the main risk category linked to examples of the risk itself and proposed mitigation strategies.

5 Table 5.1 Supply Chain Risks and Mitigation Strategies

Risk Category	Example of risk	Example of mitigation
Turbulence	Unexpected context conditions variations	Flexible production planning, inventory buffers
Deliberate threats	Intentional disruptions like intellectual property theft	Cybersecurity systems, security protocols, supplier audits
External pressures	Regulatory changes, environmental policies	Regulations trends monitoring, technology adaptation
Resource limits	Shortages of raw materials or production capacity	Supplier diversification, alternative sourcing
Sensitivity	Dependence on controlled conditions or complex technologies that have little variation possibilities	Quality management systems, process standardization, technical redundancy
Connectivity	Interdependence among supply chain actors	Control of supply chain trough visibility tools, digital platforms
Supplier / customer disruptions	Operational or financial failures of suppliers	Multi-sourcing strategies, supplier periodical assessment

This section provided an overview of the main risks to be assessed by supply chain stakeholders, with the specific focus on automotive supply chain. The next challenge is, for suppliers and OEMs involved, the identification of the most critical components, in order to have more substantial mitigation capabilities on the most relevant parts. To address this challenge, the section 5.2 introduces a quantitative assessment proposal for EV strategic components.

5.2 Evaluation of possible Resilience Practices among Suppliers

5.2.1 Objective of the Risk Assessment

The structure and the complexity of automotive supply chains is significantly changing due to the implementation of the electrification transition. The shift from ICE vehicles to EVs entails new architecture and strategic parts like battery cells, semiconductors, power electronics and battery management systems. The production of these components has a different elements architecture compared to ICE components, from raw material resources to cluster of suppliers capable to provide these parts. These peculiarities translate to various forms of supply chain risks that can condition manufacturers production. The ability to assess the supply risks for strategic components is a crucial element for supply chain resilience and procurement strategy.

To address this challenge, this section presents a structured framework for the evaluation of the supply risks coming from strategical components for EVs. The objective of the analytical framework is to find, along some selected key components, which are the ones that present higher exposure levels. To provide a more reliable structure, industry insiders have been questioned for gathering all the inherent information regarding strategies, analysis, weighting of the criteria.

The evaluation adopts a multi-criteria decision-making (MCDM) approach based on the Weighted Sum Model (WSM) presented in Chapter 3.

5.2.2 Identification of Risk Criteria & Strategic components

The first passage requires the identification of the evaluation criteria set for EVs strategic components. These criteria are directly produced from the supply chain vulnerability framework discussed in 5.1.

The risk categories considered are mainly the ones presented by Pettit et al.: by considering those and the industrial information gathered, criteria for evaluations have been contextualized in the EVs automotive supply chain. Categories of vulnerabilities includes resource limits, supplier disruptions, connectivity, turbulence, sensitivity and external pressures.

From these categories, a set of more measurable criteria has been defined, to capture the most impacting sources of supply chain vulnerability for EVs.

6 Table 5.2.2 Risk Evaluation Criteria for EV Supply Chain Components

Criterion	Description	Example in EV supply chain	Derived from Pettit et al. risk category
Resource availability	Stability and availability of raw materials and inputs for manufacturing	Rare hearts minerals and lithium, cobalt, nickel for battery cells	Resource limits
Supplier reliability	Risk of supply disruption due to financial, quality or operational reasons	Dependency on limited EVs parts manufacturers	Supplier disruptions
Supply chain connectivity	Level of interdependence among actors involved and complexity of the connection grid	Multi-tier pattern for semiconductor or battery supply chains	Connectivity
Technological maturity	Degree of technological advancement and probability of new change of paradigm	Fast technological evolution for chemicals and minerals involved in battery and semiconductors production	Sensitivity
Geopolitical exposure	Exposure to geopolitical risks or global transportation issues from production regions	Rare earth mining concentration outside EU, logistic distance of production plants	Turbulence
Demand volatility	Uncertainty on production levels, variable expected market growth	Unstable adoption rates in Evs	External pressures

These criteria aim to catch the most relevant dimensions of EVs supply chain risks and allow a structured comparison for each component

After the definition of the criteria, the next step is to identify some strategic components relevant for the EVs production.

Several new technologies have been introduced by electrification transition, that require global supply chain and multiple stakeholders patterns.

For the scope of the evaluations, five components have been selected:

- Battery cells: most crucial part for EVs, accounting for a significant portion of the overall production cost of a single vehicle. They are dependent on rare raw materials present only in some global regions
- Semiconductors: key components for power management and digitalization of automotive systems. High numbers of semiconductors are required in EVs compared to ICE cars. They rely on critical raw materials.
- Power electronics and inverters: the role is to convert electrical energy within the drivetrain, crucial for consumption efficiency and performance. The technology itself is nearly mature but the increasing demand may create pressure on supply chain.
- Battery management systems: essential for monitoring batteries status and guarantee a safe and efficient operation. Typically supplier by automotive specialized firms, they include both hardware and software.
- Electric motors: relatively mature technology in relation to others EV components. The overall supply chain is technologically stable but they are vital elements for electric vehicles.

5.2.3 Risk Evaluation

The evaluation of supply risks for the set of chosen components has been conducted using the model described in Chapter 3. This approach permits to aggregate multiple evaluation criteria, that combined trough adjusted weights, are synthetized into a single risk score per each component.

