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IMPROVING SUPPLY CHAIN PERFORMANCE

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Introduction

Tesla has become the world's largest electric vehicle manufacturer. Founded in 2003 by the visionary entrepreneur Elon Musk, Tesla has emerged as a global leader in electric vehicle manufacturing, known for its cutting-edge technology, sleek designs, and commitment to sustainability (Shao, et al., 2021).

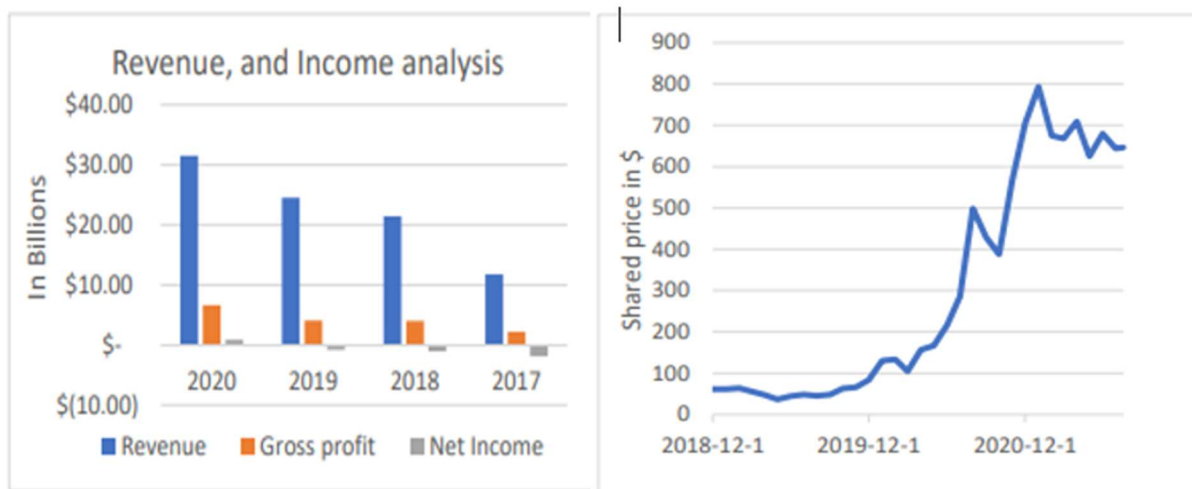


Figure 1a. Revenue and income of Tesla

Figure 1b. Share of Tesla from 2018 to 2021

Figure 1. The exponential growth of Tesla in sales (Shao, Wang, & Yang, 2021,p.400)

The author highlighted the exponential sales from 2017 to 2020 in Figure 1a. Figure 1b shows that in December 2018, the share cost was around \$61.71 per share. However, this improved, and by February 2020, the company's shares were valued at \$161.68; both trends are evidence of the car manufacturer's exponential growth. (Shao, et al., 2021). Tesla has reshaped the automotive landscape and diversified into energy storage solutions, solar energy products, and renewable energy generation.

The fundamental section of supply chain management plays a vital role in Tesla's ensuring the efficient flow of materials, components, and finished products throughout its global network of suppliers, manufacturing facilities, and distribution channels. However, Tesla's supply chain encompasses a complex network of suppliers spanning various regions and countries who procure raw materials, components, and subsystems essential for producing its electric vehicles and energy products. (Sathish, 2013).

This report aims to assess Tesla's international supply chain, identifying potential risks and vulnerabilities using the Failure Modes and Effects Analysis (FMEA) methodology. Primarily, the aim is to conduct a rigorous risk assessment, highlighting potential failure modes where disruptions may occur. The FMEA aims to identify potential failure modes in these processes, including supplier delays, material shortages, quality issues, and logistic problems. Additionally, measures to enhance the resilience and efficiency of Tesla's supply chain will be explored.

The main outcomes of the FMEA analysis in this report are:

- **Objective:** The primary aim is to develop an FMEA analysis framework pointing at the international supply chain to find potential risks and vulnerabilities.
- **Product Chosen:** The analysis will primarily target two critical aspects: raw material sourcing and quality assurance for battery components within Tesla
- **Focus:** Through meticulous risk assessment and analysis of potential failure modes, six significant steps have been identified and elaborated. Clear examples illustrate each step, ensuring a comprehensive understanding of the potential risks.
- **Outcome:** The selected models will equip companies with the foresight and predictive capabilities to anticipate and mitigate potential failures effectively.

Fmea Analysis

Scope

The FMEA is focused on the critical stages of Tesla's supply chain, which includes raw material sourcing, battery cell manufacturing, assembly integration and Transportation logistics.

Geographical Boundaries

As EVs have become increasingly important in the market, around 2.7 million new EVs, including full-battery electric and plug-in hybrid models, have been registered worldwide. Figure 2 illustrates the significant growth of the EV market, with Europe emerging as the leading region in adoption, surpassing China. Meanwhile, the United States ranks third, registering 259,000 new electric cars. Europe has now exceeded 10 million EVs, while China maintains its position as the largest market, with 4.5 million electric vehicles. (Jones, et al., 2023).

