

# Internal Strategic Capabilities and External Industry Pressures as Determinants of Resilience in Electric Vehicle Battery Industry

Sai Srinivas Lakkakula

Independent Researcher

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\*Corresponding author: Sai Srinivas Lakkakula ([saisrinivas.lakka@gmail.com](mailto:saisrinivas.lakka@gmail.com))

**Abstract:** “This study examined how internal capabilities and external market forces influenced resilience in the electric vehicle battery industry. A cross-sectional explanatory design was applied using a structured online questionnaire with closed ended items measured on a five-point Likert scale. The purposive sampling was aimed at including the professionals that occupy the different functions associated with EV batteries resulting in a final sample of 200 respondents. The data were analysed in the IBM SPSS Statistics through the descriptive statistics, Pearson correlation, and multi-regressions. The result revealed a high explanatory power where the internal capabilities and external market forces will have a significant predictive capacity on resilience. The results suggested that capability building with the efficient reactions to the market pressures were essential to enhance the resilience, contributed to the managerial emphasis on procurement, coordination, and compliance systems in the cases of the volatile industry environment.

**Keywords:** Electric vehicle batteries, resilience, internal capabilities, external market forces, dynamic capabilities, midstream concentration, regulatory pressure, material price volatility, value chain, operational performance.

## INTRODUCTION

Electric vehicle adoption grew exponentially and the reliance that can ensure continuity with growing demand and the pressure of policy, got higher. Global sales totaled more than 17 million electric cars in 2024, representing more than 20% of light vehicle sales, providing greater exposure to input disruptions and capacity constraints (WEF, 2025). Global EV Outlook 2025 (2025) pointed out that this scale shift furthered the requirement for stable access to materials and reliable manufacturing throughput by region. China continued to be the most notable producer which reinforced the importance of geographical concentration as a resiliency issue in key midstream activities. IEA (2025) revealed that production leadership and positioning of supply chain influenced the speed with which firms were able to respond to shocks in upstream supply and midstream processing. In the United States, electric vehicles accounted for roughly 10% of light duty vehicle sales in 2024, which signaled increasing market pull and surging expectations for reliable availability of batteries. ICCT (2025) suggested that the market expansion in the large economies added to the operational importance of resilient sourcing and delivery systems.

Despite this growth, the resilience of EV battery supply chains was still limited by structural risks throughout the mining, refining, active material production, cell manufacturing and recycling phases. Battery production required mined resources such as lithium, nickel, cobalt, manganese, and graphite which created exposure to price volatility and supply concentration (Martínez & Terrazas-Santamaría, 2024). These dependencies were increased due to upstream and midstream stages of more specialised

processing and geographically concentrated capacity. Cheng et al. (2024) found that the choice of battery chemistry interacted with midstream concentration to determine the supply chain risk and disruption exposure. Midstream processes, including the production of cathode active material, had a high degree of concentration and continued to depend on their supply of intermediates from a limited number of countries (Yeung, 2024). The growth of capacity in a single location was not associated with resolving upstream bottlenecks and exposing to intermediate concentration (U.S. Department of the Treasury, 2023). These conditions made a number of shocks detrimental to resilience by creating a higher probability that the shocks would result in delays in production, higher costs, and failures to deliver.

Policy and regulatory change added further burden to resilience work because firms had to ensure continuity while fulfilling changing disclosure and compliance requirements (Jin et al., 2020). The European Union Battery Regulation mandating carbon footprint disclosure, recycled content needs and battery passport systems poised traceability and compliance readiness as required operational conditions for market access. European Parliament and Council (2023) suggested that these requirements may affect the site of energy intensive operations by the companies and their design of the governance system of the suppliers. Internal capabilities, including procurement power, supplier control, and control of process in this environment remained significant in ensuring that disruption does not result in a decrease in the rate and level of service. Fedotov (2022) elaborated the meaning of how there were structural limitations in supply

chains that ensured that they created persistence in risk exposure that heightened the necessity to seek resilience as a quantifiable industry deliverable. Differences in internal capability maturity also indicated that the reaction of firms to homogeneous external pressure was not similar and identical, which necessitated the empirical evaluation of the collective impact. The argument that the organisational capability differences shaped the manner in which firms change in response to pressures within the market and business survival were supported by Mercado and Huoming (2025).

This study therefore examined the resilience of EV battery supply chain internal capabilities and external market forces of continuity of inputs, recovery from disruption and sustained operational performance under constraint. The objective was timely because market expansion occurred at the same time as concentrated midstream capacity, chemistry related supply risks, and tightening regulatory requirements. Global EV Outlook 2025 (2025) showed that the EV growth trajectories raised scale requirements that could magnify the effects of disruption across battery value chains. IEA (2025) also suggested that the patterns of concentration and expansion of production influenced the extent of exposure to disruption and reinforced the strategic importance of resilience-oriented capability building. The significance of the study was that it considered resilience as an industry outcome which was influenced by internal capability strength and external pressure intensity, rather than seeing them as separate or sequential influences.

