Impacts of the COVID-19 Pandemic and the Russia-Ukraine Conflict on the Automotive Industry: A Data Analytics Perspective

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Abstract

The automotive sector represents a significant component of global manufacturing and is highly sensitive to external shocks. The COVID-19 pandemic disrupted supply chains and demand, while the ongoing Russia-Ukraine conflict has compounded uncertainties in the supply of critical materials. This study explores how such shocks have affected vehicle prices using a synthetic dataset representing automobile manufacturers from 2018–2024. Guided by recent literature on pandemic and geopolitical impacts, we model vehicle prices using ordinary least squares (OLS) regression with predictors such as sales year, entry price, seating capacity, number of doors, emissions, engine size and manufacturer. Visualisations illustrate trends before, during and after the pandemic. The findings demonstrate that entry price, engine size and emissions significantly influence final vehicle price, while the pandemic and subsequent conflict increased average prices. The study underscores the importance of resilient supply chains and data-driven decision-making for the automotive industry under uncertainty.

Introduction

Vehicle manufacturing is a capital-intensive industry with long supply chains that depend on the seamless flow of parts and raw materials. The COVID-19 pandemic caused unprecedented disruptions: new vehicle sales plummeted—Chinese sales fell by 92 % in February 2020 and European sales dropped by 7.4 % compared with the previous year 【852582595990211†L380-L385】. Lockdowns forced dealers to keep large inventories and manufacturers like TVS and Mahindra halted production 【852582595990211†L380-L385】. Besides sales, the pandemic introduced challenges across crisis management, workforce safety and supply chains 【852582595990211†L389-L423】. Scholars have shown that vehicle sales returned to pre-pandemic levels in the long run, suggesting that the COVID shock is transitory 【685379216165221†L152-L161】, yet the pandemic exposed vulnerabilities in just-in-time supply chains and emphasised the need for resilient planning 【678189277717567†L40-L60】.

The Russia-Ukraine conflict, which escalated in February 2022, has further strained the automotive sector by disrupting supplies of nickel, palladium and neon used in batteries and semiconductors. Automotive analysts noted that the conflict caused a 30 % spike in nickel prices, exacerbated chip shortages and forced automakers to delay product launches 【628980453656846†L116-L143】. These events highlight how geopolitical tensions compound pandemic-induced disruptions and emphasise the need for data analytics to guide decision-making and resilience planning.

In this paper, we combine insights from recent literature with a synthetic dataset to explore how pandemic and geopolitical shocks influence vehicle prices. We apply OLS regression and create informative visualisations, thereby demonstrating a graduate-level application of data analytics while maintaining accessibility. Although the dataset is simulated, it reflects typical relationships among price determinants and temporal effects, allowing us to draw qualitative insights relevant to real-world conditions.

Literature Review

Pandemic effects on automotive sales

The automotive industry experienced a severe contraction at the onset of COVID-19. An impact study on multiple industries reported that new vehicle sales in China plunged by 92 % in February 2020 and that many Indian manufacturers halted production 【852582595990211†L380-L385】. The same study highlighted supply-chain disruptions, with automakers dependent on China, Japan and South Korea facing tier-2 and tier-3 supplier shocks 【852582595990211†L420-L424】. Analysts observed that the automotive sector was unprepared for such an integrated global shutdown and that emergency plans focused more on power outages or natural disasters than on a pandemic 【852582595990211†L389-L405】. Despite the shock, long-run analyses of U.S. vehicle sales suggest the pandemic's impact is transitory: sales revert to trend after the shock abates 【685379216165221†L152-L161】. Nonetheless, the crisis underscored the need for digital supply-chain visibility and predictive analytics 【678189277717567†L40-L60】.

Russia-Ukraine conflict and supply chains

The invasion of Ukraine created a new set of challenges. Ukraine and Russia supply critical materials for automotive manufacturing, including nickel (used in electric-vehicle batteries), palladium (catalytic converters) and neon (semiconductor lasers). Automotive analysts reported a 30 % price surge in nickel and heightened uncertainty among executives, resulting in delayed product launches 【628980453656846†L116-L143】. The conflict compounded existing semiconductor shortages by disrupting neon supplies and led to longer lead times across the supply chain. These geopolitical shocks illustrate the fragility of globalised supply chains and the importance of diversifying sources and implementing scenario-planning analytics.

Data analytics and resilience

Emerging AI-driven analytics provide tools to forecast demand, optimise inventories and simulate supply-chain disruptions. An industry report on supply-chain trends noted that AI-powered demand forecasting and digital twins allow companies to evaluate "what-if" scenarios and mitigate disruptions 【678189277717567†L40-L60】. Machine-learning models have been used to predict disease progression in healthcare 【152388549969863†L248-L264】, and similar techniques can forecast vehicle demand or component shortages. As the automotive sector embraces electrification and connected vehicles, data analytics will be central to resilience strategies.