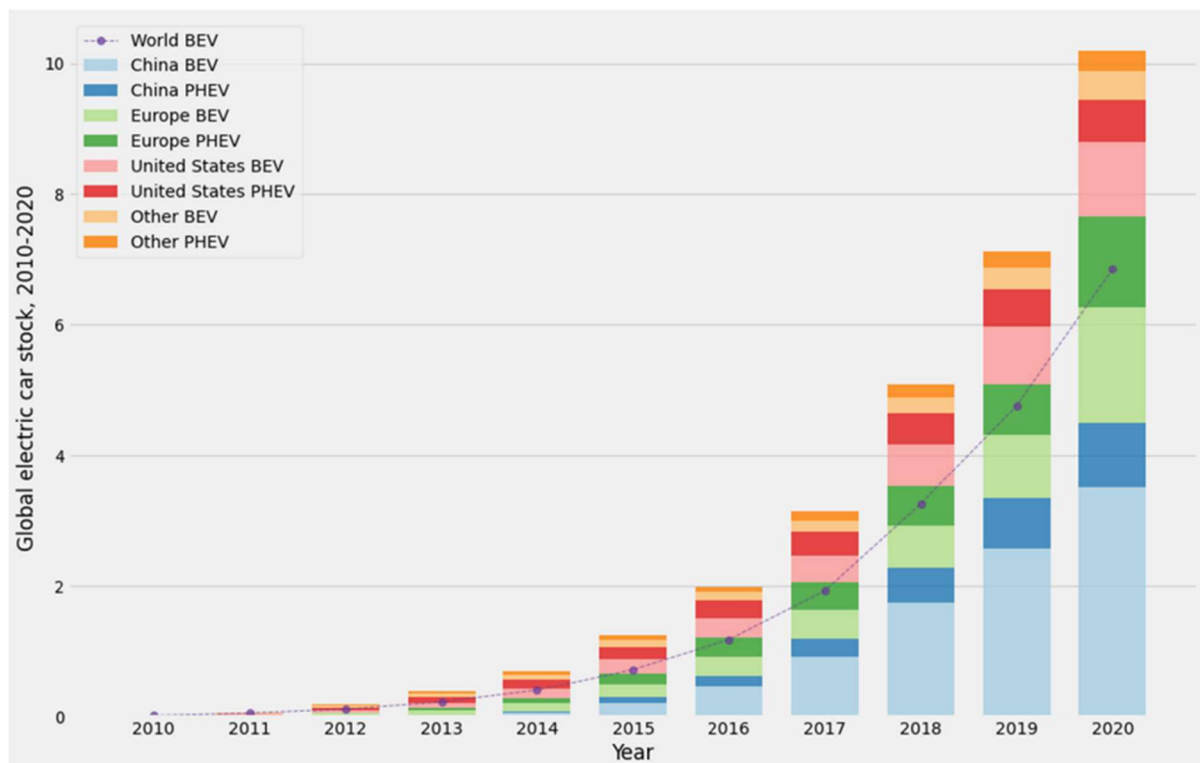


Figure 2. Glove EV stock between 2010-2020(millions). (Jones, Nguyen-Tien, & Elliott, 2023)

The Geographical boundaries of Tesla extend to various regions worldwide, such as:

Procedure: Tesla integrates both automation and human invention into the manufacturing process (Thompson, 2023). They manufacture lithium-ion, battery packs, gearboxes, electric motors and other components. Tesla's Gigafactory 1 is approximately 3.5 million square feet, having the strategic capacity for over 500,000 cars annually. (Tesla, 2023).

Facilities: The main facilities for manufacturing a Tesla vehicle occur in various locations such as in the US in Northern California, Buffalo, New York, Gigafactory New York, Austin, Texas, Gigafactory Texas and near Reno, Nevada, Gigafactory Nevada. However, manufacturing components of the battery cell and battery packs occur in China (Gigafactory Shanghai) and Germany (Gigafactory Berlin-Brandenburg).

Transportation: Nowadays, transportation is a real challenge for many international supply chain companies. However, Tesla has launched a door-to-door service known as "Tesla Direct" (Lambert, 2018). The author argues that while this strategy offers direct engagement with consumers, it can also pose the challenge of efficiency and logistics management.

Inventory: Tesla has been in partnership with Toyota, aiming to reduce inventory costs due to the implementation of Just in Time (JIT), which reduces the risks and costs associated with excessive inventory storage (Sathish, 2013).

In the business world, the supply chain has always been a critical aspect (Ellram, 1991). Recently, there has been a growing recognition of the importance of Supply Chain Management (SCM) in maximising efficiency, staying competitive, and achieving overall success. An efficient SCM can optimise inventory levels, reduce costs, and improve customer satisfaction by ensuring smooth goods and services flow. In today's evolving business landscape, where sustainability concerns are paramount, a well-coordinated SCM strategy is essential for companies to remain agile, resilient, and competitive. For instance, in 2018, Tesla aimed to produce 5,000 new Model 3 Electric cars per week but could only manage 2,000 due to operational shortages. Elon Musk, as cited in the article, explained that (Susanto & Ellitan, 2024):

QT1:" *When questioned about the shortfall, admitted that their initial reliance on heavy automation was a mistake.*" (Susanto & Ellitan, 2024,p.71)

Risk assessment before the FMEA analysis

For this report, the author has conducted a comprehensive Risk Assessment of Tesla's international supply chain using the Failure Modes and Effects Analysis (FMEA) methodology.

- 1) Raw materials sourcing:** Along with the increase in the demand for battery-grade nickel, cobalt and lithium will also increase significantly; however, the shortages of materials in the supply chains could impact the automotive industry and affect the quality of the cells (Bernhart, 2019).
- 2) Battery Cells Manufacturing:** The risk of variability in the production process could cause inconsistencies in performance and reliability (Baumhöfer, et al., 2014).
- 3) Assembly and Integration:** Relying on too many automation errors or inefficiency in the assembly process can compromise the structural integrity and functionality of the battery (Susanto & Ellitan, 2024).
- 4) Thermal issues:** Thermal management challenges, such as overheating, pose safety hazards and may lead to battery degradation or failure. Quality control (QC) is a fundamental task that ensures the correct functions of LIB manufacturing. The beauty of this method is that it prevents defects at early stages and avoids recall in the further stages (Deng, et al., 2020). In reality, estimating the failure rate of quality control in manufacturing innovations presents challenges. These new manufacturing concepts typically operate on a small scale in their early stages. Therefore, modelling and statistical methods may partially address this issue by aiding in estimating production quality (Liu, et al., 2021).
- 5) Transportation and Logistics:** Damages, delays or material loss can disrupt the production schedule and increase costs.

