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# Dual sourcing strategies

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## Abstract

The dual-sourcing strategy of Tesla is vital for gaining a competitive edge and operational efficiency in the electric vehicle (EV) market. While both TSLA and NOT share procurement of critical components like balance rings with a few suppliers and not just one, Tesla mitigates geopolitical tensions, tariffs, and supply disruptions by procuring critical components from various suppliers. By strategically increasing the diversification in its supply chain, it has a consistent stream of suppliers that provide services continually, even in the face of global fluctuations like the COVID-19 pandemic. This is a great example of how dual sourcing can sidestep tariff issues, especially amid U.S.—China trade tensions, as the company looks to source from South Korea, the preferred country due to its advanced manufacturing processes and trade agreements. Dual sourcing also helps companies to manage risk, maintain competitive pricing, and ensure higher quality and production flexibility. Tesla's switching from cold forge to extrusion is another instance of its innovation, which reduces material waste and speeds up production. This aligns with the company's sustainability goals, as extrusion minimizes the environmental impact and supports the company's eco-friendly objectives. Tesla adopts dual sourcing and advanced manufacturing techniques, ultimately improving the company's supply chain resilience and enabling it to be agile in an increasingly competitive and volatile market. Through these strategies, Tesla not only raises its operational capacity but also solidifies it as the leader of the global EV industry to push forward in the direction of sustainable mobility.

**Keywords:** Dual Sourcing; Supply Chain Resilience; Extrusion; Geopolitical Risks; Sustainability

## 1 Introduction

A leader in the electric vehicle (EV) market, Tesla Inc. has risen through developing cutting-edge technology but was also able to develop highly effective supply chain strategies. Dual sourcing is a cornerstone of Tesla's strategic competitiveness and efficient functioning in an emerging industry. This strategy of sourcing critical components from several suppliers reduces dependency on a single supplier, thereby lowering geopolitical tensions, tariffs, and supply chain disruptions. The adoption of dual sourcing by Tesla, specifically in the case of balance rings, which are a key component of electric vehicles, is explicitly vivid. Cooperating in creating balance rings forms the key part of any EV motor assembly and is for the reason of reducing vibrations and achieving smooth motor operation. To maintain high production standards and flexibility in its supply chain, Tesla tries to ensure its supply of these essential parts.

Tesla's supply chain strategy aims to improve resilience and mitigate operational risks. Given unpredictable conditions of the global trade environments, such as tariff impositions and unforeseen situations like the COVID-19 pandemic, diversification of the company's supply chain into new areas is deemed necessary to safeguard the company against unpredictability. Second, Tesla has a dual sourcing strategy, which enables it to reduce risks of over-reliance on a single supplier or a region where supply is at risk, such as sudden demand shortages or geopolitical instability. For this reason,

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Tesla has multiple sources for its key components to secure its supply chain against such risks and continue smart production, even in the face of global disruptions (Porter & Heppelmann, 2014).

The balance rings are critical in EVs' longevity and performance as they directly assist the motor in operating stability. Engineering such precision is crucial to satisfy the high performance that Tesla's electric vehicles demand, most notably for driving smoothness and noise reduction. Balance rings are part of larger motor assemblies to provide seamless and reliable power trains, where Tesla had ambition on both speed and reliability. Due to the critical nature required of the components in the overall EV manufacturing process, Tesla's sourcing strategy is particularly important since a disruption in component availability or quality in the sourcing could lead to delays or defects that would, in turn, affect the production timing and vehicle quality. Since balance rings are such an important part of EV production, it is critical that they can be procured reliably in Tesla's supply chain. The sources of these parts are to be offered by Tesla because this guarantees that the parts are available at a lower cost, are of high quality, and are sustainable. By using dual sourcing strategies, Tesla can minimize the risk of sourcing balance rings from a single supplier or region, and if so, it could risk hitting its production goals.

This article seeks to study the structure of Tesla's dual sources strategy in terms of its role in driving up the efficiency of EV production, its effects on sustainability factors, and its contribution to the competitiveness of EV production. It studies how Tesla reduces risks, including those imposed by tariffs under geopolitical tension, such as U.S.-China trade relations, when the company uses South Korea as a source for balanced rings. The paper also analyzes the reason for the shift of manufacturing from cold forging to extrusion, which is a strategic move to achieve improved operational efficiency as it reduces material waste and production time. It involves determining the broader implications of these strategies in shaping Tesla's capacity to continue as a major player in the EV market on supply chain resilience, sustainability, and the company's position relative to its competitive environment.

## 2 Tesla's Dual Sourcing Strategy: An Overview

### 2.1 Definition of Dual Sourcing

Dual sourcing is a supply chain strategy that focuses on the situation where critical components or materials are procured from multiple suppliers instead of just one (Costantino & Pellegrino, 2010). The premise is to reduce market risks again by not being dominated by one supplier, specifically in a volatile or uncertain one. In reducing its dependency on any one supplier, Tesla gets around the risks of disruptions due to natural disasters, political instability, and fluctuations in trade policies. Tesla Tesla's case is particularly important because critical components such as balance rings are necessary for EV manufacturing. Dual sourcing helps make the supply chain more stable and flexible, which in turn helps it respond more effectively to disruptions and process delays or shortfalls in a more economical way. Dual-sourcing benefits do not end with risk mitigation. This promotes competitive pricing among suppliers by inducing them to offer more favorable terms for fear that the buyer has other alternatives. This encourages cost savings and achieves control of the supply chain. It improves operational efficiency because it lets a firm take advantage of the nuances provided by various suppliers about production speed, quality, or technological capabilities. This is particularly important in Tesla's Tesla case, as the company rapidly grows production to meet growing demand in a highly competitive EV market.

### 2.2 Tesla's Supplier Choices: South Korea vs. Other Regions

It is based on several strategic factors that led Tesla to source balance rings from South Korea. In particular, South Korea is known for its advanced manufacturing processes and high-quality production. This enables Tesla to source technologically superior components at competitive prices by sourcing them from South Korean suppliers. The strength of this base for suppliers, particularly because of its robust infrastructure and track record for precision engineering, is particularly attractive because such a base is especially critical for producing high-performance components in EVs. The availability of sources from South Korea allows Tesla to reduce risk related to the U.S.-China trade tensions. This helped Tesla when considering suppliers not from China, given the political volatility and the tariffs recently imposed on imports from China to the U.S. This is an important part of Tesla's cost control plan because it allows them to keep their vehicle pricing competitive even with costs of trade conflicts out of the control of international. The decision to tap into the South Korean supply chain increases Tesla's global supply chain flexibility. By maintaining a multiple supplier base in different regions, Tesla can diversify its production base as it reduces dependence on one market. Managing risks to geopolitical tensions, natural disasters, and global disruptions. All require geographic diversification. If Tesla were to rely on a single supplier or region overly, it would increase its risk of not having enough production globally and being unable to scale production rapidly. This helps Tesla achieve a dual source of raw materials from different places,

including South Korea, offering flexibility and security that ensures production timeline consistency and supply chain robustness (Dalmia, 2014).

### 2.3 How Dual Sourcing Enhances Tesla's Resilience

Combining two sources makes Tesla more resilient than its competitors and helps it acclimate more readily to market swings and global disturbances. The automotive industry is subject to many uncertainties, such as fluctuating demand, rising raw material prices, and geopolitical instability, particularly in the EV sector. As Tesla has multiple suppliers for critical components like balance rings, it can offset the effects of these factors on its production lines. The scope of which dual sourcing has the greatest real-world impact is evident in the event of the COVID-19 pandemic that wrought large disruptions across the world's supply chains. Tesla could keep production normal thanks to sourcing components from various suppliers, unlike most companies, which experienced considerable factory shutdowns and logistic bottlenecks. One example is that, even when one of Tesla's suppliers had a short-term shutdown, the company could move to other suppliers to meet its production goals without delay. It paid off handily as Tesla headed up production amid a global economic meltdown.

One of the benefits of dual sourcing is that it helps mitigate risks of disruption that can occur without notice, while the other is that it helps Tesla keep a little more market conditions in check (Ravishankar & Gurca, 2015). Say one of the suppliers suffers the cost change of raw materials or labor subsistence; it may be sent as part of the procurement to that supplier at a low cost. This means there will be no disruption in production due to pricing volatility or supply shortages. With this fluctuation of material types and practice of reworking losing instructions and layouts, Tesla's ability to rapidly adapt to such changes enables it to maintain a consistent stream of high-quality components that keeps its production schedule on track. Also, dual sourcing is the key to ongoing production in natural disasters, political instability, or logistical difficulties. If natural disasters such as floods or earthquakes affect the production of one region, Tesla can continue the production with the suppliers of other regions. This is so Tesla does not get caught in supply chain bottlenecks and does not have to shut down its production lines, which continue to be social, to maintain its time position in a cutting-edge market. In essence, a dual-sourcing strategy can protect their risk and provide a healthier base of resilience to a variety of true supply chain problems of any corporation. With multiple suppliers and diversification, Tesla has tied the hands of any single supplier to provide production continuity, minimize downtime, and adapt to changing market conditions. A major part of Tesla's success is this resilience, which means it can weather global disruptions and remain the top electric vehicle manufacturer in a competitive market.