To each evaluation criterion, a specific overall weight has been assigned, in order to scale the magnitude of the possible disruption impact. The weights were decided basing on the qualitative insights collected from industry insiders asked and the reflect the perceived impact of each index within the EVs supply chain. As per methodology, the sum of each assigned weight equals one, so they can be used for normalization purpose

Each index risk has been rated trough a five-point scale ranking from 1 very low risk/impact in case of disruption) to 5 (very high risk/ impact in case of disruption). The scores have been assigned through expert judgement based on qualitative insights from industry practitioners with experience in automotive supply chains and electrification technologies.

Below are presented the two tables:

1. Table 5.2.3A for the weights assigned to each criteria
2. Table 5.2.3B for scores assigned to each criteria, per component

7 Table 5.2.3A – Criterion Weights Used in the WSM Model

Criterion	Weight	Rationale
Resource availability	0.25	Critical raw materials are a major contraint for EV parts
Supplier reliability	0.20	Supplier continuity is crucial for stable production by OEMs
Supply chain connectivity	0.15	Complex multi-actor supply chains have the intrinsic risk of partial or total propagation of disruption
Technological maturity	0.15	Emerging technologies involve uncertainty but OEMs request new technologies with medium term forecasts
Geopolitical exposure	0.15	Geographical clusters of concentrated resources create geopolitical exposure
Demand volatility	0.10	Fluctuating demands must be absorbed by supply chain

8 Table 5.2.3B- Expert Evaluation of Supply Risk for Strategic EV Components

Component	Resource availability	Supplier reliability	Connectivity	Technological maturity	Geopolitical exposure	Demand volatility
Battery cells	5	4	4	3	5	4
Semiconductors	4	4	5	4	4	4
Power electronics	3	3	3	3	3	3
Battery management systems	2	3	3	3	2	3
Electric motors	2	2	2	2	2	2

These scores highlight the different levels of exposure per each component. Expectedly, Battery cells and semiconductors are the highest-risk components, due to their multiple dependencies on global supply chains, critical raw materials and low number of supplier with specific capabilities.

5.2.4 Risk Ranking & supplier selection evaluation

By using the scores presented above, the WSM has been applied to aggregate a single risk score for each component. The ranking resulted reveals the exposure risk of each component within the EV supply chain. To facilitate the interpretation, and to align the research to the instruments that also automotive companies are using (source: managers from inside automotive firms), a RAG -Red Amber Green- classification has been used. It is widely used in risk management and project evaluation and it is visually beneficial also for the scope: this classification allows decision-makers to identify which components or technologies must receive higher attention for resiliency purposes in sourcing phases.
In Table 5.2.4A it is possible to see all the aggregate scores and the RAG visual evaluation.

9 Table 5.2.4A – Risk Ranking of EV Components Based on WSM Results

Component	Risk Score	Risk Level	RAG
Battery cells	4.20	High	🔴
Semiconductors	4.15	High	🔴
Power electronics	3.00	Medium	🟡
Battery management systems	2.65	Medium	🟡
Electric motors	2.00	Low	🟢

As expected, results represent again how batteries and semiconductors are the most critical technologies in relation to the supply chain resilience.

The final step is the most complex from an operational point of view: adopting a correct resilience strategy in relation to the color received. The table 5.2.4B shows some recommendation proposal according to the risk level of each component.

10 Table 5.2.4B – Supplier Selection Strategies Based on Risk Classification

RAG	Risk Level	Recommended Supplier Strategy
🔴	High risk	Multi-sourcing, strategic partnerships, long-term contracts
🟡	Medium risk	Dual sourcing, supplier monitoring
🟢	Low risk	Standard sourcing practices

Low risk components are the less exposed ones: in this case, standard sourcing practices can be adopted. Normally OEMs and the firms that are awarding a supplier trough official nomination for the component production, perform ad-hoc audits at supplier. Audits are done typically performed by OEMs or Tier-1 and entail some assessments, performed by different department:

- Technical capability: the scope is to assess if the proposing firms detains the technological knowledge for the development and production of the part
- Quality assessment: in order to understand if the firms has the production capability and capacity installed in the plant and if there are Quality management plans
- Logistic check: performed to assess if the firm has the logistic know how to handle production volumes and traceability
- Financial control to check if the firm is financially stable and capable to sustain investments

Even in low-risk conditions, risks are not absent but they can be managed easily and they are not so impacting for the scope of production. For example, electric motors can be produced by many companies and share lot of standard parameters that permit to switch from different suppliers easily.

For medium risk components, further preventative actions must be put in place. For power electronics and battery management systems for example, a good strategy can be the dual sourcing: in this way production can be ensured by always having a back-up supplier that can cover part of the disrupted production of the other. Another important element can be the constant monitoring of all the possible critical elements in supplier production: overseeing levels of raw material orders in place, tracing the time-to-production of the raw goods and having weekly on monthly updates of the stock of finished product ready to be delivered for vehicle production.