Fmea analysis

The Failure mode and Effect Analysis (FMEA) is a valuable technique in reliability management, crucial for identifying the root causes of system or product failure and mitigating associated risks (Stamatis, 2003). Widely utilised in failure detection, the FMEA traditionally calculate the Risk Priority Number (RPN) by multiplying the scores assigned: Occurrence (O), Severity (S) and Detection (D) (Liang & Li, 2021).

Therefore, the RPN can be calculated as illustrated in Equation 1 (Liang, et al., 2023):

Equation 1 RPN value

$$RPN = O * S * D$$

Table 1. Brainstorm of the FMEA analysis

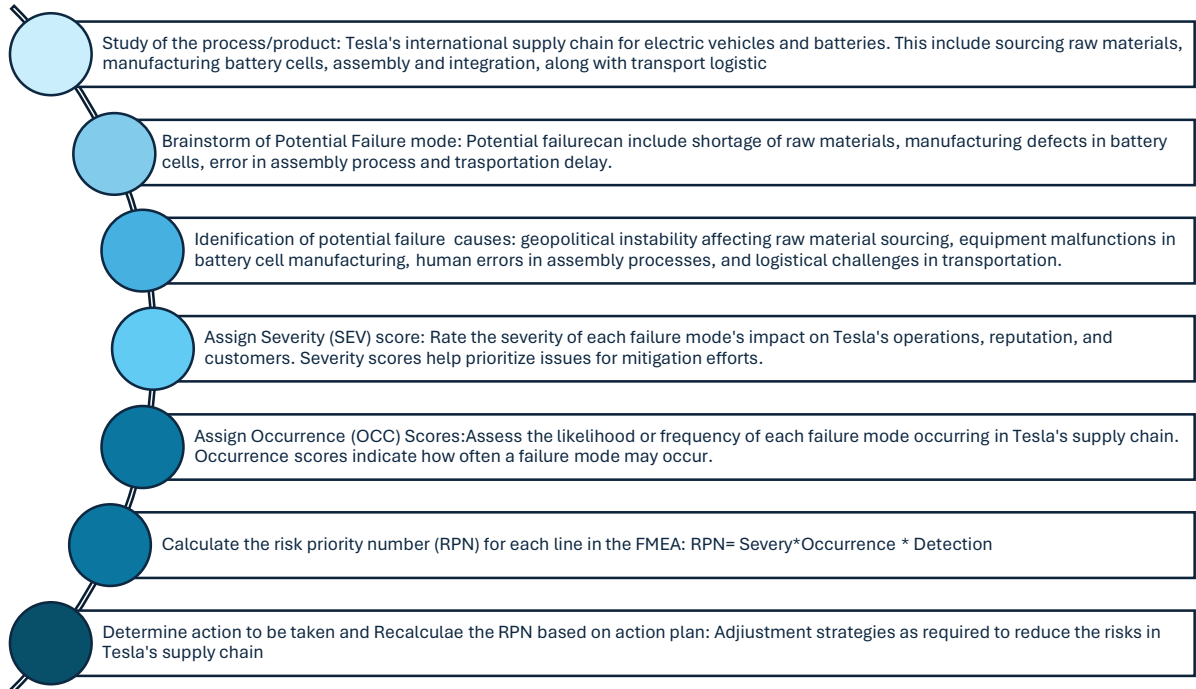


Table 2. Fmea analysis of the author1_

Process/Product Name:		Raw material sourcing and Quality Assurance for Battery components in Tesla				Prepared By:		Pierluigi Bonagura							
Responsible:		Pierluigi Bonagura				FMEA Date (Orig.):		1-Apr (Rev.): 16/04/2024							
Process Step/Input	Potential Failure Mode	Potential Failure Effects	SEVERITY (1 - 10)	Potential Causes	OCCURRENCE (1 - 10)	Current Controls	DETECTION (1 - 10)	RPN	Action Recommended	Responsibility	Actions Taken	SEVERITY (1 - 10)	OCCURRENCE (1 - 10)	DETECTION (1 - 10)	RPN
What is the process step or feature under investigation?	In what ways could the step or feature go wrong?	What is the impact on the customer if this failure is not prevented or corrected?		What causes the step or feature to go wrong? (how could it occur?)		What controls exist that either prevent or detect the failure?			What are the recommended actions for reducing the occurrence of the cause or improving detection?	Who is responsible for making sure the actions are completed?	What actions were completed (and when) with respect to the RPN?				
1)Raw material sourcing	Shortages of materials in the supply of raw material such lithium, cobalt	Delays in product delivery and increased cost	7	Geographical instability and political issue along with labour strikes	6	Evaluating supplier sustainability	5	210	Establish relationship with suppliers to mitigate risk of shortage distribution	Supply Chain Management teams: Responsible for end to end flow of material within the supply chain	Identifications of alternative supplier, Developing risk monitoring to implement real time updates	5	6	4	120
1)Raw material sourcing	Poor quality of raw materials, defects in battery components	Malfunctioning thermal management systems can cause overheating, thermal runaway, and battery pack failure, posing significant safety risks to operators and end-users	8	Not using the safety standards and can be environmental damage	6	Tesla has implemented risk management strategies to proactively identify and mitigate risks associated with raw material sourcing	9	432	Providing Training and support to raw materials suppliers to help them to understand the Tesla's quality requirements	Quality Assurance Team: Responsible for monitoring quality of raw materials	It will be established a rigour supplier evaluation criteria to assess the quality and compliance of a raw materials. Ensure that quality control system and regulatory standards are meet	7	6	6	252
2)Battery cell manufacturig	Battery cells Manufacturing Defects in battery cells	Contamination or incosistent cell performance	6	Automated assembly process	5	Complex manufacturing process and human error due to the lack of knowledge	6	180	Implement stringent quality control protocols during the manufacturing process to detect and prevent defects early on.	Quality Assurance Team: Responsibility that the action address the manufacturing defects in battery cells	Implementing stringent quality control protocolls, enahncing inspection procedures and provide adeguate training to manufacturing people	6	4	6	144