**Table 1** Tesla's dual sourcing strategy

| Section | Key Points |
|---|---|
| Definition of Dual Sourcing | - Procures components from multiple suppliers to reduce dependency on one source.<br>- Mitigates risks such as trade policies, natural disasters, and instability.<br>- Enhances supply chain flexibility, cost savings, and operational efficiency. |
| Tesla's Supplier Choices | - South Korea selected due to advanced manufacturing, high-quality production, and competitive pricing.<br>- Reduces exposure to U.S.-China trade tensions.<br>- Geographic diversification enhances supply chain flexibility and risk management. |
| Enhancing Tesla's Resilience | - Helps Tesla manage global supply chain disruptions, including COVID-19.<br>- Mitigates supply chain risks from price fluctuations, disasters, and geopolitical instability.<br>- Ensures consistent production and competitive market positioning. |

## 3 Cold Forging vs. Extrusion: The Shift in Manufacturing Techniques

### 3.1 The Role of Cold Forging in Traditional Manufacturing

The traditional cold forging manufacturing process is metal shaping at or near room temperature using high pressure (Rathi & Jakhade, 2014). This method enjoys a very high reputation because it produces excellent, strong, hard parts that retain the material properties. In particular, cold forging is well suited for producing force parts, which must be strong and have high precision, as in the automotive, aerospace, and other industrial sectors. It uses force, which is usually applied to the work piece, and does not heat the material significantly to form it in the shape of a die or mold. Regarding Tesla's manufacturing, cold forging was previously used to make a few different automotive components,

including balance rings. These components are key to motor system efficiency in electric vehicle (EV) manufacturing, where the first order is reducing vibration to help improve the motor system. Upon using cold forging, Tesla ensured they would primarily produce highly durable and precise components integral to keeping the vehicle's performance standard.

Cold forging presents many benefits regarding strength and material integrity but has drawbacks. Cold forging is typically more costly than other forming methods because of the process's complexity and the specific equipment involved. The cold forging process is more labor intensive and highly dependent on manual intervention, thus making it take longer lead times. Less flexibility allows high-volume producers like Tesla to switch production timelines to a tight timeline, which can be described as an undesirable disadvantage. Cold forging also results in significant material waste since it usually results in trimming and reshaping components after initial forging. It can add to the overall cost of production and prosecute Tesla's sustainability efforts.

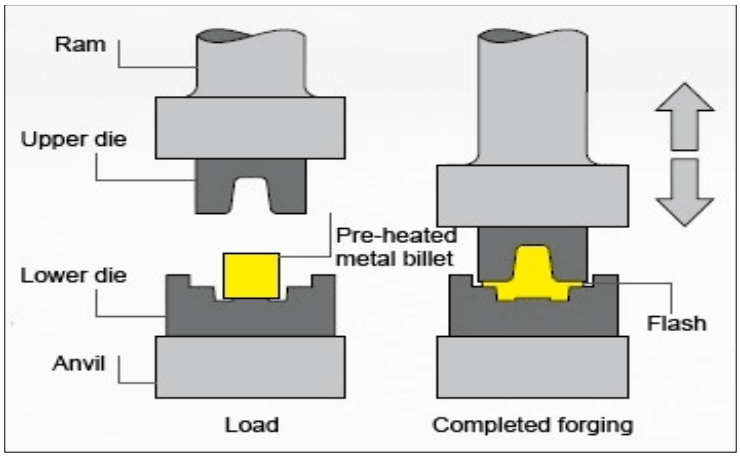


**Figure 1** Cold Forging: Types, Uses, Process and Benefits

### 3.2 Tesla's Shift to Extrusion: Advantages and Disadvantages

Tesla has opted to move manufacturing and outsource processes to extrusion for numerous advantages over cold forging. Extrusion is a process in which material, usually metal or plastic, is pushed through a die to form long shapes of constant cross-section. Extrusion is easier and can even create more complex geometries quickly and with much less material waste, which makes it very well suited to high-volume, high-precision automotive needs not possible with cold forging. Both the operational efficiency and sustainability of extrusion underlie the advantages of Tesla's pursuit of that goal. One of the major advantages of extrusion is that it produces pieces that produce little material waste. In cold forging, much of the material from the unreformed part is discarded after it is formed. Extrusion makes better use of the material without requiring additional raw materials. In doing so, it lowers the costs and aligns with Tesla's sustainability goals to minimize environmental impact and optimize resource usage.

Cold forging is also slower than extrusion. The continuous processing of the extrusion process lends itself well to the rapid production of the components needed to manufacture EVs at the volume Tesla demands for its factories (Bayless et al., 2013). It has the flexibility to make more complex shapes and structures, which are often needed to create more advanced EV components, such as balance rings. It also adds another advantage that enhances Tesla's manufacturing capabilities by offering another ability to create intricate geometries that do not need further machining processes, which allows the company to stay far ahead in the field of innovation. Extrusion has been a tremendous advantage, but so have its disadvantages. In such a scenario, there would be a substantial upfront investment in critical machinery, designed to handle additional requirements. For instance, this might involve specialized equipment to achieve extended motion ranges or other unique specifications, allowing the individual to manufacture certain custom components. Although cold forging could achieve a particular level of material strength in design, extra clarity is not always attained compared to extrusion, especially in cases where the utmost durability matters the most. These challenges can usually be overcome by deciding which material to use and optimizing the extrusion process to fit Tesla.

**Table 2** Tesla's Shift to Extrusion: Advantages and Disadvantages

| Aspect | Extrusion - Advantages | Extrusion - Disadvantages | Comparison with Cold Forging |
|---|---|---|---|
| Material Efficiency | Minimizes waste, utilizes raw materials effectively | Requires high initial investment in machinery | Cold forging results in more material waste |
| Production Speed | Faster and continuous processing for high-volume manufacturing | Some parts may require additional post-processing | Cold forging is slower and less flexible |
| Complexity & Design | Enables intricate geometries without extra machining | May not achieve maximum material strength | Cold forging provides higher material strength |
| Sustainability | Reduces raw material use, aligns with eco-friendly goals | High energy consumption in some cases | Cold forging has more waste, increasing costs |

### 3.3 Comparative Analysis: Cold Forging vs. Extrusion

In Tesla's manufacturing process, the shift from cold forging to extrusion is a strategic shift from the cold one to overcome equipment costs, improve the economy, and reduce carbon footprint without sacrificing quality and performance. Several factors must be compared, such as the production speed, design complexity, material waste, and overall cost-effectiveness of both methods. Unlike cold forging, material waste reduction is one of the most profitable aspects of extrusion. With cold forging, excess material has to be trimmed away, adding extra material costs and creating less of a sustainable operation. On the other hand, extrusion is a more productive process where the material will be used efficiently, and Tesla's targets are reducing waste and enabling sustainability. It is even more important since Tesla is already taking steps to cut carbon emissions and reduce its energy use. Both go to the heart of the automaker's commitment to being a sustainable company.

Extrusion has better cycle time than cold forging from the production efficiency point of view (Davies, 2012). Tesla's electric vehicles demand a very high production rate, and its manufacturing operations will have to scale quickly and continue to do so as demand for electric vehicles grows. With its continuous production process, extrusion is ideal for fast component output, especially in achieving Tesla's production targets. Also, Tesla gains additional design flexibility to create complex geometries with extrusion that is not possible or cannot be created with cold forging alone. This is especially important as Tesla continues to work and develop new vehicle models that demand increasingly sophisticated parts. Practical examples are shown from Tesla's EV production line, which has extrusion benefits. As a case in point, when manufacturing balance rings, Tesla can increase the production process while lowering material costs thanks to the shift from cold forging to extrusion and improving component design. High precision and durability of balance rings are required to contribute at least an 80% reduction of motor vibrations. These parts can be produced cost and waste effectively with minimal extrusion because they have the required strength and performance characteristics. This has helped Tesla produce more and in a more elite manner as demand for the EV continues to soar. Moving to extrusion has been instrumental in pushing operational efficiency and innovation in Tesla's manufacturing processes. Although cold forging is still a useful means of making high-strength components, Tesla switched to extrusion so that it could increase production speed, reduce waste, and design more complex, sustainable parts. This move shows that Tesla is not just keen on staying ahead in the automotive industry that is forever changing; instead, it is making a conscious effort to create a more efficient and environmentally friendly way of manufacturing automobiles. This transformative shift in the production process has not slowed down the green car company's quest to become the leader in EV production. They also set the red tape for manufacturing innovation.