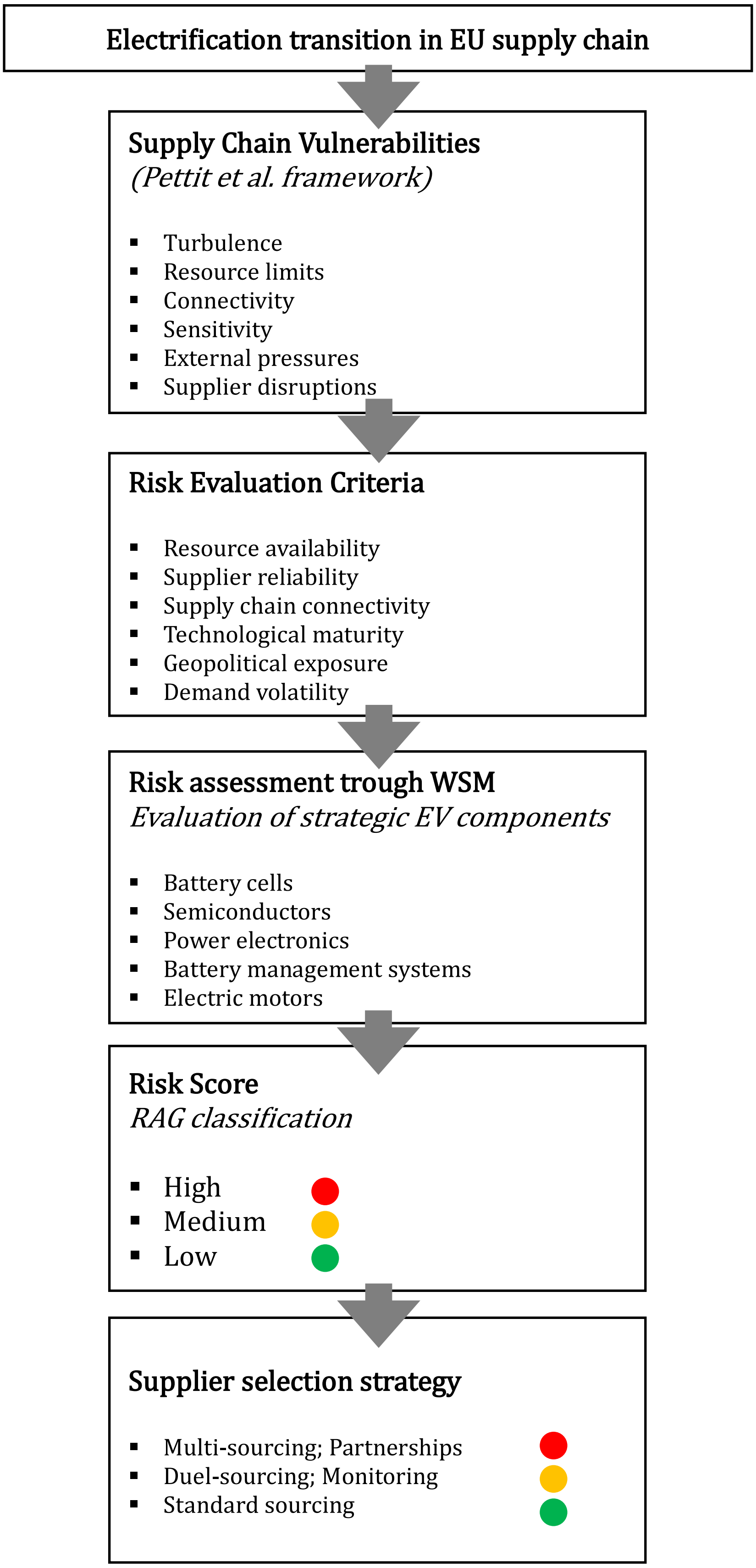
High risk components include Battery cells and semiconductors, the most critical elements for an EV production. In this case nearly all possible preventative actions must be put in place and possible “escape plans” can be programmed in case of disruptions. All the measures of the previous RAG levels must be put in place and in addition, new measures must be taken.

Strategic partnership is the first measure: with this scenario, supplier and OEM are bundled together and the supplier is fully committed to avoid any possible disruptive scenario. While in normal supply contracts suppliers are producers basing on the quantity ordered, in a partnership scenario supply and OEM are together committed to solve and prevent any arising

issue. Possible problems will impact in the same way the two entities and so there is a natural focus in anticipating and reducing all the possible exposures.
In case partnerships are not possibles, multi-sourcing is another chance for OEMs. Having multiple suppliers nominated for component production, with optional volumes clauses that permit to have capacity coverage also in case of disruption of one or two nominated suppliers. Another way to mitigate high risks is to set up very long-term contracts, binding for many years the supplier to produce the component. In this way, the firm will be called to a big initial investment, that will have a lock-in effect for the supplier to produce the part continuously. As seen also in Bosch case, for Battery production, partnerships are already in place since years.
Overall, the proposed framework tries to provide a structured approach to standardize the supply chain risk resilience decision in the context of the electrification transition.

In the section 5.1 all the risk typologies have been analyzed within the electrification of the automotive supply chain, in the section 5.2 a structured analysis scheme has been provided for a risk analysis and strategic measures to be taken. Below in table E, a conceptual framework of what discussed in chapter 5 aggregates all the fundamental elements for the risk management of the automotive supply chain

11 Table 5.2.4C – Conceptual framework



Chapter 6

Competitiveness of raising countries

6.1 Global Industrial Reconfiguration in the Electric Vehicle Transition

The electrification of the automotive sector does not imply only the transformation of vehicle architecture, but it reshapes the global industrial footprint of the automotive industry. Previous chapters analyzed the impacts on the supply chain and the new resilience requested to firms involved, while now this research tries to frame the transition within the global framework.