Process Step/Input	Potential Failure Mode	Potential Failure Effects	SEVERITY (1 - 10)	Potential Causes	OCCURRENCE (1 - 10)	Current Controls	DETECTION (1 - 10)	RPN	Action Recommended	Responsibility	Actions Taken	SEVERITY (1 - 10)	OCCURRENCE (1 - 10)	DETECTION (1 - 10)	RPN
What is the process step or feature under investigation?	In what ways could the step or feature go wrong?	What is the impact on the customer if this failure is not prevented or corrected?		What causes the step or feature to go wrong? (how could it occur?)		What controls exist that either prevent or detect the failure?			What are the recommended actions for reducing the occurrence of the cause or improving detection?	Who is responsible for making sure the actions are completed?	What actions were completed (and when) with respect to the RPN?				
2) Battery cell manufacturing	Equipment malfunction	Production delays or quality issue	7	Equipments breakdowns which cause wear and tear	6	Advanced automation and maintainance control	6	252	Implement preventive maintenance programs, conducting regular equipment inspection.	Production Manager: day to day operation to ensure that maintaining the equipment functional	Advanced monitor system was installed on critical manufacturing equipment to continuous track performance	6	7	6	252
3) Assembly and Integration	Errors during the Assembly	Improperly connections of the battery cells	8	Human error due to the lack of training	8	Visual inspection and automated scan	8	512	Robotic automation and replacing human error	Operational manager: Have an overall responsibility for the efficient and effective function of the production	The organization will receive the right training to ensure that the robots and human will be fully prepared for a proper assembly techniques	4	5	6	120
3) Assembly and integration	Thermal management installation	overheating on the thermal battery packs	7	Wrong cooling system and thermal insulation	8	Thermal imaging technology	9	504	Conduct a comprehensive design review of the thermal management system to ensure it effectively dissipates heat generated during battery operation	Engineering Thermal Department: Engineering that will be responsible of the thermal management system of the battery.	Improving heat desseparations, optimization of airflow in the battery, enhance the temperature regulations within battery packs	5	5	7	175
3) Assembly and Integration	Incorrect installation of safety features	compromise the safety and reliability of the battery	5	compromise the structural integrity or insulation properties of battery packs	6	Track parameter of each assembly	8	240	Develop a standalization procedure for the installation of safety features, including the casing and insulation of the battery pack and	Production Manager: As the project manager inspect the assembly process, will ensure that the safety feature are correctly installed	Tesla will ensure that comprehensive training programs for assembly line workers and technician involved in the instation of safety features	4	5	6	120

Process Step/Input	Potential Failure Mode	Potential Failure Effects	SEVERITY (1 - 10)	Potential Causes	OCCURRENCE (1 - 10)	Current Controls	DETECTION (1 - 10)	RPN	Action Recommended	Responsibility	Actions Taken	SEVERITY (1 - 10)	OCCURRENCE (1 - 10)	DETECTION (1 - 10)	RPN
What is the process step or feature under investigation?	In what ways could the step or feature go wrong?	What is the impact on the customer if this failure is not prevented or corrected?		What causes the step or feature to go wrong? (how could it occur?)		What controls exist that either prevent or detect the failure?			What are the recommended actions for reducing the occurrence of the cause or improving detection?	Who is responsible for making sure the actions are completed?	What actions were completed (and when) with respect to the RPN?				
4) Transportation and Logistics	Transportation delays	Accidents and labour strikes	8	storms, earthquakes and labour strikes such as truck drivers	7	Tesla has an advanced tracking system to check on the location and the status shipments.	7	392	Work closely with transportation providers to assess potential risks and vulnerabilities in the supply chain. Identify critical transportation routes, modes, and dependencies that could be affected by disruptions.	Supply Chain Management teams: conducting risk assessment to identify the potential transportation vulnerabilities and disruptions	Risk assessment and analysis to identify the potential transportation vulnerability and disruptions considering relative factors like weather and labor strikes	6	7	7	294
4) Transportation and Logistics	Improper storage of battery pack during the transportation	Physical and degradation damage	6	performance and reliability, leading to potential warranty claims or product recalls.	8	Tesla conduct regular quality checks to detect physical damage of the battery	6	288	Implementing robust packaging design specifically design to protect the battery pack	Transportation department: Ensure that the battery are covered with the right materials.	Implementing specialized packaging and handling procedures to ensure the safe transport of battery packs.	5	5	6	150
4) Transportation and Logistics	Inaccurate documentation	Delays in the cross border shipments	5	Delays or rejection of shipment in Tesla's supply chain	6	Tesla performs audits of transportation documentation, including shipping manifests, customs paperwork, and regulatory compliance documents.	7	210	Ensure that all shipment documentation, including invoices, packing lists, and customs declarations, is thoroughly reviewed	Logistic Coordinator: Responsible for coordinating shipment documentation, ensuring compliance with customs regulations	Provide training sessions and educational materials to relevant staff members involved in preparing shipment documentation. This training should focus on understanding customs regulations, proper documentation procedures, and compliance requirements	6	5	6	180

In the context of Tesla's supply chain analysis, Table 1 describes the brainstorming session conducted before the FMEA to identify potential risks and vulnerabilities. While Table 2 presents the comprehensive FMEA analysis undertaken for Tesla, outlining fundamental failure modes and associated risks across various supply chain stages.