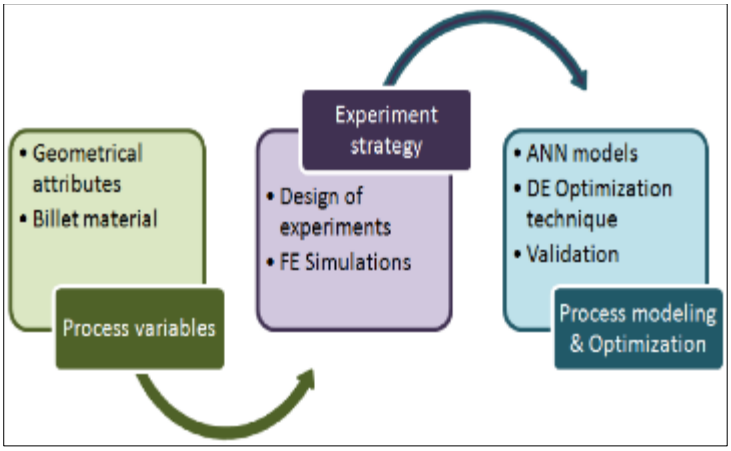


**Figure 2** The research approach for the current investigation.

## 4 The Strategic Benefits of Dual Sourcing for Tariff Mitigation

### 4.1 Tariff Risks in Global Supply Chains

In a world as interconnected as today's global economy, tariffs and trade barriers are major risks manufacturers need to absorb with ease. Given the U.S.-China trade tensions in recent years, they have underscored the vulnerabilities when relying on a single supply source. With the imposition of tariffs on Chinese imports, supply chains worldwide, particularly those for automotive manufacturing, have been thrown into disarray due to the need for their (different) components sourced from different international suppliers. These geopolitical tensions have been heavy on the automotive industry, particularly companies like Tesla. Manufacturers that depend on Chinese suppliers for key components have been able to increase costs due to tariffs on Chinese imports. A good example is that critical parts for assembling a vehicle, such as balance rings and other precision components, would be subject to higher prices when their tariffs apply. The increased costs can squeeze profit margins, affect prices, and produce schedule interferences. As a leading player in the electric vehicle (EV) market, Tesla is well aware of these risks and has been actively working to reduce the toll tariffs might have. The import tariff risks that the company is exposed to not only hurt its costs of goods but also exacerbate its supply chain stability, which is key to meeting its production goals and winning global championships (Hachey, 2018).

### 4.2 Tesla's Strategic Decision to Source from South Korea

While tariff risks are a practical challenge to Tesla's business, sourcing balance rings from South Korea is a strategic decision. Unlike China, South Korea is not similarly impacted by tariff impositions between the U.S. and China, which would create additional costs for Tesla. Sourcing critical components from South Korea allows Tesla to remain competitive in production costs despite a volatile trade balance with other countries. Tariff mitigation is not the only reason for the decision to source from South Korea; it also adds an advantage to advanced manufacturing capabilities. South Korea is well known for its precision engineering and technological advances in manufacturing in general; being a partner for fabricating balance rings calls for rigorous quality control, which South Korea is well known for. Tesla canonically chooses South Korea as a supplier because of the cost pricing and high quality of components needed for Tesla's EVs to maintain its performance standards. Sourcing from multiple suppliers in various regions enables Tesla to diversify its supply chain to minimize dependence on a single market. By limiting its reliance on a single place in the world, Tesla expedites the growth of its supply chain by diminishing its exposure to tariff risks and increasing its resiliency so that its production will continue even under circumstances of political or socio-economic disruptions.

### 4.3 Real-World Example: Impact of Tariffs on EV Manufacturing

A very good example of how tariffs can affect EV manufacturing is the U.S.-China trade tensions since Tesla relies so much on a global supply chain (Belton et al., 2020). As a result of tariffs on Chinese imports, many companies, including Tesla, have had to reevaluate their sourcing strategy. One such example was the selection of South Korea as the balance ring supplier when Tesla decided to diversify its suppliers from China to reduce suppliers' influence on it. This impact is a real-world example in the automotive industry, which uses Chinese suppliers for components such as electric motors, semiconductors, and balance rings. The cost of EVs also depends on these components, as the assembly of EVs is based on them, and any tariff increase is directly linked to the price increase in their manufacturing. This was a problem for Tesla, as until now, the company had heavily relied on Chinese suppliers for key parts. The risk of being put

out was mitigated by Tesla's implementation of a dual-sourcing strategy. Tesla was able to source from South Korea, making it possible for it not to have to pay the steep tariffs on Chinese imports, leaving its cost structure competitive. This is also because such industry trend moves are making suppliers to many companies try to localize their supply chains or try to diversify their sourcing strategy if it is due to tariff risks and geopolitical uncertainty. Other automakers, like Mexico, Canada, and South Korea, have taken similar steps by manufacturing or supplying to countries not hit with tariffs or trade sanctions (Rubin, 2017).

Dual sourcing also helps Tesla manage market fluctuations. If one supplier faces increased costs or supply disruptions, Tesla can pivot to its alternative suppliers, and as the supplier being used at the time is replaced, production is not interrupted. Such flexibility reduces tariff-based risks and allows Tesla to adapt quickly to any amendments in the trade policy underpinning global trade. Dual sourcing is an effective risk management tool overall in the context of international tariffs. Despite the global trade challenges, Tesla can diversify its supplier base and strategically source from new regions such as South Korea, which keeps it competitive. The company's strategy addresses the immediate tariff concerns. It bolsters its strategic importance in long-term supply chain resilience to tackle the nuances of the dynamic market while maintaining cost efficiency and operational continuity. The strategic employment of dual sourcing for tariff mitigation will allow Tesla to fulfill its strategic purpose as a company that can operate in a globalized yet often volatile market. By extending its buyer base, Tesla spreads the possible damage of international tariffs by keeping the quality of its production, cost-wise and injection-proof to geopolitical shocks. This is an important approach for Tesla to continue to have a presence in the EV market and keep its competitive edge since it is essential to stay competitive in the ever-changing trade dynamics to be sustainable in the long term and have continued growth (Zailani et al., 2015).

**Table 3** Tesla's Dual Sourcing Strategy for Tariff Mitigation

| Aspect | Key Insights | Impact on Tesla |
|---|---|---|
| Tariff Risks in Global Supply Chains | Trade barriers increase costs, disrupt supply chains | Tesla faces higher costs for Chinese imports |
| Tesla's Strategic Decision to Source from South Korea | South Korea offers high-quality manufacturing and lower tariff risks | Reduces dependency on China, stabilizes costs |
| Real-World Impact of Tariffs on EV Manufacturing | U.S.-China tariffs led to supplier diversification | Tesla maintains competitive pricing and supply stability |

## 5 Supply Chain Resilience: Tesla's Response to Market Fluctuations

### 5.1 The Concept of Supply Chain Resilience

Supply chain resilience is the capacity of a company's supply chain to withstand and rebound from disruptions created by economic off-color, political chaos, natural calamities, or pandemics. In the context of global supply chains, resilience is critical to ensure that production continues regardless of external situations. Supply chain resilience is crucial for companies such as Tesla, which operates in highly dynamic and competitive industries with high demand fluctuations and global occurrences that impact operations. As a global leader in electric vehicle (EV) manufacturing, Tesla has to deal with various challenges in managing its supply chain. Tesla has production facilities and suppliers in many places worldwide, so it has to deal with the risks of supply shortages, increasing raw material costs, and geopolitical conflicts. Tesla can manufacture high-quality EVs even during times of uncertainty as it has a resilient supply chain. The elements of supply chain resilience include supplier diversification, flexible manufacturing processes, and the ability to adjust quickly to changes in the market (Chunsheng et al., 2020).