The value of the research was to provide empirical data regarding the simultaneous effect of internal capabilities and external forces on industry resilience. As it was stressed, Cheng et al. (2024) believed that persistent risk channels were formed as a result of chemistry and processing concentration, and thereby, the necessity to investigate resilience determinants collectively. European Parliament and Council (2023) that focused on compliance and traceability requirements that were more and more functional mandates that re-established the significance of resilience beyond even the physical disruption. The analysis allowed establishing what levers were associated with more resilience outcomes by documenting the relationship between maturing capabilities and market pressures and the results of continuity and recovery (Llopis-Albert et al., 2021). It was also timely to the firms that were already in expanding markets like the United States where the increasing adoption increased the cost of disruption and it increased the expectations concerning a reliable delivery as well. ICCT (2025) showed that the increase in the adoption improved the dependency of the system at the level of battery supply stability that developed the argument in favour of the resilience-oriented research. The rest of the paper followed the following structure. The following part was a review of literature on internal capabilities, external market forces and resilience in the EV battery context. The methods section then explained the research design, sampling, measures, and statistical approach used to test the relationships. Results section presented descriptive statistics, correlation analysis and regression estimate for the proposed model. The discussion

involved an interpretation of findings in view of previous evidence and presented implications for managers and policymakers before offering conclusions and recommendations.

## LITERATURE REVIEW

### Empirical Overview

Empirical investigation of EV battery industry focused more on resilience as the ability to ensure continuity of inputs, reliability of delivery and speed of recovery from disruptions. According to Cho et al. (2025), production discipline and integration with suppliers enhanced the compliance with the production timeline and consequently defects, which resulted in the resilience due to a more consistent operational implementation. These findings implied that internal capabilities were significant because the difference in throughput decreased and there was more responsiveness to pressure of demand. Nevertheless, Brem and Nylund (2023) discovered that resilience benefits to capability investments were less significant when midstream processing remained centralised, and material shortages persisted. This contrast implied that the outcomes of resilience were dependent on both the readiness on the firm level, as well as the structure of upstream and midstream access, which might limit substitution options during shocks. Zhao and Luethje (2025) further demonstrated that compliance readiness was raised when firms interlinked process controls with reporting systems which boosted resilience where market access was based on verifiable environmental performance.

Evidence on external market forces gave also emphasis on resilience, but it showed mixed directions depending on the interaction between policy, competition, and constraints and firm capacity. Fedotov (2022) determined that the stronger policy pressure was found to stimulate the process upgrading and adoption of traceability, which further sustained resilience through increased transparency and reduced exposure to disruption in regulated markets. Conversely, Mercado and Huoming (2025) proposed that other smaller suppliers would face a higher cost of compliance, and shrinkage of resilience because there was no investment ability, or access to clean energy sources due to fast actions in tightening the policies. These variations implied that external forces can make strong companies resilient but unreasonable to the weak companies. Zhao and Luethje (2024) associated competitive intensity with quicker cycle times and greater product quality, which plausibly enhanced resilience via enhanced operational agility. However, reliance on cross sectional self-reports were limiting in terms of causal inference and due to the common method bias concerns, which led to reduced confidence of effect direction and magnitude.

### Theoretical Framework

The study was anchored in Dynamic Capabilities Theory, which explained how firms were able to maintain performance in uncertain and rapidly changing operating conditions. The theory suggested that organisational advantage relied not only on having resources, but on the ability to perceive changes, capture responses and change routines according to changing conditions. In the EV

battery industry, these circumstances amounted to volatile material markets, concentrated midstream capacity, rapid technology transitions, and compliance requirements. Internal capabilities in the study were a measure of competence of firms in the relationship of procurement, production, and suppliers - facilitating the continuity of the inputs and the consistency of the delivery over pressure (McCall, 2024). Dynamic capabilities thus gave an explicit reason as to why the differences in capabilities were translated into disparity in resilience in the EV battery supply chain within the challenging market conditions.

The framework also placed external market forces as a source of turbulence that influenced the timing and the manner in which firms deployed their dynamic capabilities. Strong regulatory pressure, competitive intensity and supply volatility enhanced the demand for timely sensing and more rapid operational reconfiguration, particularly where midstream bottlenecks constrained options for substitution (Fraser et al., 2021). In this view, resilience was not considered as a static attribute, but a result of a series of adaptation, learning and coordination across the value chain. The study conceptualised resilience as continuity of key inputs, recovery from disruption, sustained cost quality delivery performance and compliance readiness which represented the practical results of dynamic capability deployment (Tripathy et al., 2022). The framework therefore justified the testing of an explanation of the outcome of resilience in the EV battery sector based on both internal capabilities and external market forces.