Throughout the FMEA process, numerous actions were recommended to mitigate identified risks and reduce the Risk Priority Number (RPN). However, it is essential to acknowledge that certain factors, such as natural disasters, may lead to unpredictable RPN values. With the appropriate teams' involvement, proactive measures have been implemented to effectively address and minimise the remaining risks.

Steps to make the supply chain more resilient

Six main Steps for the Resilience of Tesla's International Supply Chain

To ensure the resilience of Tesla's international supply chain, it is essential to address critical issues and implement strategic measures to enhance its power. Here are six main steps evaluated in detail:

1) **Supplier Collaboration and Relationship Management:**

Tesla's primary focus should be prioritising a solid relationship with the supplier and establishing new communication channels. Recent research on collaborative innovation indicates a tangible increase in practical application beyond academic interest. Integrating Open Innovation (OI) into innovation management is vital. Numerous manufacturers and industries, including renowned firms, have recognised the benefits of adopting open and transparent innovation practices. (Ettabaa, et al., 2019).

Additionally, digital technologies can significantly enhance supply chain partnerships and foster sustainability collaboration. A lean management approach is also essential to increase efficiency and benefit the supply chain. For Tesla, collaboration can mitigate the risk of supplier failures by promoting transparency and enhancing the quality and sustainability of operations. (Beltagui, 2022) (Montecchi, et al., 2021).

2) **Supply base rationalisation**

To streamline operations and reduce supplier numbers, Tesla should carefully select suppliers with a proven track record of reliability. Many suppliers dominating the production of power batteries hold a monopoly, leading to inflated purchasing costs for electric vehicle manufacturers (EVMs). Consequently, some EVMs have adopted diversified sourcing strategies to avoid dependence on a single supplier.

By sourcing components from multiple suppliers across different regions, Tesla can mitigate the risks of supply chain disruptions caused by geopolitical tensions, natural disasters or supplier bankruptcies (Chen, et al., 2023). However, Tesla's primary focus remains on ensuring flexibility within its supply chain. Additionally, the company

consistently maintains relationships with several suppliers for its parts, enabling agile responses to challenges (Sypko, 2022):

QT2: *“This gives Tesla the control and agility to change things quickly and not be dependent on a strict supply chain”*(Sypko,p.34).

Moreover, one example of preventing inventory management shortages is following the closed-loop supply chain (CLSC). According to Hasani et al.(2014), cited in Giancesello et al. (2017), creating an agile and resilient CLSC can improve the adaptability and flexibility of use when emerging opportunities in the market. CLSC focuses on recovering, recycling, and reusing products and materials, thereby minimising waste generation throughout the supply chain. By closing the loop and reintegrating materials back into the production process, CLSC reduces the reliance on virgin resources, as shown in Figure 3 (Giancesello, et al., 2017).

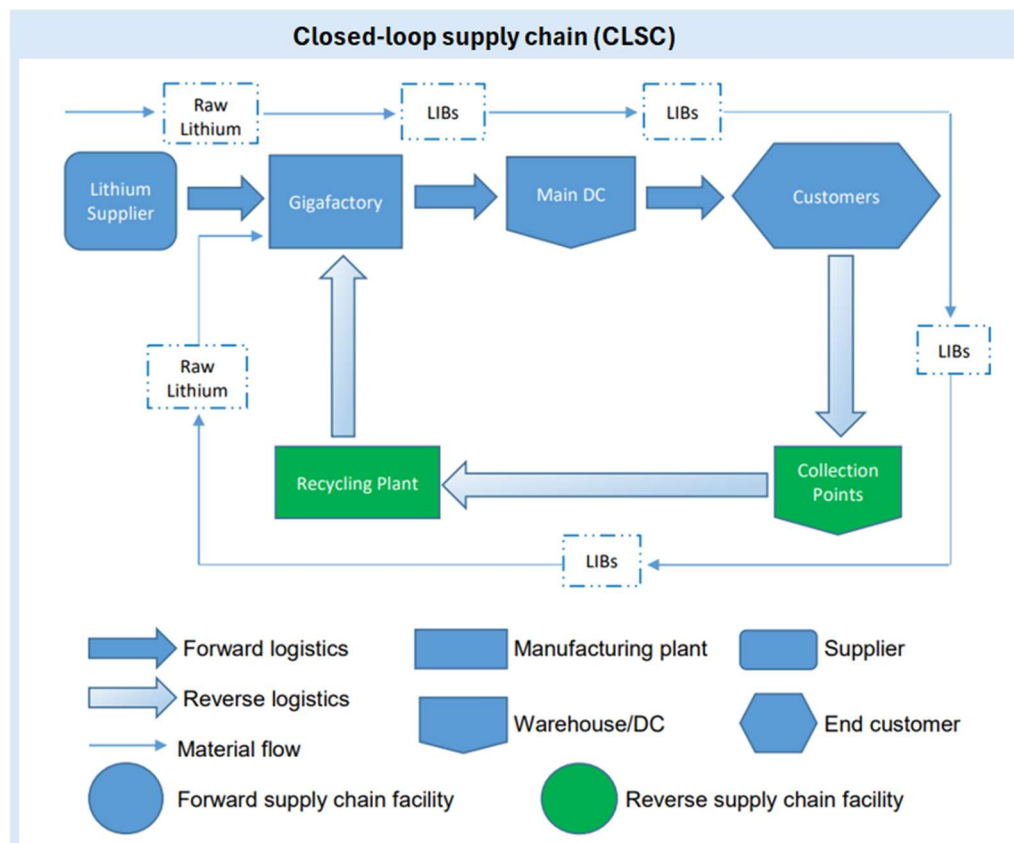


Figure 3. The framework of the CLSC for LIB (p.262)