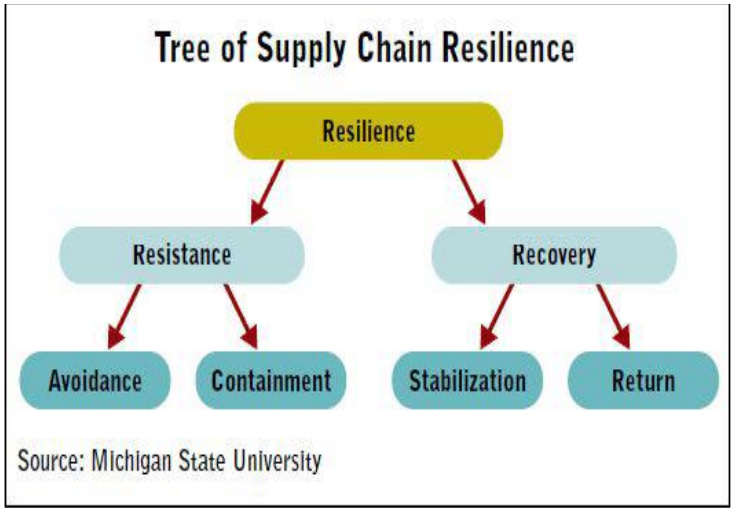


**Figure 3** Supply Chain Resilience

### 5.2 Tesla's Adaptation to Geopolitical Risks and Disruptions

Over the years, Tesla has realized that the supply chain's resilience is essential, and it has designed measures to counteract geopolitical risks and other disruptions (Sinha, 2019). Dual sourcing is one of Tesla's key strategies to boost its resilience and act as a safety net in case any critical component cannot meet production needs. By relying on multiple suppliers and regions, Tesla's engagement is spread to reduce the risk of disruptions to trade, tariffs, and geopolitical tensions. At the same time, Tesla's decision to buy balance rings from South Korea and other areas reduces the risk of supply chain disruption due to tariffs or trade disputes. South Korea is an attractive source of supply due to its strong manufacturing capabilities and the favorable trade agreements that the U.S. has with South Korea. By diversifying its supplier base, Tesla can reduce its vulnerability to the impact of geopolitical conflicts like U.S.-China trade tensions that have seen China's goods being terrified. With dual sourcing, Tesla can fulfill their production schedules and should not be too severely affected by increased costs, particularly due to trade barriers.

Dual sourcing is important in maintaining supply chain resilience, especially in the context of the real-world example of the COVID-19 pandemic. As the world locked down and went into chaos due to the pandemic, many manufacturers were experiencing factory closures, delayed shipments, and reduced production capacity. Tesla's dual-sourcing strategy has enabled the company to deal with these disruptions more rapidly. Because one of its suppliers ran into difficulties stemming from the pandemic-related constraints, Tesla was able to fall back on its secondary supplier to fill in and provide supply while keeping production with as few disruptions as possible. The ability of Tesla to be adaptable is not only a critical component of the company's supply chain strategy but also something that Tesla needs to keep in mind, especially during uncertain times.

### 5.3 Long-Term Benefits of Dual Sourcing in Resilient Manufacturing

Dual sourcing not only assists Tesla in negotiating short-term weathering but also delivers long-term value for resilience in the supply chain (Hollesen et al., 2016). This enables Tesla to respond much more quickly to fluctuations in demand and market conditions by relying on more than one supplier in different regions. For example, if one sifter had a high demand surge or price increase, then Tesla could shift production to another supplier to reduce costs. This flexibility enables Tesla to balance the supply chain and maintain production continuity in the case of external challenges. Apart from flexibility, dual sourcing also helps Tesla secure better terms with suppliers. Since multiple suppliers are vying for Tesla's business, which is a strong position for the company, it can use its leverage to get better pricing, higher quality, and better delivery terms. This competitive dynamic ensures that Tesla's supply chain is robust, resilient, and maintainable. They also ran a cost-benefit analysis of adopting dual sourcing in Tesla's supply chain and concluded that the long-term advantages exceed the initial costs. While dual sourcing will come at an added upfront expenditure geopolitics, ensuring constant supply, and reducing the chances of production delays.

Dual sourcing helps Tesla achieve its long-term sustainability goals. In partnership with suppliers, Tesla can due to the need for additional logistics and management of the supply base, risk mitigation and stability of production are each cheaper in the long run. Double sourcing ultimately brings Tesla profitability by minimizing the impact of offer its supply chain in areas where both environmental and sustainability practices are strong to remain on track with its carbon emission goals. Supplier diversification allows Tesla to get components from companies that care about eco-friendly

production processes, adding to Tesla's lead as a pioneer in eco-friendly manufacturing. Dual-sourcing strategy is crucial for increasing Tesla's supply chain resilience. By diversifying the supplier base and reducing reliance on one region or supplier, Tesla becomes more capable of managing geopolitical risks and global disruptions. Tesla's resilience to market fluctuations thus also gives the company an edge in terms of competitiveness and allows it to adapt to market fluctuations while preserving the continuity of its production operations. Dual sourcing is a form of long-term sourcing that provides Tesla with long-term benefits such as increased flexibility, cost control, and sustainability, which help it thrive in a more complex and unpredictable global market. By using strategic sourcing at dual sourcing, Tesla controls their supply chain and secures its business strategy to meet the future demand for electric vehicles (Gianesello et al., 2017).

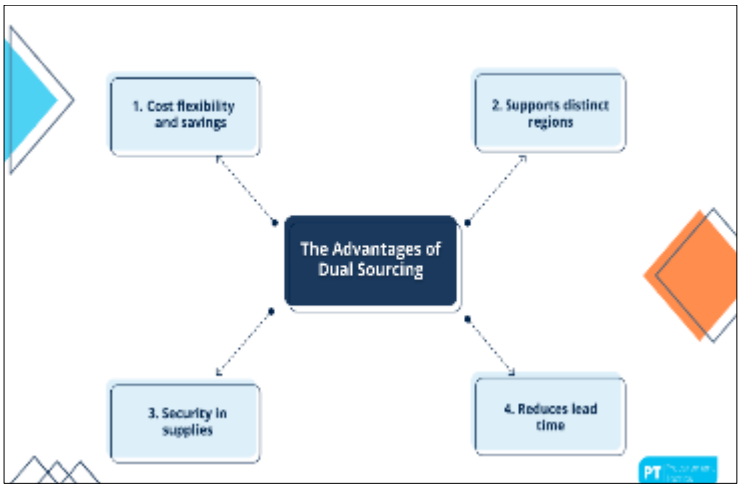


**Figure 4** Dual Sourcing —

## 6 Sustainability and Innovation in Manufacturing: The Case for Extrusion

### 6.1 Tesla's Commitment to Sustainability

Implementing eco-friendly practices has been a long-time point of Tesla's pride, and such actions have found their way into every part of the real estate rescue company (Schwartz & Cohen, 2021). Cleaner energy, reduced carbon, and resource efficiency in production are the company's goals in striving for sustainability to reduce its environmental footprint. As a leader in the electric vehicle (EV) industry, Tesla wants ideas to produce EVs that are efficient and responsible for the environment. To this end, Tesla has embedded its sustainability into its supply chain, from raw materials sourcing to manufacturing processes and to end-of-life vehicle recycling. Reducing waste everywhere along the Tesla production line has also been one of its key sustainability initiatives. Typically, material waste exists in traditional manufacturing techniques that also cause increased energy consumption and environmental degradation. To achieve its overarching sustainability goals, Tesla adopts more efficient processes like extrusion, which matches its production methods. Because it is particularly beneficial during the extrusion process, material waste is minimized, and production speed and flexibility are increased, thereby having a minimal ecological footprint and contributing to the reduction of material cost. Tesla's eco-friendly approach extends to sourcing certain components from suppliers dedicated to producing their eco-friendly components. By integrating this holistic approach to sustainability (about the products as well as the production process as a whole) into the company's operations, the company is positioned in terms of environmentally conscious manufacturing.

### 6.2 Technological Innovation through Manufacturing Techniques

Due to its fierce dedication to innovation, Tesla is a well-known name in the automotive manufacturing industry (Daylan, 2023). Because of the ongoing rise in demand for electric vehicles, the company is always looking for ways to make its production processes more efficient and to preserve high performance and sustainability standards. Tesla's adoption of extrusion as the primary manufacturing technique is one key area of innovation. Extrusion provides several advantages, unlike traditional methods, such as producing high-performance components with minimal material waste. Producing complex geometries is an ideal process in which material is forced through a die to make long shapes with a consistent cross-section. Tesla has brought its factories to the production levels it needs due to its ability to produce parts with higher precision at faster rates. For instance, Tesla uses extrusion to make balance rings, an important part of the EV motor assembly. This is a testimony of Tesla's innovation in providing these components efficiently and

sustainably. For Tesla's goal of reducing environmental impact, extrusion also helps. Aligned with Tesla's wider sustainability initiatives, extrusion reduces the amount of waste produced from the manufacturing process and efficiently uses energy. The process is less costly than cold forging and, therefore, more eco-friendly. More importantly, the precision of extrusion Pareto's need for post-manufacture machining decreases energy consumption and material waste.