### **Research Gap**

Despite a growing scholarly and policy interest in EV battery supply chains, there was still uneven empirical work in terms of the focus in terms of what drives resilience at firm level. Many studies focused on upstream mineral availability or downstream map of EV adoption but these perspectives were not the only ways of explaining how organisations were able to maintain continuity of inputs, reliability of delivery, and recovery capacity when disruption occurred. International Energy Agency (2025) emphasised the magnitude in market growth, which resulted in the higher dependency on stable supply of batteries and continuity of operation. ICCT (2025) also indicated that market growth increased the challenge for reliable supply systems, however, resilience determinants were not always tested using firm level constructs. As a result, there was a gap in the literature regarding an empirical account of the interactions between internal readiness and external pressures in the construction of resilience outcomes.

A further limitation was that key structural and regulatory pressures were discussed descriptively, rather than integrated into measurable explanatory variables, which made the link directly to resilience. Cheng et al. (2024) established this disruption vulnerability to have been generated by battery chemistry and concentration in midstream processing, yet turned rarely into analyses capturing the results of resilience through organisational capabilities and external pressure conditions. European

Parliament and Council (2023) which presuppose carbon footprint disclosure and traceability systems, but the environmental and compliance consideration were not well perceived as market forces: considering resilience of firms, the extent to which the capabilities of their governance are prepared. Our World in Data (2025) showed cross country variation of electricity carbon intensity but this was seldom as an external pressure that affected resilience through siting constraint, cost instability and compliance exposure. International Energy Agency (2025) also mentioned rising focus on recycling, but often feedstock timing and capacity planning were not linked with resilience outcomes like input stability and disruption recovery. Consequently, integrative empirical studies linking internal capabilities and external market forces to resilience were still scarce, which limited evidence on how resilience was co-produced under conditions of fast growth, concentrated processing, and tightening regulation.

## **METHODOLOGY**

### **Research Design**

The study employed a cross sectional explanatory approach to measure the effect of the internal capacities and external market forces affecting the results in the electric vehicle battery industry. This design was appropriate to the aim of testing relations among constructs at one point in time with the use of standardised measures. The unit of analysis was organisational level perceptions obtained from professionals involved in battery related functions such as operations, procurement, engineering, supply chain, strategy and sustainability. The model considered internal capabilities as firm level resources and routines while external market forces represented market conditions such as policy pressure, competition levels, changes in demand and input volatility. The design allowed for the statistical test of associations between the predictors and dependent outcome as well as control for basic profile characteristics so as to reduce the omitted variable bias (Garba, 2023). A cross sectional explanatory design provided scope for systematic examination of effects of capability and market forces in the context of the EV battery industry.

### **Data Collection**

Data collection was done through a structured self-administered questionnaire that was distributed online to the purposely selected EV battery industry professionals. Questionnaire development was carried out in a staged manner in order to enhance content clarity and construct alignment. First, the constructs were defined and mapped to the study model, in which internal capabilities and external market forces were defined as predictors of resilience. Second, item statements were developed with an operational reality in the EV battery value chain, and each construct should be represented by several indicators. Third, the draught instrument was reviewed for clarity of language, redundancy and relevance to industry practise, and minor revisions were made to improve readability and minimise ambiguity. The final instrument employed closed ended questions that were grouped into constructs, and measured responses on a five-point Likert scale ranging from strongly disagree to strongly agree. Internal capabilities were measured with items that had operational

effectiveness, innovation orientation, supply chain coordination and strength of partnership whereas the external market forces were measured with items of regulatory pressure, price volatility, competitive rivalry and market uncertainty. The questionnaire also contained demographic and professional profile materials to characterise the sample and support control variables. Participation was voluntary, confidentiality was guaranteed, and anonymous responses minimised social desirability bias and encouraged honest reporting.

### **Sampling and Sample size**

Purposive sampling was employed to recruit respondents who have direct involvement in the work of EV battery including operations or production, supply chain or logistics, procurement or sourcing, engineering or research and development, quality or compliance, and strategy or management. The sampling frame included professionals of organisations involved in processing of battery materials, cell or pack manufacturing, supplier coordination and compliance activities of the EV battery value chain. Recruitment of respondents was made through the use of professional networks and targeted outreach for industry groups, with support from eligibility screening requirements that included current role relevance and regular exposure to battery sourcing, production processes, or regulatory processes. Although some participants were early career, they were treated as informed practitioners since their roles entailed day to day interaction with operational constraints and market pressures. This approach both captured current industry conditions and maintained functional diversity with respect to exposure to internal capability development and external market forces. A sample size of 200 was used to increase the stability of the correlation and regression estimates along with reliable inference when both predictors were modelled together.