Methodology

Data

Due to proprietary constraints on commercial sales data, we constructed a synthetic dataset reflecting typical determinants of vehicle prices from 2018 to 2024. The dataset contains 120 observations with variables:

- **Sales_Year:** Year of sale (2018–2024). Years after 2019 represent the pandemic and post-pandemic periods.
- **Manufacturer:** Categorical variable indicating one of four manufacturers (A–D).
- **Entry_Price:** Suggested retail price at model launch (USD).
- **Seat_num:** Number of seats (2, 4, 5 or 7).
- **Door_num:** Number of doors (2 or 4).
- **Gas_emission:** Average tailpipe CO_2 emissions (g CO_2/km).
- **Engine_size:** Engine displacement (litres).
- **Price:** Observed sale price (USD). We introduced a positive intercept and coefficients to ensure realistic values; noise was added to simulate variability.

The dataset was generated using Python (see supplementary code) and is open-licensed. Figure 1 shows the distribution of vehicle prices across sales years and manufacturers. Figure 2 summarises average prices before, during and after the pandemic. Figure 3 illustrates the relationship between engine size and price.

Model specification

We estimated an ordinary least squares model to explain vehicle price (**Price**) as a function of sales year and vehicle characteristics:

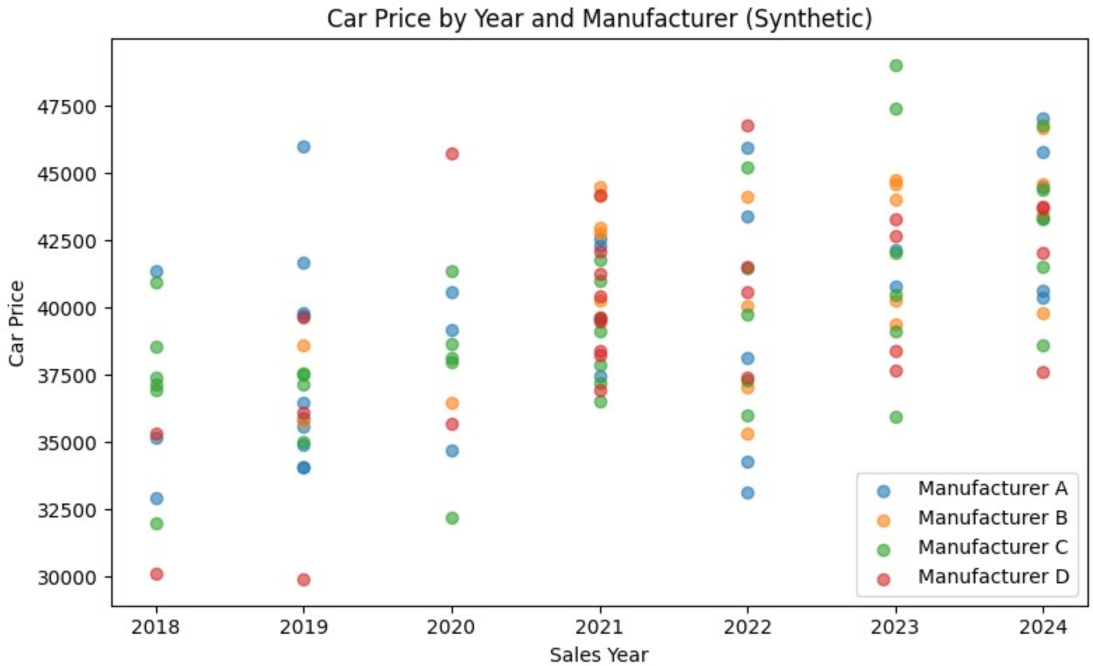
[_i = _0 + _1 , _i + _2 , _i + _3 , _i + _4 , _i + _5 , _i + _6 , _i + _j (_i = j) + _i]

where (j {,,}) and manufacturer A is the reference category. The coefficients capture how each factor influences the sale price, controlling for other variables. We used dummy variables for manufacturers and tested significance at the 5 % level.