As widely described, in Europe the automotive sector is one of the strongest industrial domains concerning technological and manufacturing leadership. The development of mechanical engineering capabilities spread across decades, enhancing the creation of extensive supplier ecosystems and deep collaboration between suppliers and OEMs for highly specific components. The electric mobility transition introduces a technological disruption that in part erases or weakens the legacy advantages of incumbents.

Electric vehicles depend on a substantially different architecture compared to internal combustion engine cars. There is no more the necessity of complex mechanical systems or exhaust treatment structures, while there is new focus on battery technologies, power electronics, semiconductors and software integration. This change redistributes value creation along the chain: some sectors or industries that before were only peripherical now are increasing their strategic importance for EVs manufacturing.

As a consequence, not only the European automotive sector, but also the global mobility industry is undergoing a profound transformation. New industrial systems are emerging, in particular from geographic regions that anticipated the shift and invested strongly in key technologies and large-scale EV manufacturing capacity. The new electric paradigm entails a retirement of traditional production strategies and increase the dependency of having full control over technologies capability, critical materials supply and fast implementation of scalable electric platforms.

According to the International Council on Clean Transportation (ICCT), the global electrification of mobility sector is proceed rapidly within the global market: EVs are gaining market shares over ICE vehicles. The EVs adoption by consumers is growing "from 4.5% in 2020 to 21.4% in 2024 to an estimated 25% in H1 2025 [...] and the projected EV share exceeding 70% by 2050"

(ICCT, 2026): global electrification is increasing across major global markets and the trend forecasts, based on 2025 adoption rates as baseline, are confirming the strength of the adoption rate. This acceleration suggests that electric mobility cannot be considered anymore as a niche industry but rather the future structural industry paradigm of the automotive industry.

Within this evolving global context, it is relevant to note how the geographical distribution of industrial manufacturing and developing capabilities is shifting. The dominant emerged actor in the electric mobility is China, thanks to large-scale industry policy programs set up by government, alongside a stable domestic demand and a full control over the supply chain, from the minerals extraction to the installation in the vehicle. In parallel, while Chine has already established itself as industry leader, emerging countries like India are gradually enhancing their manufacturing structures and positioning as possible emerging players for the global EV industry. These new entrants automotive ecosystems are increasing their EVs productive and technological capabilities thanks to the aggregation of technical know-how in key technologies. Their production volumes are expanding: this triggers many beneficial consequences for the industry. They can benefit from learning effects, cost reduction efficiencies and also faster technological development: all these are dynamics that contribute to reinforce the competitive advantages and to create knowledge barriers to entry for late adopters.

The implications of this global new setting are impacting directly European automotive supply chains. Currently Europe still retains strong engineering ability and the most developed supplier network, but the shift toward electrification entails fast reconfigurations and relevant investments in new technological domains. As stated in the previous chapters, battery production, advanced semiconductors and integrated electric powertrain systems are the new core competencies of the sector and they will be the drivers for long-term competitiveness.

Therefore, the position of Europe must be assessed considering all the global actors involved in the electric vehicle competition. For this reason, the following section provides a comparative qualitative analysis of the automotive industrial ecosystems of Europe, China and India as emerging one. The objective is to find structural differences that may condition the future ability of Europe to remain competitive.

6.2 Comparative Industrial Ecosystem Analysis

The transformation of the automotive sector toward electrified mobility is certainly a global phenomenon with different paces and directions, in relation to the maturity od each domestic productive fabric. To better understand the dynamics of industrial competition in the EV sector, it is necessary to analyze the structural characteristics of the main industrial ecosystems involved. Alongside Europe, this research will focus on China and India because of their peculiarities in relation to the anticipation of the market (China)and fast emerging pace (India). This comparison will provide useful insights for relative strength and weaknesses of different automotive production models: Europe that has a mature ecosystem, China that developed a dominant position in the last years, India that can be in the future a new manufacturing hub for automotive technologies.

6.2.1 The European Automotive Ecosystem

The European automotive industry is one of the most relevant industrial sectors of the continent's economic, financial and manufacturing structure. Europe has set the standards for the creation of a highly sophisticated automotive fabric, capable of strong engineering abilities, extensive and complex suppliers networks and advanced manufacturing technologies. The sector includes all the relevant stakeholders: OEMs, Tier-1, a multitude of Tier-n sub-suppliers, all supported by a strong academic and institutional base. The sector withholds significant relevance in the continent economic balance. In addition, also the employment relatable to the automotive sector is significant: according to the European Automobile Manufacturers' Association, the EU automotive value chain employs "13.2 million jobs = 6.8% of EU employment" (ACEA, 2024). These data underline the important role of the automotive sector not only in relation to manufacture, but also as a very impacting contributor to employment and value creation stability across the Union.

An additional beneficial effect of the automotive sector to the European GDP is the import-export balance: the EU is a strong exporter of vehicles, with positive outcomes in the trade balance. Trade surpluses have been achieved through the export of finished vehicles but also high-value automotive components. Despite recent years production volumes have been less stable than before, recent data are confirming more than 10 million vehicles produced, signaling the relevance in global automotive manufacturing.