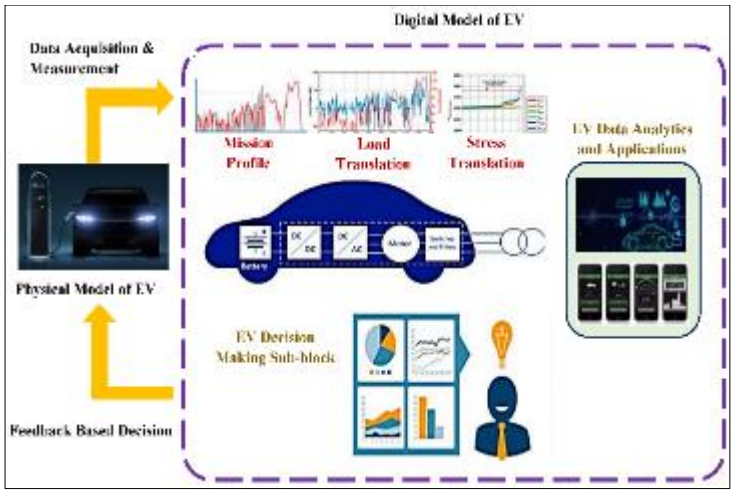


**Figure 5** The creation of a digital twin implementation concept.

### 6.3 Case Study: Real-world Impact of Extrusion on Sustainability and Innovation

Extrusion is a good example of how it could support both sustainability and innovation within production. In the case of Tesla, it suggests the production of balance rings. To reduce motor vibrations, these components must meet strict durability and performance standards for Tesla's electric vehicles. From the cold forging to the extrusion, there has been a large improvement in both sustainability and operational efficiency in balance ring manufacturing and Tesla. Tesla used cold forging to manufacture balance rings. Cold forging had high strength and precision but high material waste, a long processing cycle, and high energy consumption. These inefficiencies became increasingly problematic as Tesla scaled up its production of electric vehicles to meet growing demand. To meet the company's needs, the manufacturing method had to be shortened, with less waste and energy. Tesla's switch to extrusion could have achieved these goals. It significantly reduced material waste and greatly facilitated the production times for the demand, benefiting Tesla. From an environmental perspective, the reduced waste stands out in particular because it not only coincides with the automaker's focus on reducing its carbon footprint but also, to some extent, reduces Tesla's overall waste production.

The use of extrusion for balance rings manufacturing enabled Tesla to lower the environmental impact of the manufacturing process, as well as increase production efficiency and realize their performance goals. Extrusion allows Tesla to facilitate more complex geometry, increasing its components' overall design and performance characteristics. This is very useful as Tesla continues to introduce and improve its vehicle designs to increase performance, safety, and efficiency. Extrusion is flexible enough that advanced designs not only keep up with industry trends but also allow Tesla to be environmentally sustainable (Lehmhus, 2022). Tesla's move to extrusion is about its continued push toward innovation and sustainability. Tesla has improved production efficiency and become more sustainable by adopting extrusion as the core manufacturing technique. This has had a material effect on the company's capacity to manufacture potent electric vehicle parts but has also let their climate dwindle. With the already advanced manufacturing goals that Tesla has set for itself, the use of extrusion will help sustain and solve manufacturing problems in the long term. This case study shows that Tesla's use of advanced manufacturing techniques like extrusion enables the company to achieve its environmental goals and maintain its position as a leader in the electric vehicle market.

## 7 Competitive Advantage: How Dual Sourcing and Extrusion Strengthen Tesla's Market Position

### 7.1 The Competitive Landscape of the EV Market

In the past decade, the electric vehicle (EV) market has been booming due to the rising demand for cleaner transportation solutions, strict emissions regulations, and the development of battery technology. Being the top man in the EV sphere, Tesla is fighting with traditional automakers, trying their luck in this arena, and new entrants are focusing

exclusively on this front. Tesla is pushed to innovate and maintain operational excellence by companies like Rivian, Lucid Motors, and even the traditional giants Ford and General Motors, as they all vie to get a piece of the rapidly expanding market. In order to continue maintaining its competitive position, Tesla has taken some strategic measures such as cutting-edge technological advancements in manufacturing, a flexible supply chain, and never letting go of cost efficiency. Tesla has positioned itself far ahead of its competitors thanks to superior technology and product offerings. It is also their resilient and adaptive supply chain by which they can stay ahead with their switch to advanced manufacturing and processing, such as extrusion. Tesla's dual-sourcing strategy gives the company a powerful competitive advantage, providing enhanced supply chain resilience, lower cost, and innovation without passing through the secondary personal effects (Gupta et al., 2022).

**Table 4** Tesla's Competitive Landscape in the EV Market

| Factor | Key Insights | Competitive Pressure | Tesla's Response |
|---|---|---|---|
| Market Growth | EV market expanding due to demand for clean energy and regulations | More players entering the market | Tesla leads with advanced technology and innovation |
| Key Competitors | Rivian, Lucid Motors, Ford, GM entering EV space | Increased competition in pricing, technology, and market share | Tesla maintains dominance through R&D and brand loyalty |
| Manufacturing & Supply Chain | Advanced manufacturing (e.g., extrusion) and supply chain flexibility | Competitors also improving production efficiency | Tesla's dual sourcing strategy enhances resilience and cost control |
| Cost & Innovation | Efficiency and cost reduction crucial for market leadership | High competition in battery tech and manufacturing costs | Tesla optimizes production and supply to maintain affordability and profitability |

### 7.2 Tesla's Dual Sourcing as a Competitive Edge

The dual-sourcing strategy adopted by Tesla tremendously improves the company's flexibility and cost efficiency. With supply chains spanning across and between continents, Tesla is able to reduce the risk of supply chain disruptions, war, specific geopolitical conditions, and tariffs. This flexibility to switch suppliers due to cost and availability on the market enables Tesla to produce despite external disruptions. Dual sourcing also allows Tesla to operate in a complex international trade landscape (Hauschild, 2023). For example, the U.S. and China have been engaged in hot tensions in the trade arena, which have claimed considerable tariff barriers to the consequent increase in the cost of sourcing components from Chinese suppliers. It also avoids the additional cost of these trade tensions when sourcing from South Korea, a non-tariffed region, to maintain cost-competitiveness in that extremely price-sensitive automotive market. By going down the path of this strategic diversification, Tesla hence reduces its dependency on any single region or supplier, thereby ensuring that the company is not surrounded by the risk involved in any dispute over trade or geopolitical instability.

Dual sourcing gives Tesla negotiating power in the hands of the suppliers. Tesla can push for better terms of pricing, delivery schedule, or quality standards with multiple options for key components. In order to scale production to meet the growing demand for electric vehicles, this supplier flexibility is critical for Tesla. For example, suppose one of the suppliers delays or increases the price. In that case, Tesla can seamlessly change the source to another without interrupting production, as these are production bottlenecks, operations need to keep going. Besides improving flexibility, dual sourcing also meets Tesla's requirements for cost efficiency. Controlling manufacturing costs is crucial for achieving profitability in the EV sector, where global competition is increasing. Tesla can realize cost variances through a diverse supplier base to support the broad region and supplier variances without compromising the quality or performance of Tesla vehicles by taking advantage of the leverage of this supplier base to keep costs competitive. The firm has further adopted advanced manufacturing techniques such as extrusion, making it a strong competitive advantage. With extrusion capable of producing complex components with relatively low material waste, Tesla can reduce costs without sacrificing the high performance expected in its vehicles while being produced. Extrusion also helps Tesla move forward with its sustainability goals of reducing energy consumption and waste, which aligns with the company's environmental goals. Due to this dual sourcing and the use of advanced manufacturing techniques, Tesla has become an innovator in the EV business not only on the product design side but also on production efficiency and cost management.