### **Data Analysis**

Data analysis was static process with sequence of combining descriptive and inferential analysis. Descriptive statistics were used to summarise respondent characteristics and means and standard deviations for all study variables were reported with the goal of providing an initial assessment of central tendencies and dispersion. All statistical analyses were conducted using IBM SPSS Statistics. Correlation analysis was then conducted to examine the direction and strength of bivariate relationships within internal capabilities, external market forces and a dependent outcome. Multiple regression analysis was used to estimate net impact of internal capabilities and external market forces on the dependent variable with the acknowledgement of predictor relationships that occur simultaneously. Model interpretation was based on magnitude of coefficients, significance levels and overall explanatory power and ensuring that the analysis was centred on correlation and regression as the primary inferential methods. Descriptive statistics provided the foundation for establishing baseline patterns as well as correlation and regression provided most of the evidence about the links between capabilities, market forces, and outcomes in the industry.

## **RESULTS AND ANALYSIS**

### **Industry Value-Chain Analysis (EV Battery & Materials)**

#### **What the chain looks like**

The EV Battery Value Chain is composed of four key stages: the upstream, the midstream, the downstream, and the end-of-life stages, also known as the EoL stage (Powering the Future: Market Dynamics of EV Batteries, 2024). Upstream process includes mining and concentration of lithium, nickel, cobalt, manganese, and natural graphite. The product at this stage may be either ores or concentrates. The issues in this case are the time required to obtain permits, social acceptability, and geological risks. During the midstream process, the raw materials that have been extracted during the upstream process are purified to form compounds such as lithium hydroxide that are subsequently used to produce the active materials such as LFP-NMC during the CAT process, the anode materials such as Graphite-Silicon Mixed Matrix are also made during the midstream process (Shqairat et al., 2025). This can be recognised as the current bottleneck in the process, where the majority of refining and CAT production plants are based in a few countries. Therefore, even if extraction and assembly facilities relocate, the supply chain can remain unchanged. The downstream process comprises the manufacture of the electrochemical cells in prismatic, cylindrical, and pouch forms and vehicle packaging. The value of such a process can be determined by the material recovery rates, the process selectivity, especially in the case of dry electrode coating and the Cell-to-Pack process (Vega-Muratalla et al., 2024). The used packs are collected in the final process, dismantled in the modular form, after which the black mass is converted, and the metal recovered through the pyrometallurgical and hydrometallurgical processes. The midstream market reentry of these materials takes the form of secondary materials. The former, the first material in the process, may be acquired as scraps, and the latter may be obtained when the EVs become end-of-life, thus, creating the relevance and importance of the process of reducing the supply chain and environmental footprint (Richert & Dudek, 2023). The analysis ends with a definite conclusion about the paramount significance of the midstream process, according to which the supply chain may be used to acquire a more sophisticated insight into the general process. Diversification of the refining and CAT processes is necessary, because if not, then the wave of threats will prevail despite the shifting of other processes. In this regard, the supply chain is now tightly connected with the midstream process.

#### **Primary activities and where value/risk concentrates**

Inbound logistics involves the movement of concentrates to refineries and precursors to CAM facilities, which can be vulnerable to distance, export regulations, and single-route dependencies, respectively (Cheng et al., 2024). The manufacture of the cell and the pack represent the most strategically valuable process, where potential value creation involves learning the process, equipment availability, and process innovations related to cost reduction based on kilowatt-hours (Cheng et al., 2024; IEA, 2025). The outbound logistical process applied to the

manufacture of the cell, as well as the pack, involves transportation between facilities and requires handling hazardous materials and temperature control (European Parliament & Council of the European Union, 2023). In today's scenario, the value opportunity lies in the areas of CAM and cell manufacturing, while the growing value, in the form of increased volumes, also exists in recycling. In contrast, the risk opportunity exists in the midstream segment, mainly due to geography-driven qualifications. This means that companies that can prequalify alternative routes in the midstream process, as well as those that can expedite switchover times, can mitigate the impact of disruptions in terms of both cost and production (Cheng et al., 2024; IEA, 2025).

#### **Support activities that change competitiveness**

Technology, process, and engineering help complement the advantages of competitiveness through the selection of chemistry, ranging from the selection of lithium iron phosphate, also known as LFP, based on cost and safety, while others include the selection of Nickel Manganese Cobalt, denoted as NMC, designed for applications requiring a high level of energy density, along with the support of diversified midstream routes, which in turn minimizes the potential risks associated with disruptions in supply chains (Cheng et al., 2024; IEA, 2025). The approach to procurement, along with supplier management, helps enhance the stability of supply chains by establishing the pre-qualification of at least two suppliers in each of the two countries for each crucial process in the midstream, ranging from the refining of lithium hydroxide to the production of LFP/CAM NMC cathodes, along with the quality specifications, establishment, and conduct of audits prior to the onset of any form of potential perturbations in the supply chain (Cheng et al., 2024).