However, the EU automotive sector is called to face new competition from external actors, in the transition for electrification. The shift from ICE vehicles to EVs is creating lacks in production capacity and cost competitiveness and the value allocation is changing. EU suppliers must face new international industrial emerging players, that are backed-up by strong government policy supports and are rapidly expanding manufacturing capacity.
As a result, the global transition toward electric mobility is creating new industrial dynamics and new emerging actor a threatening the long-standing dominance of European manufacturers and suppliers

6.2.2 China: The Leading EV Industrial Ecosystem

China has developed and implemented in the last two decades, one of the most organic electric vehicle industries in the world. The country has become a dominant global player thanks to massive industrial policies, that have been finely coordinated with large scale investments to match the growing domestic demand.
The magnitude of the Chinese EV market is clear from the statistics available in relation to global sales. For example, the IEA reports that "In 2023, just under 60% of new electric car registrations were in the People's Republic of China." (IEA, 2024) and more "than one in three new car registrations in China was electric in 2023." (IEA, 2024). These figures are useful to understand the pivotal role of the Chinese market in impacting the global electric vehicle transition.
Surely, the most relevant characteristic of Chinese automotive sector in the extreme level of vertical integration of the supply chain for fundamental EV components. Domestic suppliers are directly operating on all the productive lifecycle of the product: from the raw material processing to the final component. By consequence, all the parts manufactured are fully integrated in a domestic supply chain that operates with high degree of specialization on battery cell production, raw material processing, power electronics and software integration. Having this level of integration entails significant beneficial effect in terms of cost control, supply chain coordination and technological development.

Chinese ecosystem detains another important advantage in relation to EVs: the upstream integration of battery calls production. “China represents nearly 90% of global installed cathode active material manufacturing capacity and over 97% of anode active material manufacturing capacity today.” (IEA, 2024) Up to now, this represents a de-facto quasi monopolistic market condition, that provides huge industrial leverage to China and direct cost control over the firms or OEMs that rely on these materials. The strategic advantage of China is clear and the country owns a supremacy position over the others involved in the global EVs industry.

The result of these combined factors made China to evolve from a follower in traditional ICE vehicles to a global leader in technology, production and dependency in the electric vehicle global ecosystem.

6.2.3 India: An Emerging EV Manufacturing Ecosystem

India represents surely a less mature automotive ecosystem compared to Europe and China, but due to its dimensions it can be increasingly relevant in the context of electric mobility transition. The country has a large automotive manufacturing sector, sustained by a large domestic market and cost-efficient production capabilities.

The Indian automotive sector is in the center of a Government’s plan to reduce carbon emission and have a more sustainable mobility. As highlighted by Rajendran et al., “India’s electric vehicle (EV) market is poised for substantial growth, driven by the government’s ambitious goals to reduce carbon emissions and transition towards sustainable mobility.” (Rajendran et al., 2025, p.1). The same author also underlines that “the nation’s commitment to EVs is underscored by various policy initiatives aimed at promoting EV adoption and infrastructure development.” (Rajendran et al., 2025). As a consequence, these policies are contributing to increase investments and interest in the EV sector.

However, despite the favourable dynamics, the Indian automotive ecosystem has still several structural constraints in relation to EV components production that decrease its competitiveness. Domestic manufacturing capacity is nearly absent, if compared to other global industrial leaders: “production capacity meets only about 20% of the demand for lithium-ion batteries, which are crucial components for EVs.” (Rajendran et al., 2025). The reliance on imported battery technologies naturally increases the dependency on external stakeholders and grows production costs, while exposing all the supply chain to vulnerabilities. Currently, even if India could be able to install the production capacity needed (plants, machineries) there would anyway another critical issue: the lack of technology know-how. Advanced manufacturing technologies are still far to be fully developed and this is a critical flaw for Indian automotive EV production. “The Indian EV manufacturing sector currently lags behind global leaders like China, the United States, and Europe.” (Rajendran et al., 2025), this is confirmed by the relatively limited adoption of specialized manufacturing capabilities and the shortage of specialized labor.

Currently these elements are crucial and they are the reason why India is facing huge barriers to entry in the EVs ecosystem.

Nevertheless, the country presents extremely relevant long-terms opportunities: large domestic market, growing technological capabilities and increasing industrial strategical policies can be keys to enable India to enter the global EV production landscape.

India can become a future competitor in the global electric automotive supply chain, if it will continue to expand in manufacturing capabilities, specialization of workforce and strong research and development for EV technology.

Table 6.2.3 summarizes the main elements presented before.

12 Table 6.2.3 – Comparative overview of automotive industrial ecosystems

Automotive Ecosystem	**Industrial maturity**	**Technological capabilities**	**Supply chain integration**	**Battery & critical materials**	**Industrial policy**
Europe	Mature	Advanced engineering	Specialized multi-tier network	Limited domestic capacity	Consumer focused; low investment support
China	In expansion	Batteries & Electronics leadership	Vertically integrated	Global leader	Strong state support
India	Emerging	Growing know-how	Developing supply chain	Low domestic capacity	Increasing support

6.3 Rising Industrialization and Technological Know-How

The comparative analysis presented in 6.2 describes how the automotive ecosystems exhibit different levels of industrial maturity and technological capabilities. These characteristics are not fixed and can vary upon specific inputs. In the past decades, emerging ecosystems exploited new industrial capabilities thanks to large-scale production, technological learning and specific industrial policies.

To explain the fast emergence of new competitors, this research is going to analyze the main elements that are crucial for the industry evolution and how countries like China are confirming the importance of these factors.

6.3.1 Industrial Scaling and Learning Effects

Among the drivers that enhance a fast development of production of new emerging vehicles ecosystems, the industrial scaling is one of the most impacting. Large- scale manufacturing allows to gain operational knowledge and on field experience, that later translates in a more cost effective production. This process is also known as “learning-by-doing” and it is very impacting in complex manufacturing processes, such as the ones for Electric vehicles components. Repeated production cycles allows to understand the production flaws to be fixed and to find possibilities of cost reduction proposals in order to refine production efficiency.