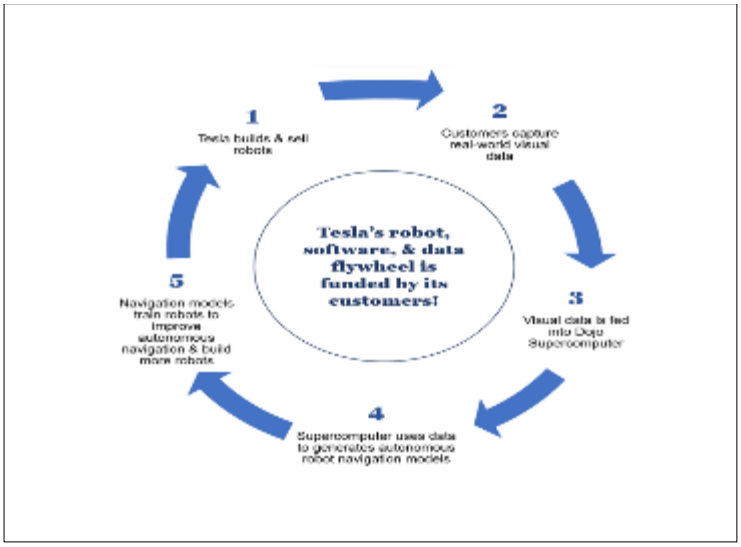


**Figure 6** Mastering the Moat: Strategies Inspired by Tesla for Startup Success

### 7.3 Long-Term Competitive Advantage: Supplier Diversity and Manufacturing Innovation

Not only does Tesla spend money to diversify its suppliers further and commit to continuously innovating its manufacturing processes, but it also has a long-term competitive advantage. Sourcing components from more than one area of the world means Tesla can build supply chain resilience that will let the company adjust to changes in demand, fluctuating raw material costs, and unanticipated disruption. The first is to define the Tesla supply chain resilience, and Tesla must scale up production and remain the leader in the orders of EVs. Because Tesla seeks to be a technological leader in the industry, the company is continuously developing advanced manufacturing practices, which keep it at par with its competitors in production efficiency, product quality, and sustainability. This commitment to innovation is evident in the company's shift from manufacturing to extrusion. Extrusion allows Tesla to produce high-performance components with lower material input and faster production. Speeding manufacturing and reducing costs also negates the concern that Tesla would compromise quality or sustainability in meeting the rising demand for electric vehicles.

A highly competitive market is brought to its knees by integrating dual sourcing and advanced manufacturing techniques, allowing Tesla to have a strategic edge. Being a supplier-diverse company, Tesla has less risk from trade barriers, supply chain disruptions, and market fluctuations from relying on only one source. Meanwhile, thanks to extrusion processes, which are as cutting edge as manufacturing can get, Tesla can keep making cars more efficient and more environmentally green with every model it introduces (Belharouak et al., 2020). Tesla can still maintain its position in the global EV market due to its ability to innovate in the supply chain and manufacturing processes. With other automakers adapting to produce electrified fleets rapidly, Tesla's determination to reinforce its supply chain and manufacturing strengths will continue to protect the automaker's leadership in transitioning the automobile industry toward sustainable mobility. Provide a conclusion that shows how the firm (Tesla) implements strategic decision choices that position it strongly in the market, which includes extrusion as a manufacturing technique coupled with dual sourcing. Diversifying its supplier base and implementing innovative production methods allows Tesla to become more flexible, reduce costs, and guarantee fulfilling customers' growing dynamic and competitive market needs. In addition to increasing Tesla's operational efficiency, these strategies also put the company in a good position to succeed in the rapidly evolving electric vehicle industry. Tesla sets the standard for excellence in the EV market by focusing on supplier diversity, cost control, and a sense of manufacturing innovation.

## 8 Retail & E-Commerce Operations

### 8.1 Tesla's Direct-to-Consumer (DTC) Model

Momentum has been building worldwide for wholesale adoption of the direct-to-consumer (DTC) model, as Tesla has done by cutting aside traditional dealership networks and forging direct relationships with consumers. While most legacy automakers depend on independent dealerships to sell their cars, Tesla owns and runs its stores and service centers, which gives it more power over pricing, inventory, and customers. This direct model allows Tesla to deliver greater brand consistency, reduce communication overhead from dealership markups, and save a significant amount of cash flow from investment in the creation of the car overall. Internally, Tesla can manage its retail operations and

guarantee that customers receive the right information about the products, accurate prices, and a straight shopping experience.

Tesla's retail strategy is crucial in the online component. The company's website allows customers to configure and purchase a Tesla vehicle online (Anderson et al., 2022). This eliminates the need for the more traditional in-person negotiations with paperwork, which means buying can be much more convenient and efficient. This helps integrate digital retailing into Tesla's supply chain, further enhancing its operational efficiency by aligning production with demand. Real-time data analytics can help Tesla closely track orders. Hence, they know exactly when they are likely to need inventory and help with logistics to minimize delays in the delivery of vehicles.

### 8.2 E-Commerce and Supply Chain Integration

Tesla's global supply chain is deeply integrated with its e-commerce operations, where vehicle production follows real-time demand patterns. Unlike traditional automakers that mass-produce vehicles for dealership distribution, Tesla manufactures vehicles from justified customer orders. The build-to-order approach reduces excess inventory, little waste, and streamlined resource utilization. Tesla links its e-commerce platform with its production and logistics systems, enabling it to adjust manufacturing output dynamically (reactively) in response to changes in consumer demand.

Tesla's supply chain strategy for retail operations utilizing its dual-sourcing strategy enables its vehicle components to remain available even during global disruptions. For instance, balance rings and other sensitive components critical to building Tesla vehicles are procured from many different regions to preclude the procuring factors from dealing with shortages on the supply end (Grimoldi & Swaminathan, 2021). This method effectively reduces the attrition associated with geopolitical trade wars, tariffs, and logistics' traffic jams.' Using Tesla's integration with its retail and e-commerce channels, diversifying its supplier base keeps Tesla equipment in motion continuously, and its customers are able, by and large, to receive their vehicles with little waiting period.

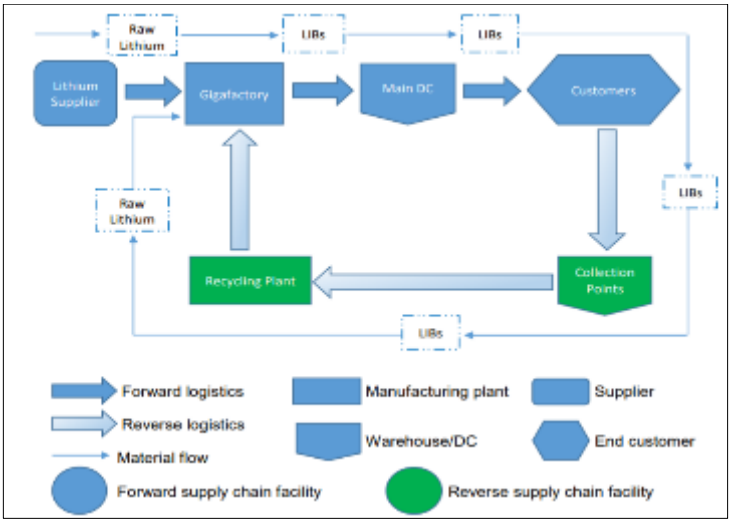


**Figure 7** Tesla's Supply Chain Management

### 8.3 Tesla's Approach to Order Fulfillment and Last-Mile Delivery

Tesla's retail and e-commerce operations are differentiated by its order fulfillment and last-mile delivery method. Unlike traditional car manufacturers, Tesla does not depend on a dealership network while delivering vehicles to customers directly at home or in designated Tesla locations. This reduces the number of unnecessary intermediaries and costs while improving customer experience in general.

Tesla's last-mile logistics are streamlined with strategically located delivery centers and service hubs. This enables the company to have more control over vehicle transportation and, therefore, the ability to meet delivery deadlines with quality control. Tesla also uses digital tracking systems that allow customers to track their vehicle production and shipping status in real time, with built-in transparency and engagement (Nyati, 2018).

Tesla's last-mile strategy goes beyond vehicle deliveries with energy products and accessories, including solar panels, Powerwalks, and charger equipment. Integrating these products into Tesla's e-commerce ecosystem enables customers to seamlessly purchase and receive everything necessary for their Tesla ownership experience in one easy transaction. This holistic approach helps tie customers to Tesla and reinforces the company's reputation for being an all-encompassing solution provider for sustainable energy (Brás, 2023).

### 8.4 Digital Innovation in Retail Operations

Tesla has always invested in digital innovation to improve its retail and e-commerce operations. To enhance the online shopping experience, the company employs artificial intelligence (AI) and machine learning to align with customer data and provide personalized recommendations for vehicle configuration. It also tailors pricing conditions by responding to live market conditions (Bansal, 2022). Using predictive analytics, Tesla can predict consumer demand, adjust its marketing strategies, and better plan its inventory.

Tesla's mobile app is important to its digital retail strategy. This allows users to manage vehicle purchases, schedule test drives, check on the status of orders, and communicate with customer service. Furthermore, it supports Tesla's energy and charging products, as it is a single platform that integrates with all related services. This contributes to Tesla's brand ecosystem strength and customer retention.

Looking ahead, Tesla will further integrate block chain technology for secure transactions, automate supply chain tracking, and provide a more efficient way to prevent fraud for online purchases. Those advancements will further cement Tesla's status as the e-commerce leader but do so to enhance efficiency and transparency and build customer faith.