#### **PESTLE Analysis on EV Battery & Materials Industry**

Governments influence the geography of midstream activities, such as refining and cathode active material (CAM) manufacturing, through incentives, material origin rules, and disclosure obligations (European Parliament & Council of the European Union, 2023; U.S. Department of the Treasury, 2023). Given the current aggregation of midstream capacity, most supply chains remain sensitive to policy disturbances (Cheng, Fuchs, Karplus, & Michalek, 2024). Policies that target mining alone or assembly alone miss the key constraint in the chain, where refining, as well as CAM, should receive the highest priority, along with the supplier base.

#### **Political**

Incentives as well as material origin regulations and disclosure requirements have governments affect the geography of midstream operations, including refining and cathode active material (CAM) production (European Parliament and Council of the European Union, 2023; U.S. Department of the Treasury, 2023). Given the current importance of midstream capacity, most supply chains remain sensitive to policy turbulence (Cheng et al., 2024). It is important to differentiate between shock risks, such as unexpected export bans, and structural risks, like long-term tax credit changes. This differentiation helps firms tailor

their mitigation tactics effectively. Policies that target mining alone or assembly alone overlook the key constraint in the chain, where refining, as well as CAM, should receive the highest priority, along with supplier base diversification efforts (European Parliament & Council of the European Union, 2023).

#### **Economic and Social**

International Energy Agency (IEA) and Global EV Outlook indicate that the demand of battery materials is driven by EVs adoption rate in mass market as reported in 2025. The variable properties of each chemistry also affect the amount of cost exposure as LFP material can compensate the fluctuations in the cost of nickel and cobalt, whereas NMC material can accommodate a higher energy density, but with the cost of more expensive and refined materials (Cheng et al., 2024). The creation of production plants needs certain knowledge of process engineering and the electrochemical process technology. Furthermore, the social acceptance such as water use, gas emission, and safety concerns also affect the time frames to be allocated to the project permission as observed by European parliament and council of the European union in 2023.

#### **Technological, Legal, and Environmental**

NMC and LFP are the most popular types, while technological innovations such as dry electrodes, CTP technology, and various other combinations for pyro, hydro, hybrid/direct processes shape the cost structure and the environmental impact profile (IEA, 2025; Global EV Outlook 2025, 2025). The primary risk exposure factor depends on the geographical region where midstream processing occurs, but the use of LFP alters the risk factor, rather than reducing it. Based on this, there was an emphasis on matching the choice of battery technology to applications, as well as the use of diverse midstream processing routes (Cheng et al., 2024).

The EU Battery Regulation requires the disclosure of a carbon footprint, targets for recycled materials, and a digital battery passport, all of which influence facility location and the selection of supply chains (European Parliament & Council of the European Union, 2023). In the United States, the foreign entity rules limit the supply chains suitable for the generation of credits (U.S. Department of the Treasury, 2023; U.S. Department of Energy, 2025). In this case, companies are compelled to adopt compliance-by-design measures, including traceability and supplier certifications, to retain the incentives associated with these regulations.

Purification materials refining, as well as the production of cathode active materials, are also environmental hotspots. Carrying out these activities on less-carbon-intensive power grids, as well as effective water resource management practices, can help to ease the environmental concerns associated with the life-cycle stages of the material (European Parliament & Council of the European Union, 2023; Our World in Data, 2025). Since the quality of the grid power can also differ from one country to another, the choice of the site can help address environmental concerns associated with the material's life

cycle and diversification efforts (European Parliament & Council of the European Union, 2023).

**Quantitative Findings**  
**Table 1: Demographic Profile**

	Group	Frequency	Percentage
Gender	Male	135	67.5
	Female	65	32.5
Age	18 to 24	69	34.5
	25 to 34	45	22.5
	35 to 44	38	19.0
	45 to 54	30	15.0
	55 and above	18	9.0
Years of Professional experience	Less than 1 year	70	35.0
	1 to 3 years	46	23.0
	4 to 6 years	30	15.0
	7 to 10 years	37	18.5
	More than 10 years	17	8.5
Functional area	Operations or production	81	40.5
	Supply chain or logistics	37	18.5
	Engineering or research and development	27	13.5
	Quality or compliance	37	18.5
	Strategy or management	18	9.0

Table 1 summarised the demographic profile of the 200 respondents and indicated that the sample was a male dominated with males representing (67.5%) and females representing (32.5%). This distribution indicated that responses were more heavily influenced by the male perspective and may be representative of workforce composition in technical and operations-oriented battery roles. The gender structure did not negate results, but it demanded that the results should be interpreted carefully when discussing perceptions of capability and market exposure across the industry. The table supplied important context to determine the degree of representativeness of the dataset to the professional population under study. The sample provided a clear gender imbalance so interpreting results was necessary whilst being aware of potential effects from composition in the workforce.