3) Postponement strategies

Delaying customisation or final assembly until customer demand is accurately known is a core aspect of postponement strategies. There are four primary types: labelling, packaging, assembly, and manufacturing (Schwartz & Voß, 2014). Tesla ensures

alignment with consumer demand by employing a production-to-order approach, maintaining fewer vehicles in stock than traditional automakers. One example is that Tesla must implement postponement strategies like Just-in-Time (JIT) to reduce inventory holding costs, minimise the risk of excess inventory, and respond effectively to changing market demand (Susanto & Ellitan, 2024).

4) Supply chain Agility

Managing supply chain risks, including supplier reliability, geopolitical tensions, and transportation disruptions, is imperative for maintaining the flow of raw materials and components essential for Tesla's production. (Ionela-Roxana, et al., 2021). Enhancing supply chain visibility is vital for identifying potential risks, allowing monitoring of supplier performance, and ensuring end-to-end transparency.

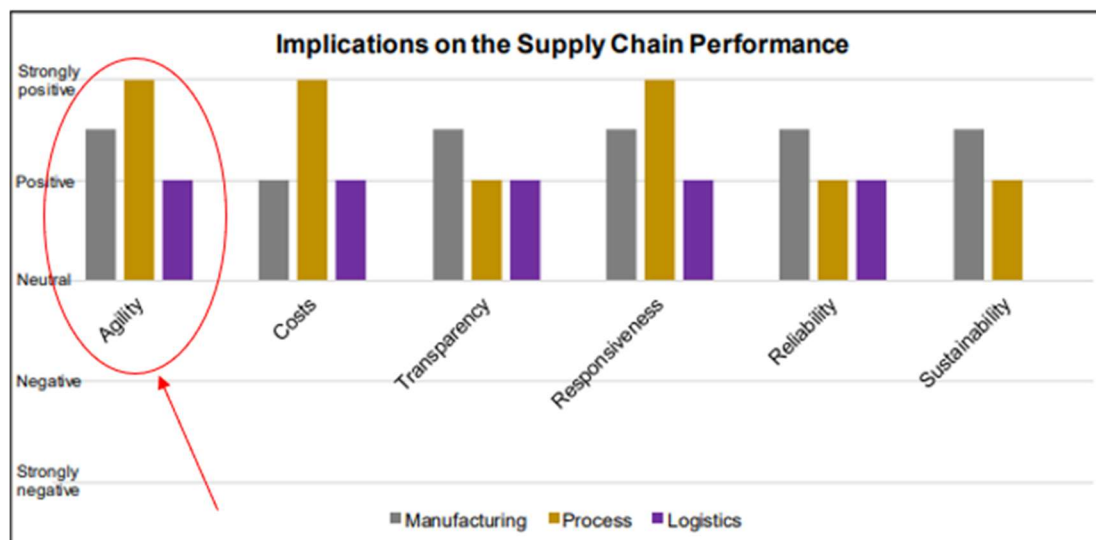


Figure 4. Implement of the Supply Chain Performance (Sardesai et al., 2018,p.53)

While Supply Chain Performance encompasses various critical factors such as Cost, Transparency, Responsiveness, Reliability, and Sustainability, the author highlights Agility as the most important, as shown in Figure 4. Agility empowers Tesla to tackle disruptions proactively, capitalise on opportunities, and sustain competitiveness in the dynamic automotive sector (Sardesai, et al., 2018).

To enhance quality control measures in the manufacturing process, the primary example is the adoption of Total Quality Management (TQM), which emphasises the importance of improving process and system performance. Adopting TQM principles in Tesla can

enhance the quality and efficiency of their manufacturing operations (Mohd, et al., 2012).

5) Supply chain Visibility

The technological core holds significant value across four key dimensions: extending visibility and traceability, digitalising and streamlining the supply chain, enhancing data security, and enabling smart contracts. Tesla could leverage Internet-of-Things (IoT) and blockchain technologies to track and trace products effectively throughout the supply chain. The primary example is the implementation of Blockchain technology, in particular, which offers a foundational framework for shared data infrastructure that updates in real-time and executes transactions rapidly using computer algorithms, eliminating the need for third-party intermediaries (Wang, et al., 2019).

Therefore, the blockchain can be summarised as (Wang, et al., 2019):

QT3: " Within the financial sector, the blockchain is proposed as a means for the management of financial transactions without the need for trusted intermediaries such as banks" (Wang et al., 2019,p.62).

Tesla must enhance visibility within its supply chain to anticipate disruptions, optimise inventory levels, and make informed decisions, ultimately improving supply chain resilience (Martini, 2021).

6) Supply chain Velocity and Acceleration

Supply chain velocity refers to the speed at which the product can flow from the supply chain, from the raw material sourcing to delivery to the final consumer at a high-velocity market. For example, Tesla is working on a low price to activate the required demand, where lithium-ion battery manufacturing has a fundamental part, producing more lithium-ion batteries each year compared to 2013 (Bruijl, 2017).