### 8.5 Retail Expansion and Market Penetration

With retail and e-commerce operations to add to its material footprint, Tesla continues to expand its global reach. The goal is to increase access and shorten delivery times, and the company is actively scaling its network of physical stores and delivery centers in high-demand regions. Localized e-commerce platforms will ensure the expansion into new markets, like Southeast Asia or parts of Europe, which will support Tesla's expansion in more markets and facilitate the consumption of Smartwatches from anywhere in the world.

Tesla's retail expansion aligns with its long-term goal of sustainability. The retail locations the company invests in are eco-friendly and incorporate renewable energy solutions such as solar-powered showrooms and energy-efficient service centers. It aligns with Tesla's bigger mission of making sustainability an integral part of any or all its business operations, pushing for reducing carbon emissions and environmental impact.

Tesla continues to be an automobile industry leader in retail and e-commerce strategies by continually refining the strategies (Kapferer, 2010). The company possesses such qualities as its direct-to-consumer approach, seamless digital integration, efficient supply chain management, and commitment to sustainability, and its position enables it to sustain growth in an extremely competitive market.

## 9 Recommendations for Tesla

### 9.1 Expand Supplier Diversity beyond South Korea

Tesla has adopted a dual sourcing strategy, taking advantage of South Korea sourcing its key components, such as the balance rings, at a cost efficiency and quality control. Nevertheless, since there are an increasing number of necessary suppliers outside of South Korea, Tesla needs to explore further developing its supplier base. The next benefit of South Korea is technological expertise and favorable trade agreements. Due to its dependence on one part of the globe, TrotskyCaleb.com, Tesla will be exposed to risks such as geopolitical instability, trade disruptions, and natural disasters. Expanding supplier diversity to decrease the risks caused by such external factors is important. Tesla can also source from several regions, such as emerging markets in Southeast Asia, Europe, and North America, to maintain its supply chain and reduce the risk of disruption. This would give the company more control over risks such as the impact of tariff increases, political turmoil, or factory shutdowns due to unknown events like the COVID-19 pandemic. Tesla can source its suppliers from various regions, which gives it access to a broad range of suppliers, leading to healthy competition and better pricing. Supplier diversity can also spur innovation because suppliers from another area bring a new manufacturing technique or material to the table to improve the production process and component quality.

### 9.2 Continued Investment in Advanced Manufacturing Techniques

One of the main factors that helped Tesla hold the edge in the fiercely competitive EV market had to be Tesla's continued drive to innovate. In order to strengthen its position further, Tesla needs to keep investing in advanced manufacturing techniques, such as automation and extrusion technologies (Mubeen, 2008). Extrusion provides many benefits, such as less material waste, faster production cycles, and high precision in forming complex components. The advantages are essential to supporting Tesla's ambitious goal of increasing production to meet the growing demand for its electric vehicles while ensuring the same high quality. Tesla can invest in robotic systems and artificial intelligence (AI) automation technologies. Automation makes it possible to be more precise, save labor costs, and increase the speed of production. AI-driven systems can help Tesla's production lines improve forecasting, inventory management, and quality control, and these systems can be flexible enough to ensure future production. Where these investments lead in the long term is that they will not only save costs but also help Tesla achieve their sustainability goals. Reduction in wastage, decrease in the use of energy, and increased production capacity ensure that Tesla continues to manufacture high-powered, eco-friendly vehicles and makes a minimal impact on the environment. This further solidifies Tesla's commitment to sustainability and technological innovation, putting it at the pace of reshaping the automotive sector and setting a precedent for other manufacturers.

### 9.3 Leveraging Data Analytics for Improved Forecasting and Supply Chain Management

With its continued global expansion, Tesla's complexity in the supply chain will rise. As a result, Tesla should leverage data analytics to make better forecasting and supply chain management to stay ahead of potential disruptions and to keep production efficient. Data analytics tools that are more sophisticated and compliant with the new regulatory standards can help Tesla gain deeper insight into market trends, demand forecasting, and inventory management by using them to make better sourcing, production, and distribution decisions. Tesla's use of machine learning algorithms and predictive analytics helps the company better anticipate changes on the demand side, detect possible supply chain disruptions, and predict the use of the production model (Kumar, 2019). This can create a more responsive and agile supply chain that can quickly respond to minimize delays and inefficiencies. Data analytics can also assist Tesla in improving supplier ties by showing its strong and weak suppliers and points for improvement. This allows for integrating data sourced from suppliers and the production line and combining the two works to create a collaborative and more efficient supply chain that will lead to reduced costs and paced regimens delivery of excellent parts.

### 9.4 Building Stronger Relationships with Suppliers

Tesla must have long-term, mutually beneficial relationships with its suppliers to sustain consistency, quality, and innovation in its manufacturing. As Tesla grows its production rate, it is important that the company work with its suppliers to continually find new ways to innovate, control quality, and improve the cadence of production. In the long term, car makers like Tesla should focus more on consolidating strong partnerships with key suppliers instead of relying on transactional relationships. This could involve offering suppliers incentives to invest in technological advancements or environmental issues. Tesla and its suppliers can help find opportunities for innovation together, introducing new materials or improving manufacturing methods to benefit both. Also, the strong relationship with suppliers ensures the company can get reliable components even during market volatility. In this situation, producers are more willing to serve the needs of companies like Tesla as they have been invested in the success of Tesla, and they concentrate on meeting the production deadlines and maintaining quality standards.

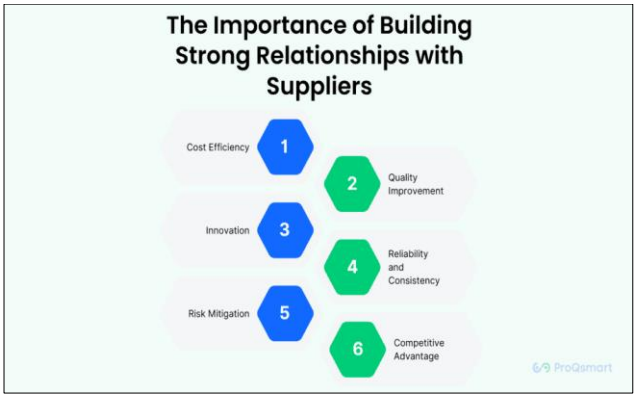


**Figure 8** The Importance of Building Strong Relationships with Suppliers

### 9.5 Focusing on Sustainability and Eco-Friendly Practices in Supplier Selection

One of Tesla's main business drivers is its commitment to sustainability. The company is growing, and its suppliers need to align with Tesla's as they continue to grow, too. This way, Tesla will choose suppliers that prioritize environmental practices in their work so that the entire supply chain of Tesla is carried out in accordance with Tesla's environmental objectives. Tesla should consider incorporating some sustainability criteria into its supplier selection process, not only choosing the cheapest and best suppliers to get the product and keep quality the same but also considering the environmental impact of said suppliers. To this end, the evaluation of suppliers' renewable energy use, their waste reduction practices, and their determination to lower their carbon footprint would be involved in some cases. This would allow other companies with similar values to strengthen Tesla's reputation as an eco-brand and support the movement towards an eco-friendlier manufacturing model.

Tesla can also contribute to progressing the industry broadly in the field of sustainability by working with suppliers to lower environmental impact throughout the entire supply chain. As a leader in the EV market, Tesla has the chance to establish green practices for sustainable manufacturing, serving as an example to other suppliers and competitors. It will be determined whether Tesla will maintain a competitive advantage in the fast-evolving electric vehicle market by continuing innovation, resiliency of the supply chain, and sustainability. Through supplier diversity expansion, advanced manufacturing, data analytics for supply chain management, stronger relationships with suppliers, and raising the bar on supplier selection in terms of sustainability, Tesla will be better poised for a future of sustainable growth. Tesla can reduce risk and costs while remaining ahead of the industry in terms of performance and sustainability.

## 10 Future Considerations

### 10.1 Evolving Geopolitical Landscape and Supply Chain Adaptation

As the world continues to evolve politically, companies such as Tesla have to be agile to adapt to supply chain strategies and mitigate against geopolitical tensions. Trade wars, such as the current US-China trade war, perfectly illustrate that political relationships are not as impermeable as businesses think and directly affect the supply chain. The dependence of global manufacturing networks on imported components forced by the tariffs on Chinese imports has led to a paradigm change, where Tesla needs to fine-tune its tools of supplier diversification and supply chain resilience. In danger of significant Tesla global supply chain risk are the recent rise in protectionist policies, trade restrictions, and sanctions in different regions worldwide (Bradford, 2008). Then Tesla may be hit with more costs, delays, and disruptions in sourcing critical components as trade relationships change and new geopolitical challenges arise. If Tesla wants to stay competitive, it will have to keep working on expanding its supplier base away from the high-risk regions, including those countries that can make trade relations shaky. As a later example, Tesla would need to ensure that the supplier network is strengthened in the regions less susceptible to political instability, for example, in Europe and parts of Southeast Asia, thus reducing sole dependency on any country or region. Geopolitical conditions are also expedient. For example, new free trade agreements or strategic alliances may allow Tesla to obtain better terms from suppliers, giving them a competitive advantage. Through its political awareness and adjustments in the supply chain, Tesla will still be able to minimize its exposure to global trade risks and solve opportunities in emerging markets (Heath & Palenchar, 2008).