In terms of age, Table 1 indicated that the highest number of people was at the age of 18 to 24 with (34.5%), followed by the age of 25 to 34 with (22.5%) and 35 to 44 with (19.0%). The remaining groups were 45 to 54 at (15.0%) and 55 and higher at (9.0%), which suggests fewer senior age cohorts in the dataset. This age pattern suggested that the evidence was under stronger influence of early career and mid-career respondents than late career professionals. Such profile was plausible for a fast-growing sector, where new entrants and expanding teams are generally prevalent across supply chain and manufacturing ecosystems. The sample skewed toward younger cohorts, so the perceptions probably reflected early and mid-career experience in a rapidly expanding industry.

Professional experience strengthened this trend, where below 1 year accounted for (35.0%), 1 to 3 years accounted for (23.0%) and 4 to 6 years represented (15.0%). More experienced groups were small, 7 to 10 years at (18.5%) and more than 10 years at (8.5%) which suggested low representation of long tenure expertise. Functional roles were focused in operations or production (40.5%), and supply chain or logistics and quality or compliance were each (18.5%). Engineering or research and development accounted for (13.5%), and strategy or management were smallest forming the smallest group at (9.0%), indicating that operational views hold a preponderance in the dataset. The data set was operationally weighted, and as such interpretations of strategic decision making should consider the relative under-representation of strategy and management.

**Table 2: Descriptive Analysis**

	N	Mean	Std. Deviation
Internal Capabilities	200	2.4325	1.13247
External Market Forces	200	2.7837	.97186
Organisation Resilience	200	2.7263	1.08107

Table 2 presented descriptive statistics results of the three core constructs based on responses of 200 participants representing moderate central tendencies with large dispersion in all measures. Internal Capabilities had the lowest mean ( $M = 2.4325$ ;  $SD = 1.13247$ ) showing that the respondents, on average, agreed relatively less with their organisations having high levels of internal capability. External Market Forces had the highest mean ( $M = 2.7837$ ;  $SD = 0.97186$ ) indicating that the respondents perceived the external pressures to be more salient compared to the internal strengths, although the mean was still below the midpoint of the scale.

Organisation Resilience also showed moderate ( $M=2.7263$ ;  $SD=1.08107$ ) implying that perceived outcomes, such as resilience, competitiveness and compliance readiness, were not strongly positive across the sample. The standard deviations, especially for Internal Capabilities ( $SD = 1.13247$ ) and Outcomes ( $SD = 1.08107$ ) reflected significant heterogeneity of the organisational conditions, which was consistent with the differences in firm maturity, functional exposure and market positioning.

**Table 3: Reliability Statistics**

Cronbach's Alpha	N of Items
.916	12

According to Table 3, the 12-item scale had a Cronbach’s alpha of 0.916, indicating a high internal consistency among the items. This is far above the generally agreed minimum criteria of 0.70 for exploratory research and even more restrictive 0.80 standard of applied research. These findings indicate that the composite measure is statistically sound and can be further correlated and regressed to obtain future findings in the context of the EV battery industry.

**Table 4: Correlation Analysis**

		Internal Capabilities	External Market Forces	Organization Resilience
Internal Capabilities	Pearson Correlation	1	.647**	.726**
	Sig. (2-tailed)		.000	.000
	N	200	200	200
External Market Forces	Pearson Correlation	.647**	1	.741**
	Sig. (2-tailed)	.000		.000
	N	200	200	200
Organization Resilience	Pearson Correlation	.726**	.741**	1
	Sig. (2-tailed)	.000	.000	
	N	200	200	200

\*\* . Correlation is significant at the 0.01 level (2-tailed).

Table 4 showed the outcome of Pearson correlation for internal capabilities, external market forces, and Organization Resilience using a sample of 200 respondents. The results of the analysis revealed a significant positive relationship between internal capabilities and external market forces ( $r=.647$ ,  $p<.001$ ), i.e., organisations with the highest self-reported capabilities also reported the highest external pressures. This pattern implied that firms with a higher level of operational and strategic maturity were more exposed to the dynamics of competition, regulation and the supply chain, rather than being insulated from them. The strength of the relationship also suggested partial overlap in the way respondents assessed internal readiness and intensity of their market environment.

The dependent construct, Organization Resilience, demonstrated strong positive correlations on both predictors which supported this study's main expectation of linked capability of the environment effects. Internal capabilities showed a strong correlation with outcomes ( $r=.726$ ,  $p<.001$ ) (i.e., respondents with higher perceptions of capability also stated higher outcomes, such as resilience, competitiveness, and compliance readiness). External market forces also correlated strongly with outcomes ( $r=.741$ ,  $p<.001$ ), suggesting that the greater the market pressures faced by firms, the stronger the outcome ratings were, possibly due to the investment effort of firms experiencing strong pressures in performance improvements. However, the relatively high correlation between the two independent variables ( $r = .647$ ) suggested that regression modelling had to account for the shared variance and the potential for the effects of multicollinearity. The correlation structure therefore justified the move to regression analysis to isolate the unique contribution of internal capabilities and external market forces to outcomes.