The automotive industry can provide a clear view of these industrial dynamics: China, for example, represents a country that implemented a large-scale industrial expansion in the EV components sector. Over the last two decades, China has rapidly implemented production plants for electric vehicles and batteries, enhancing the chance of gaining manufacturing experience and production efficiency. As seen in previous sections, now China detains the leadership in battery and EV components production, consequences of a good scaling process and advanced manufacturing knowledge.

As production volumes increase, firms involved can physically try new production techniques, promoting reliability of the component itself and of the production lines. All these elements bring cost efficiencies to the firm and, by consequence, enhance competitiveness, strengthening the competitive position of the company in the EV sector.

6.3.2 Technological Capability Development

In addition to production scale, the technical knowledge development strongly influences the competitiveness in the automotive ecosystem. The electric transition entails a change in the set of engineering and research skills required, shifting from a more mechanical specialization toward electronic, informatic, chemical know-hows.

EVs rely massively on electronic systems and software, so all the companies involved in the production must be capable to handle these subjects extensively. A deal breaker for firms that wants to be new entrants in the EV production scenario must acquire expertise on these domains, otherwise they will face the risk of bad investing or underestimating possible project risks.

The Chinese EV industry again provides an example for demonstrating the technological capability development. Firms that have been first entrants in the battery manufacturing started gaining strong competencies in lithium-ion battery production from the raw minerals extraction to the end of the productive process. Adding the fully verticalized production, Chinese firms detain high levels of knowledge across all the manufacturing value chain, in advance to competitors and with more on-field experience. As highlighted in previous chapters, now China is the world's biggest lithium-ion battery producer and it's home to the majority of the global battery manufacturers.

Through continuous investments in the field of research, efficiency of production and supplier network development, firms are accumulating technological know-how and are gaining strategic positioning across the EVs value chain.

6.3.3 Industrial Policy and Capability Accumulation

In addition to the dynamics explained before, in the context of electric mobility industrial policies are still playing a crucial role. Governments have implemented industrial policy frameworks that are designed to improve the adoption of electric vehicle in order to make more environmentally sustainable the mass mobility. There are different policy possibilities, from subsidies and incentives to final consumers, to direct investments support to strategic firms.

One of the most effective industrial policies is again the Chinese one. As analyzed by He & Yin, China has been an early entrant in the sector of electric mobility, subsidizing the market already in 2009. The support programs were introduced with the aim of stimulating early market demands to enhance industry attractiveness for domestic investments.

Policies for the EV sector are intervening in a very complex industry, where choosing one type of policy can threaten the open market, thus triggering the exit of firms. Governments usually tries to combine balanced policy instruments: these may include direct subsidies to consumers, financial support for academic technological research or for technological development inside the firms and also investments directed to the complimentary services (electrical recharge grids).

Such policies, according to the magnitude of the intervention, can vary significantly the velocity of a new technology adoption, triggering a faster productive expansion and knowledge increase. In the early stages of a new technology, government support can facilitate the entry of new firms in the sector by overcoming technological barriers and covering partially high start-up costs. During time, these policies contribute to the implementation and development of domestic industrial fabric by enhancing the entrance of national companies or promoting the collaboration agreements between stakeholders. As the industry attracts new capitals and the core technologies start to stabilize, state intervention can be gradually reduced, in order to allow the creation of a fully self-standing and competitive industry.

The dynamics illustrated in this chapter highlight how the electric mobility sector is affected by multiple factors and the industrial results are derived from a vast set of conditionalities. The interaction of markets expansion, technological learning and development and policy support are the most effective drivers of a successful electric transition industrial implementation.

Chapter 7

Discussion

7.1 Interconnections Between Electrification, Supply Chain Resilience and Global Competitiveness

The results of this research point out that electrification, supply chain resilience and global competitiveness must be considered as cross-related dimensions of the structural transformation of the automotive industry. Therefore, it is mandatory to not discuss these elements as separate. The core of the electric transition production relies on the supply chain: alongside the overall change in the technology definition, there are the strategic repositioning choices of companies operating in it.

The progressively restructuring of the strategic role of supplier is the first key finding emerging from this study. As discussed widely in previous chapters, the electric mobility transition radically modifies the technological architecture of key components and changes the established equilibria of the value creation in the supply chain. Previously vital parts for internal combustion engine cars are gradually losing relevance, while new technological domains (batteries, electronics, software, …) are gaining strategical importance. In this evolving context, suppliers are called the assess their core competencies and technological capabilities and evaluate the sustainability of their current portfolio and business concept.

The consequences of this transformation impact directly how suppliers must position themselves within an industrial environment that is under the pressures of uncertain demand dynamics, high investment requirements and intensifying global competition.

The analysis performed in this thesis suggests that companies involved in the supply chain may pursue different strategic decisions on the basis of their technological capabilities, financial resources and exposure to internal combustion engine segments.

Some suppliers could try to moderate their exposure to the uncertain automotive sector during the transition phase by a strategy of diversification of businesses toward other markets. The shift over can be possible only if their technological competencies can be applicable to the "new" market. This choice can allow firms to reduce the exposure to automotive sector specific disruptions and, in parallel, continuing to exploit current engineering capabilities.