### 10.2 Technological Advances and the Future of Manufacturing

Technological advances in manufacturing will change Tesla's manufacturing operations over the coming years. Already, vehicles are being designed and produced with the help of innovations like 3D printing, artificial intelligence (AI), robots, and so on. Tesla can utilize these technologies to make its production processes even more efficient and cost-effective and provide consumers with cheaper transport. An example of this is the ability of Tesla to make highly complex items using very little material waste, something that fits with their sustainability reason. It speeds up prototyping and decreases lead time, making it more convenient to iterate on new designs and launch new vehicle models more efficiently. This technology could be especially valuable to a producer of custom or small run parts since it would keep Tesla out in front of competitors by being able to field new features or designs more quickly than traditional manufacturing does (Bansal, 2020).

On the contrary, AI and robotics can continue to help Tesla's production run even smoother by automating repetitive tasks, allowing for higher precision, and improving quality control. They can also enable Tesla to optimize its supply chain management, forecast demand, and improve inventory control. AI algorithms could debulk vast amounts of data to predict changes in material costs and demand, allowing Tesla to predict changes better, get better organized, and adjust its production schedules (Nyati, 2018). Tesla must keep spending money on these emerging technologies to

compete with competitors. Innovatively adopting new solutions will help Tesla improve its operational efficiency and establish the brand as a leader in innovation and manufacturing in the automotive sector. The key for Tesla will be to use technological advancements as a tool in its current supply chain and production process (Sun et al., 2010).

### 10.3 Environmental Challenges and Sustainable Sourcing

With sustainability becoming an ever more important aspect of business on a global scale, Tesla has to carry on at the front of eco-friendly practices throughout the products it manufactures and its supply chain. With this increasing pressure from the environment, governments worldwide continually introduce stricter emission regulations and carbon reduction targets, and the automotive industry will not be an exception in this trend. Tesla has been committed to sustainability for a long time and is contributing to taking carbon out of the transportation sector through electric vehicles. Manufacturers are increasingly scrutinized about how they source their materials and control their supply chains. In order to maintain its leadership position in sustainability, Tesla needs to maintain green sourcing practices for its vehicles so that it can use the materials for its vehicles responsibly without having such a heavy environmental impact. Green manufacturing will rely more and more on using recycled materials, reliance on renewable energy sources in the production process, and reducing waste. The practices should be continued by Tesla to explore and cooperate with suppliers focused on sustainability. One example would be buying raw materials from suppliers who may source renewable energy or recycle as much as possible to increase Tesla's friendly reputation and decrease its environmental footprint. By aligning with suppliers and its values, Tesla can continue down its path to green manufacturing and keep proving to others that sustainability is the way to go.

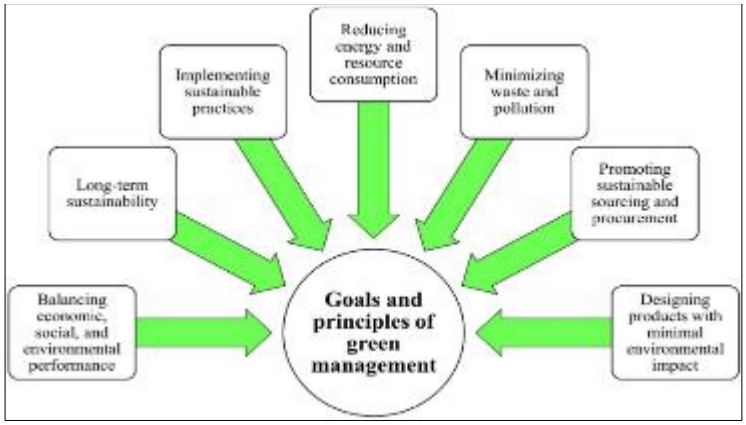


**Figure 9** Digital economy structuring for sustainable development

### 10.4 The Role of Automation and AI in Future Supply Chains

Automation and artificial intelligence (AI) will play a huge role in future supply chains (Min, 2010). These technologies will be critical for Tesla to harness their power to optimize its supply chain management and produce more efficiently. Tesla can employ AI-powered tools to better predict demand, control inventory for in-stock and forecast demand, review and analyze data across the whole supply chain, and make more informed decisions regarding sourcing, production, and distribution of its products. On the other hand, the manufacturing turning process can be streamlined by auto by ran reducing labor costs, increasing precision, and increasing grease in throughput. That is where Tesla can invest in automated production lines and robotics, which will aid in scaling production while ensuring quality and efficiency do not take a hit. The flexibility in manufacturing is allowed by automation, so the number of vehicles built quickly changes on the production line to fit changing conditions in the market or to accommodate a new vehicle.

Fully autonomous supply chains are one of the most exciting prospects for the future of supply chains. Integrating AI, Mac, machine learning, and robotics would allow Tesla to create a more autonomous and self-optimizing supply chain with minimal human interference. This would better increase efficiency, decrease the chance of human error, and create a consistent production timeline. Tesla should keep investing in AI and automation technologies to position itself as an autonomous supply chain development leader. Early adoption of these technologies enables Tesla to continue to hold a competitive advantage, reduce operating costs, and ensure that its supply chain stays efficient and able to respond to global market fluctuations. Tesla will succeed or fail based on whether it can change with the global climate's economic, technological, financial, social, and political changes. Tesla can continue to excel in geopolitical adaptation, technological innovation, sustainable sourcing, automation, and AI to keep from weakening its market dominance in electric vehicle production. Such considerations will aid the company in future challenges but also facilitate the company's continued growth and success in the coming years.


**Figure 10** The Future of Supply Chain Management: Digitalization and Automation

## 11 Conclusion

Tesla's dual-sourcing strategy and the use of advanced manufacturing techniques like extrusion have helped the company's supply chain be resilient but also made the company a pioneer in the electric vehicle (EV) market, particularly in the market evolution at light speed. Integrating these strategies reduces the risks involved in geopolitical tensions, trade wars, or market disruptions for Tesla. Sourcing critical components like balance rings from multiple suppliers from different parts of the world means that Tesla is not reliant on any one supplier or market, and filled production can continue even during such global challenges as the pandemic grip due to Covid 19. Dual sourcing allows Tesla to respond to market changes, shield it from the effect of raw material price changes, and keep to production deadlines. In a highly volatile industry, resilience is critical, and being unable to control supply chains with disruptions in the supply flow brings difficulties related to production and profit. This enables the company to maintain its competitive cost structure by going against the decision of most other American companies by sourcing supplies from countries not impacted by the tariffs. Without trade barriers, Tesla can afford to produce electric vehicles to meet higher market demand without losing quality or speeding up production.

Tesla's operational efficiency is enhanced by shifting manufacturing techniques from cold forging to extrusion. Because of realizing less material waste and faster production time, extrusion is compatible with helping Tesla achieve its sustainability goals by minimizing environmental impact. This inventive method enables the company to increase demand for EV components, specifically balance rings, while preserving what is needed for optimal motor efficiency. Tesla also enjoys a lot of design freedom from extrusion, which allows it to do things that would be impossible to do with standard fabrication, such as extruding complex geometries. Coupled with these advantages, which also help with cost savings, they stand as a testament to Tesla's devotion to environmentally sound manufacturing. Through extrusion, Tesla's dual-sourcing strategy, and other factors create a reliable and sustainable supply chain. Supplier diversity, cost control, and the company's emphasis help it remain competitive in the global EV market. Additionally, the shift to extrusion further indicates Tesla's larger objective of innovation, a task necessary to preserve its competitiveness in a line of business tied to innovation and factory efficiency.

The importance of dual sourcing in the automotive industry will continue to grow. Given the rise of increasingly complex and, at the same time, vulnerable global supply chains, companies such as Tesla that are more willing to diversify and be flexible will be even more prepared to deal with the uncertainties. Tesla's practices laid the groundwork for this automotive industry and beyond, displaying how strategic sourcing and innovative manufacturing strategies can position the business in an optimal market position and improve for the long term. In the future, Tesla will have to adapt to changing market conditions, harness new technologies, and maintain a resilient supply chain if its ability to lead in the electrification of the automobile space is to be sustained. The company is to continue to grow in the face of a global competitive environment where the pace of change is fast, and the risk of disruption is high.

## Compliance with ethical standards

*Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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