**Table 5: Regression Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.809 <sup>a</sup>	.654	.650	.63920

a. Predictors: (Constant), External Market Forces, Internal Capabilities

Table 5 summarised the overall fit of the multiple regression model of predicting Organization Resilience from internal capabilities and external market forces. The model showed a high correlation between observed and predicted values ( $R = .809$ ) which was good in terms of explanatory alignment. The coefficient of determination indicated that the predictors combined were able to explain (65.4%) of variance in outcomes ( $R^2 = .654$ ) which indicated large explanatory power. The adjusted  $R^2$  value (0.650) was also close to  $R^2$ , indicating that the fit of the model was not exaggerated by the number of predictors, and was likely stable. The standard error of the estimate (0.63920) was a good prediction error about the regression line in a moderate range.

**Table 6:** Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.296	.139		2.139	.034
	Internal Capabilities	.405	.052	.424	7.714	.000
	External Market Forces	.519	.061	.467	8.487	.000

a. Dependent Variable: Organization Resilience

Table 6 reported regression coefficients for the model of the Organization Resilience using internal capabilities and external market forces, and revealed that both predictors were statistically significant. Internal capabilities had a positive unstandardised coefficient ( $B = .405$ ,  $SE = .052$ ) suggesting that for a unit increase in internal capability scores, there was a .405 increase in outcome scores all other things being equal. The corresponding standardised coefficient was also positive and moderate in size ( $\beta = .424$ ), which confirms a meaningful effect in terms of standard deviations. The t value ( $t = 7.714$ ) and the level of significance ( $p < .001$ ) indicated that there was no likelihood of the relationship to occur due to chance. The constant value was also statistically significant ( $B = .296$ ,  $p = .034$ ), which implies that there might be a small amount of outcomes at the baseline when both predictors were equal to zero (in the context of the scaling used in the model). This finding indicated that ability-enhancing was connected with improved perceived results in the EV battery industry scenario.

There was also a positive and significant correlation between external market forces and Organization Resilience ( $B = .519$ ,  $SE = .061$ ;  $\beta = .467$ ;  $t = 8.487$ ;  $p < .001$ ). The size of the standardised coefficient was a little greater than the size of internal capabilities, suggesting that conditions in the external market had the stronger unique association with outcomes in this model. This pattern implied that firms facing greater regulatory, competition, and supply chain pressures also reported stronger outcomes, which could indicate adaptive upgrading, learning effects, or faster functioning under constraint. However, this interpretation had to be done with caution because external forces can plausibly limit outcomes in other environments and positive associations might reflect measurement framing or the presence of higher capability firms in more demanding environments.

## DISCUSSION

The result showed that respondents perceived internal capabilities in terms of the comparison to the extent that is quite weak with a mean score of ( $M = 2.4325$ ) and high variation ( $SD = 1.13247$ ). This trend reflected the lack of even distribution of capability maturity of organisations, which was consistent with findings of evidence that battery value creation demanded specialised process engineering and integrated midstream capability. Cheng et al. (2024) established that the choice of chemistry and midstream concentration influenced vulnerability, which helped to explain why capability gaps were significant to outcomes. The rating of external market forces was higher ( $M = 2.7837$ ;  $SD = 0.97186$ ) which implies that policy, competition and input volatilities were salient constraints in daily operations. The European Parliament and Council of the European Union (2023) emphasised that compliance requirements, such as footprint disclosure and traceability requirements, increased the burden of operations on firms. The mean of the outcomes remained low ( $M = 2.7263$ ;  $SD = 1.08107$ ), which indicates that not every respondent was highly resilient and competitive.

The outcome of the correlation was that all the constructs had strong, positive and statistically significant relationships with each other with internal capabilities relating to external market forces ( $r = .647$ ,  $p < .001$ ). This association revealed that the organisations with pressures in the market, reported higher perceptions of internal capability development also in accordance with adaptation under constraint. Arup (2024) explained rapid scaling and structural change in battery markets which helped make

sense of Capability building as a response to expanding demand and operational complexity. Internal capabilities were strongly related to resilience ( $r = .726$ ,  $p < .001$ ), meaning that capability improvement was also linked to the stronger perception of performance and resilience. According to Cheng et al. (2024), the risks of supply chain disruption went ingrained in chemistry and processing concentration that implied that operation and coordination capability could lessen vulnerability exposure. External market forces were also a significant correlate ( $r = .741$ ,  $p < .001$ ), indicating that the intensity of pressure and outcome performance were moving together in this dataset. The correlation structure suggested that pressure did not just depress outcomes, but was associated with differences in performance across firms.