In other cases, companies may follow a technological repositioning strategy. They redirect investment toward electrification related technologies that are aligned to their current technology portfolio and capabilities. It's a gradual repositioning that permits firms to evolve their industrial competencies toward electrification technologies without a complete sudden and radical restructuring of the business structure.
The latter is one of the most radical pathways that can be undertaken by suppliers: starting an intensive process of full alignment and transition of product portfolio to comply with electric mobility manufacturing technologies. The financial and technological efforts needed for this transformation are substantial. As said before, electric transition technologies require massive investments: this characteristic shortens the list of possible firms that have strong financial capabilities and reliable technology infrastructures, typically only large Tier-1 suppliers with close business relationships with OEMs.
Finally, a possible strategy for small suppliers can be the adoption of the "niche specialization" strategy. The decision entails a full business focus on manufacturing of small volume, highly specialized components or services where the expertise remains the core element, difficult to substitute even with a more concentrated supply chain.
These strategic adaptation paths are summarized in Table 7.1.

13 Table 7.1 – Strategic Adaptation Paths for Automotive Suppliers

Strategic Option	Description	Typical Firms
Diversification outside automotive	Suppliers expands in new industries to reduce exposure to the current automotive sector	Suppliers with transferable technological competencies
Technological repositioning	Firms undergo new EV-compatible investments in line with their current core competencies	Suppliers with established R&D capabilities and reliable financial capacity
Full EV alignment	Firms integrally reshape their portfolio, fully developing only EV strategic technologies	Large suppliers with strong financial capabilities
Niche specialization	Suppliers focus on highly specialized components or services within limited market segments	Small and highly specialized firms

A second key finding of this research relates the renewed role of risk management and resilience balance while assessing the long-term sustainability of suppliers during the electrification transition. The latter creates inherently a period of financial and industrial imbalance in which firms must handle simultaneously the current productions while investing in the new technological domains. This dual constraint pressures the short-term liquidity of firms and the long term financial sustainability, impacting a sector in which companies already are operating under traditionally low margins.

In addition to the financial constraints, the electrification transition reshapes the distribution of the technological governance along the supply chain. The new components needed are highly complex and there are only few clusters of suppliers able to produce them, typically outside the European Union. This creates a shift of development knowledge and gradually reduces the technological leverage previously enjoyed by certain firms operating in the European supply chain. In such scenario, supplier historically specialized in the full development and production of components may shift to a more limited position of only parts integration or minor assembly activities.

It is clear that if this shift happens without a parallel technological upgrading, issues and difficulties in capturing value across the chain will be faced directly by suppliers. In this context, the main risk is that European suppliers will have extremely limited influences over the directions of the overall automotive network and will reduce their scope, operating as financial buffers within the supply chain, absorbing production volatility, production costs fluctuations and investment pressures.

The third key finding of the thesis entails the geographical change of global automotive competitiveness. The rapid expansion of electric mobility is making evident the emergence of new industrial ecosystems, previously underexplored by the stakeholders in the sector. For, example, in countries like China, electric mobility is experiencing a rapid growth and thanks to coordinated industrial policies, large domestic market and a fully vertical integrated supply chain. As a result of that, these industries are accelerating their learning and industrial competitiveness.

For European suppliers, this new pattern creates a structural competitive asymmetry: emerging ecosystems are the ones that hold the majority of the elements needed for the electric transition and are fully exploiting this advantage. Volume scaling, vertical integration

from the resource mining to the final product, control over upstream chain are the main benefits that new emerging competition can leverage. For European incumbents, attempting to directly compete against these industrial conditions represents a failure strategy.
To lead the competitive challenge, a possible pathway could be increasing the development of alternative and differentiated technological capabilities and enhancing collaborative invocation strategies. To strengthen the innovation capacity of the European automotive ecosystem, strategic alliances between suppliers, joint technological programs for R&D and cross-industry cooperation may have important roles. In this way, suppliers could exploit the combination of complementary knowledge and share the costs raising from increasingly complex development processes.
Considering to overall scenario, these findings point out that the competitiveness of the European supply chain will rely on the capacity of the industry to upgrade the technological capabilities and also on the capacity to reposition itself inside an evolved and more global industrial landscape.

7.2 Strategic Recommendations for the European Automotive Ecosystem

The analysis carried out in this thesis underlines the importance of the decisions that policy makers, automotive manufacturers and suppliers must undertake. The electrification transition entails a structural transformation that must be addressed not only with technological innovation, but also through a combination of coordinated industrial, strategic and policy responses.
In the short term, management and stabilization of the transition process is the primary target. New substantial investments are needed while significant part of the industrial fabric remains operative for the production of current systems and components. The consequence of that is a primary asymmetry between investment required and the stability of the market, particularly critical for suppliers already working with limited financial margins. Under these constraints, a stable and predictable regulatory setting is a key factor for supporting the industrial planning. Clear and reliable industrial policies help companies to set their investment targets with the correct pace and appropriate long-term direction. In some cases, for critical component suppliers, additional targeted financial support from governments could be beneficial to face the simultaneous burdens of declining demand from traditional segment and increasing capital

requirements for new technologies. Another contribution to the supply chain stability can be the implementation of risk-sharing mechanisms between OEMs and suppliers. A more balanced financial risk distribution in the supply chain can mitigate the probability of structural disruptions for suppliers sustaining investments for the technological transformation.