Figure 5. Stock measurements of Tesla 2023/2024 (Nasdaq, 2024,p.1)

Figure 5 illustrates the latest updated measurement of Tesla’s stock performance, spanning over one year. The author highlights a peak at the end of July and the beginning of August. However, since the trend of Tesla’s stock has been declining since the end of January, it is now crucial for the company to focus on acceleration, as emphasised by the author post-February 2024 during the downward trends. Tesla should prioritise accelerating key supply chain processes, such as order fulfilment, production lead time, and transportation (Chen & Perez, 2018) (Nasdaq, 2024).

Providing recommendations

To enhance the resilience of Tesla’s supply chain, strategic actions should be considered, including investment in the necessary technology and building flexible sourcing. Here are some practical recommendations that Tesla should consider:

- 1) **Anticipate Distribution with a Business Continuity Plan:** Tesla should develop a comprehensive business continuity plan that incorporates anticipation, preparation, robustness, and recovery strategies to mitigate potential disruptions in its supply chain. Techniques like Multi-Criteria Decision Making (MCDM) can aid in systematically evaluating criteria and prioritising actions. For instance, MCDM can help quantify the impact of potential disruptions and prioritise mitigation efforts effectively (Namdar, et al., 2021).

- 2) **Build Resilience Through Flexibility:** While Tesla's profitability rises, the company must also prepare for scenarios where demand might decline, necessitating cost-cutting measures, including transportation costs. In addition, the company must reduce inventory management and logistics operations to be adaptable to market conditions and disruptions.
- 3) **Sourcing Decisions:** it is crucial for Tesla, given its reliance on raw materials, to improve demand forecasting accuracy, optimise inventory management, and enhance responsiveness to customer demands. By implementing advanced forecasting techniques, leveraging data analytics, and utilising IT tools, Tesla can better anticipate market fluctuations and align sourcing decisions accordingly (The_Economist, 2010).

Conclusion and suggestions for further work

Financial Issues

As a leading global automotive company, Tesla must conduct a thorough financial analysis to assess the potential impact on its economic performance. Tesla must explore various risk management strategies to mitigate the effects of future disruptions. This may involve evaluating the feasibility of insurance coverage for supply chain disruptions or considering alternative financial resilience measures. Prioritising cost-effective measures to enhance financial resilience should be a top priority. This could include diversifying the supplier base to reduce dependence on a single source, establishing contingency funds to mitigate unexpected expenses, or optimising inventory management to minimise working capital.

Legal Issues

Reviewing and potentially renegotiating existing contracts with suppliers and partners is essential for Tesla to ensure legal protections in future disruptions. Evaluating the legal implications of supply chain disruptions on contractual obligations, liabilities, and compliance requirements is vital. Close collaboration with the legal department is necessary to identify potential risks and develop effective mitigation strategies. Proactively addressing legal risks associated with disruptions can help Tesla avoid costly litigation and protect its reputation in the long run.

Environmental Issues

Assessing the environmental impact of resource utilisation, emissions, and waste generation resulting from disrupted operations is critical for Tesla. The company must prioritise improving environmental sustainability within its supply chain. This could involve implementing Circular Economy principles, such as adopting best practices, investing in eco-friendly technologies, or integrating environmental criteria into supplier selection processes. Educating workers and stakeholders to enhance the recycling process of lithium is also essential to minimise environmental impact.

Ethical Issue

This ethical issue should consider the effects on employees, suppliers, customers, and affected communities. Implementing ethical sourcing practices throughout the supply chain is paramount to ensuring fair treatment of workers, responsible resource management, and the protection of human rights.

In conclusion, the Failure Modes and Effects Analysis (FMEA) has offered valuable insights into potential risks and vulnerabilities across Tesla's operational stages. However, to effectively address these challenges and bolster resilience, the following key actions are recommended:

1. Enhancing quality control measures in the manufacturing process through Total Quality Management (TQM) initiatives.
2. Improving logistics infrastructure and implementing Just-in-Time (JIT) inventory management practices alongside a Closed-Loop Supply Chain (CLSC) approach.
3. Leveraging data analysis and leveraging the benefits of blockchain technology to enhance transparency and efficiency in supply chain operations

Continued vigilance and adaption to evolving challenges will ensure Tesla's continued success and resilience in navigating uncertain futures.

References

- Baumhöfer, T., Brühl, M., Rothgang, S. & Sauer, D., 2014. Production caused variation in capacity aging trend and correlation to initial cell performance. *Journal of Power Sources*, pp. 332-338 (Accessed: 16 April 2024).
- Beltagui, A. N. B. a. G. S., 2022. Sustainability and the digital supply chain. *In The Digital Supply Chain*, pp. 397-417 (Accessed: 12 April 2024).
- Bernhart, W., 2019. *Challenges and opportunities in lithium-ion battery supply..* s.l.:Ali Eftekhari .
- Bruijl, D., 2017. Tesla Motors, Inc.: Driving digital transformation and the digital ecosystem.. *Inc.: Driving Digital Transformation and the Digital Ecosystem*, pp. 3-28 (Accessed: 10 April 2024).
- Chen, Y., Chen, G., Xu, J. & Duan, H., 2023. Sourcing diversification: Strategy selection, sourcing allocation and brand power.. *Computers & Industrial Engineering*, p. 109307 (Accessed: 10 April 2024).
- Chen, Y. & Perez, Y., 2018. Business model design: lessons learned from Tesla Motors. *Towards a sustainable economy: Paradoxes and trends in energy and transportation*, pp. 53-69 (Accessed: 10 April 2024).
- Deng, Z. et al., 2020. Ultrasonic scanning to observe wetting and “unwetting” in Li-ion pouch cells. *Joule*, pp. 2017-2029 (Accessed: 2 April 2024).
- Ellram, L., 1991. Supply-chain management: the industrial organisation perspective. *International Journal of Physical Distribution & Logistics Management*, pp. 13-22 (Accessed: 11 April 2024).
- Ettabaa, R., Bouami, D. & Elfezazi, S., 2019. Open innovation in the automotive industry. *In 2019 8th International Conference on Industrial Technology and Management*, pp. 115-121 (Accessed: 5 April 2024).
- Gianesello, P., Dmitry, I. & BATTINI, D., 2017. Closed-loop supply chain simulation with disruption considerations: A case-study on Tesla.. *International Journal of Inventory Research*, 4(4), pp. 257-280 (Accessed: 15 April 2024).