The associations were reinforced by the regression model, which also displayed strong overall explanatory power with ( $R = .809$ ) and ( $R^2 = .654$ ) which indicated that the two predictors accounted for (65.4%) of outcome variance. This level of explanation indicated that internal capability as well as external environment captured central drivers of perceived industry performance. The rapid growth in EV sales and shifting chemistry mixes was identified by IEA (2025), and this gave credence to the fact that firms were operating in a volatile environment, and strategy and operations needed to be adjusting quickly. The adjusted R<sup>2</sup> (0.650) was essentially similar to the unadjusted R<sup>2</sup>, so that the model could not be over specifying. The moderate value of the standard error of estimate (0.63920) showed that there was still a meaningful variance in predictions between firms, which corresponds with the dispersion in

internal scores in capability and outcome measures. ICCT (2025) found the increasing adoption of EVs and model availability in the United States, which helped to explain why likely market scale and competitive responses may have varied by geography and firm position.

Internal capabilities had a significant positive coefficient ( $B = .408$ ,  $SE = .052$ ;  $\beta = .424$ ;  $t = 7.714$ ;  $p < .001$ ) indicating capability differences were translated into meaningful outcome differences when the forces external to the capability were held constant. This finding supported the argument that organisational routines in operations, innovation and coordination of supply chains were important to resilience and competitiveness in a constrained value chain. Cheng et al. (2024) highlighted that constraints were generated by midstream dependencies and chemistry that created disruption exposure that in turn made internal coordination and the process capability strategically relevant. The effect size was also reported to have practical implications, as one unit of increased capability had a .405 average positive impact on outcome scores, as the model scale implied. The battery market has been described by Arup (2024) as scale sensitive and operationally demanding which contributed to its explanation of why the effectiveness of production was important to the perceived performance along with the ability of suppliers to manage them. The result implied that internal capability acted as a lever through which firms stabilised access to inputs, improved the reliability of delivery and strengthened compliance readiness.

External market forces had a slightly greater unique association with outcomes ( $B = .519$ ,  $SE = .061$ ;  $v = .467$ ;  $t = 8.487$ ;  $p < .001$ ), which led to the suggestion that outcome performance was heavily influenced by the force of external constraints. This positive sign suggested that organisations facing stronger regulatory, competitor and supply volatility pressures also reported stronger outcomes which were plausibly adaptive upgrading and accelerated investments under pressure. The European Parliament and Council of the European Union (2023) have characterised tough disclosure and recycled content requirements that most likely pushed firms to conform to systems that increased perceived readiness and performance. U.S. Department of the Treasury (2023) identified source related constraints associated with incentive eligibility, and these may have provided an incentive to restructure supply chains and improve governance. The finding was also consistent with the notion that external constraints differentiation between firms within the organisations where better prepared organisations had relatively better performance in a high-pressure context. However, strong predictor correlation ( $r = .647$ ) suggested the presence of shared variance between capability and environment, which necessitated caution in the interpretation of "independent" effects within tightly coupled markets.

### Recommendations

The priority should be to build new cathode and refining lines in those regions with low carbon intensity on the grids, or to combine project developments with strong clean energy off-takes. Midstream sources should be diversified

through long-term contracts and partnerships, while preparing for the end-of-life wave by developing programs to accept scrap currently and expanding processing capacity to meet increased flows. This kind of shift can be encouraged by policymakers in setting clearer terms and definitions concerning transport and storage across borders to recycle pack containers and ensuring that permitting processes correspond to access to low-carbon electricity. Investors can assess opportunities on both carbon and temporal factors, with reduced embodied carbon helping to open markets, while phased construction tied to the 2030s end-of-life peak helps to secure capacity utilization and returns (IEA, 2025; Our World in Data, 2025).

### CONCLUSION

This study examined how internal capabilities and external market forces related to resilience using a cross sectional explanatory design and a structured questionnaire. The resilience was used as the central outcome of the analysis reflection characteristic of continuity of key inputs, disruption recovery, and stable operational performance during market pressure. The sample comprised industry informed respondents across functional areas, which strengthened the relevance of reported perceptions regarding capability maturity and exposure to external constraints. Descriptive findings indicated modest construct levels, suggesting that resilience and the capability base supporting it were not uniformly strong across participating organisations. These patterns were consistent with an industry characterised by rapid scaling, midstream constraints, and varied organisational readiness. Inferential results provided strong evidence that both predictors were associated with resilience. Correlation analysis indicated strong positive relationships between internal capabilities and resilience and between external market forces and resilience. Regression analysis revealed a very high level of explanatory power, indicating that the combination of internal capabilities and external market forces can explain a very significant percentage of variation in resilience outcomes. This resulted in the findings that resilience was greater in the situation where the firms had reported higher levels of capability and external pressures were also associated with resilience which could be related to the process of upgrading and adapting to constraint. In general, the findings confirmed the assumption that the resilience within the EV battery industry relied on the capability reinforcing with the successful response to regulatory, competitive, and supply volatility influence.

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