In the medium term, the structural adaptation of the European supplier base becomes crucial. While in the short-term collaborations among supplier can be a good temporary solution, after a first stabilization it is important to create new larger companies that can bear large scale technological upgrading and sustained research investments. Firms should assess and go for mergers and acquisitions in order to consolidate the industrial fabric and strengthen the financial and technological capabilities of the supplier ecosystem. These processes should be supported by the adaptation of the workforce to the new industry needs. New technological competencies are required for the electrification and digitalization advancement in the European automotive supply chain. Strengthening education systems, industrial training programs and research collaboration can be the key for enhancing the capabilities in the new fields required, like software engineering, electronics design and battery technologies. In parallel, collaborative innovation models should be put in place to consolidate the competitive position of European suppliers. In order to ease knowledge sharing, reduce technological development costs and accelerate learning processes, strategic development alliances can contribute significantly given the cost intensity of the new industrial capabilities needed. In technologically complex sector, like automotive, this cooperative innovation framework can contribute positively to the creation of an effective pattern to compete with large ecosystems that are vertically integrated and financially stable.

In the long-term, the competitiveness of the European automotive industry must be secured. The consolidation of the industrial capabilities for key technological segments for the electric value chain must be performed trough stronger competencies around batteries, power electronics and semiconductors. Strong research in development could lead in future to find alternative technologies that can reduce the dependency on external stakeholders and enhance the autonomy and resilience of the European automotive supply chain.

These strategic priorities can be summarized across different time horizons, as illustrated in Table 7.2.

14 Table 7.2 – Strategic Policy and Industry Recommendations for the European Automotive Ecosystem

Time Horizon	Strategic Objective	Key Actions
Short Term	Stabilization of the transition	Policy stability; temporary financial support for risky suppliers; risk-sharing mechanisms
Medium Term	Structural adaptation of the supply chain	Supplier diversification, industry consolidation (M&As), workforce reskilling, R&D alliances
Long Term	Strengthening industrial capabilities	Development of European competencies in critical industries, consolidation of the EU value chain, long-term industrial policy

Overall, the main findings of this thesis confirm that the electrification transition entails a full scale industrial transformation and technological shift. The success of the exploitation of this transition depends mostly on coordinated development of technological capabilities, improvement of supply chains resilience and industrial policies built to ensure the long-term sustainability of the European automotive ecosystem in a global landscape with an increasing number a new possible entrants.

Chapter 8

Conclusion

8.1 Research Context and Objectives

The transition from the internal combustion engine vehicles to electric mobility is the main cause of the profound technological and industrial transformation of the global automotive industry. This change is structural and affects the value chains of the automotive sector, the technological capabilities and the competitiveness of the stakeholders involved. As long as the change process goes on, new technological domains (batteries, power electronics, software integration, …) are becoming central for the creation of value in the automotive ecosystem. As a consequence of that, significant challenges must be faced by suppliers that for many decades built their competitive advantage thanks to technologies related to combustion engine vehicles. The natural decline of these technologies in the context of electrification raises critical questions in relation to the positioning of incumbent suppliers in the industry: some supplier may be able to exploit investments in new EV technologies, while others could face greater difficulties in adapting their core competencies to the new electric paradigm. In parallel to this, electrification transition is also developing new equilibrium across global regions. Countries like China have been able to increase technological development and industrial competitiveness thanks to coordinated industrial policies, large domestic markets and vertically integrated supply chains. These emerging industries are consolidating as leaders in the automotive sector and they're putting new pressures on the European and North America incumbents.

By considering this background, this research addresses this question: *how the European automotive suppliers can adapt their strategies and capabilities in order to remain competitive during the electrification transition?*

To answer this complex question, the combination of industry insiders feedback, multi-criteria decision-making framework and industry analysis have been considered to evaluate alternative strategic pathways for automotive suppliers. By integrating all the criteria considered, the framework proposed presents a structured approach for comparing different adaptation strategies to the new dynamic industrial fabric.

8.2 Key Findings and Strategic Implications

There are three main findings as output from this thesis.

First, the electrification transition reshapes fundamentally the technological paradigm, changing the role of historical suppliers inside the value chain. With the new electric powertrains increasing in selling volumes, competitive advantage is shifting from old engineering domains to new ones like batteries, electronics and software integration. Suppliers, in order to remain in the market, must evaluate strategically their long-term strategies and portfolios, without impacting current legacy businesses.

Second, the electrification transition is cause of structural imbalance, making resilience of the supply chain an increasingly important element. Firms are called to handle the coexistence of old components production and parallel large-scale investments to be implemented. This double pressure triggers financial vulnerability for suppliers operating with traditionally low margins. In order to face these conditions, suppliers are risking to loose the technical leadership over key components and being more and more exposed to cost instability and investment burdens.

Third, the electrification transition is reconfiguring the global competitiveness balance. China for example, thanks to industrial scale, vertically integrated supply chains and coordinated industrial policies is now becoming the leader for strategic components development and production. These dynamics create structural asymmetries between emerging new entrants and historical European incumbents.

By considering the overall frame, these findings highlight that the long-term competitiveness of the European automotive sector will depend both on technological upgrading and also the repositioning ability of the suppliers involved in the supply chain. Suppliers are called to assess new strategies to face this transformation, depending on their financial capabilities, technological core competencies and strategic positioning in the supply chain.

As the automotive industry continues the evolution toward electric mobility and software integrated vehicles, supplier's strategical choices in the coming years will play a decisive role in the establishment of the future competitiveness within a more global supply chain industry.

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