- Ionela-Roxana, P., BOȘCOIANU, M., VRĂJITORU, E. S. & BOȘCOIANU, E., 2021. Procurement in Automotive Industry. *Recent Journal*, p. 64 (Accessed: 12 April 2024).
- Jones, B., Nguyen-Tien, V. & Elliott, R., 2023. The electric vehicle revolution: Critical material supply chains, trade and development.. *The World Economy*, pp. 2-26 (Accessed: 15 April 2024).
- Lambert, F., 2018. *Tesla launches 'door-to-door service' called 'Tesla Direct' to help with Model 3 delivery during rush week.* [Online] Available at: <https://electrek.co/2018/09/22/tesla-direct-door-to-door-service-model-3-delivery-rush-week/> [Accessed 31 March 2024].
- Liang, D. & Li, F., 2021. Risk assessment in failure mode and effect analysis: improved ORESTE method with hesitant pythagorean fuzzy information.. *IEEE Transactions on Engineering Management*, pp. 2115-2137 (Accessed: 10 April 2024).
- Liang, D., Li, F. & Chen, X., 2023. Failure mode and effect analysis by exploiting text mining and multi-view group consensus for the defect detection of electric vehicles in social media data.. *Annals of Operations Research*, pp. 1-36 (Accessed: 10 April 2024)
- Liu, Y., Zhang, R., Wang, J. & Wang, Y., 2021. Current and future lithium-ion battery manufacturing. *Science* (Accessed: 2 April 2024).
- Martini, F. D., 2021. *Supply chains and disruptive events: An inventory management system perspective.*, Venezia: Master's Degree.
- Mohd, A., Salleh, N., Kasolang, S. & Jaafar, H. A., 2012. Review study of developing an integrated TQM with LM framework model in Malaysian automotive industry. *The TQM Journal*, 24(5), pp. 399-417(Accessed: 16 April 2024) .
- Montecchi, M., Plangger, K. & West, D., 2021. Supply chain transparency: A bibliometric review and research agenda. *International Journal of Production Economics*, p. 108152 (Accessed: 6 April 2024).
- Namdar, J., Torabi, S., Sahebjamnia, N. & Pradhan, N. N., 2021. Business continuity-inspired resilient supply chain network design.. *International Journal of Production Research*, pp. 1331-1367 (Accessed: 2 April 2024)

- Nasdaq, 2024. *Tesla, Inc. Common Stock*. [Online] Available at: <https://www.nasdaq.com/market-activity/stocks/tsla> [Accessed 15 April 2024].
- Sardesai, S., Kamphues, J. & Parlings, M., 2018. *Next generation technologies for networked Europe—Report on future scenarios generation*, s.l.: EU-Programm Mapping the path to future supply chains, NEXT-NET project report D, 2 (Accessed: 12 April 2024).
- Sathish, S., 2013. *Case Study of Tesla*, s.l.: Maastricht School of Management.
- Schwartz, F. & Voß, S., 2014. Postponement strategies in supply chain management.. *Journal of the operational research society*, pp. 796-797 (Accessed: 1 April 2024).
- Shao, X., Wang, Q. & Yang, H., 2021. Business Analysis and Future Development of an Electric Vehicle Company. *Psychology Faculty Publications*, pp. 395-402 (Accessed: 14 April 2024).
- Stamatis, D., 2003. *Failure mode and effect analysis*. s.l.: Quality Press (Accessed: 1 April 2024).
- Susanto, M. & Ellitan, L., 2024. Unveiling the Tesla Touch in Supply Chain Effectiveness.. *International Journal of Research*, pp. 71-90 (Accessed: 11 April 2024).
- Sypko, D., 2022. *Time-based Competition in Tesla's Supply Chain in the Era*, s.l.: Degree programme: International Business.
- Tesla, 2023. *ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934*. [Online] Available at: <https://ir.tesla.com/flysystem/s3/sec/000095017023001409/tsla-20221231-gen.pdf>. (Accessed: 1 April 2024)
- The_Economist, 2010. *Resilient supply chains An Economist Intelligence Unit report*. [Online] Available at: https://graphics.eiu.com/upload/eb/Oracle_Supply_Chain_WEB.pdf
- Thompson, A., 2023. *Tesla's Operations Management: 10 Decision Areas, Productivity*. [Online] (Accessed: 5 April 2024) Available at: <https://panmore.com/tesla-motors-inc-operations-management-10-decisions-areas-productivity>. (Accessed: 4 April 2024)

Voelcker, J., 2013. *First Tesla Model S fire Caused by Collision With Road Debris*. [Online]
Available at: https://www.greencarreports.com/news/1087393_first-tesla-model-s-fire-caused-by-collision-with-road-debris

Wang, Y., Han, J. & Beynon-Davies, P., 2019. Understanding blockchain technology for future supply chains: a systematic literature review and research agenda.. *Supply Chain Management: An International Journal*, pp. 62-84(Accessed: 15 April 2024) .