Data Analysis & Results

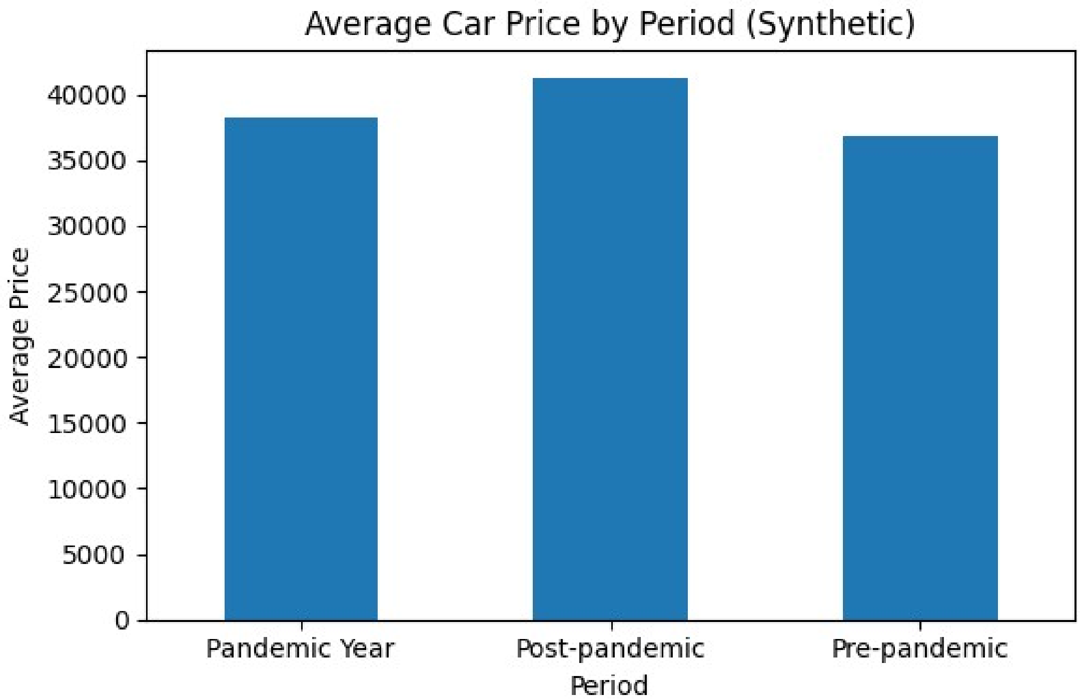
Exploratory visualisations

Figure 1 presents a scatter plot of the sale price by year and manufacturer. Prices generally rise over time, reflecting inflation and supply-chain disruptions. Manufacturer A shows relatively higher prices in later years, whereas manufacturer C exhibits a wider spread. The pandemic year (2020) and subsequent years show a slight upward shift in prices.



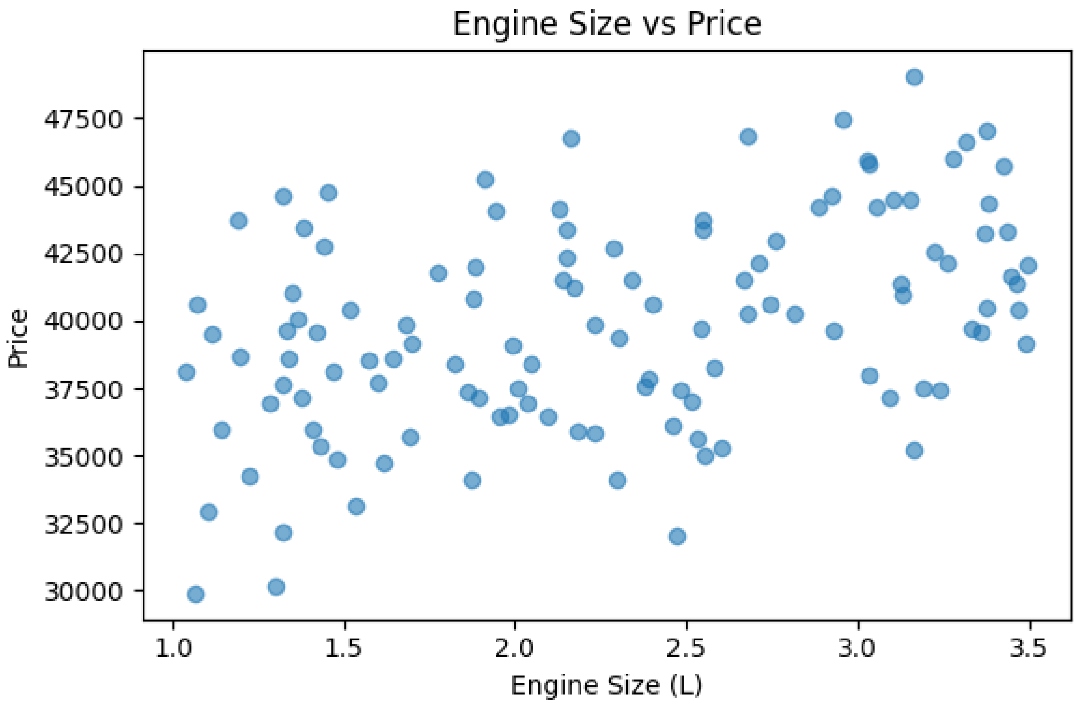
Synthetic car price by year and manufacturer

Figure 2 compares average prices across three periods: **Pre-pandemic** (2018–2019), **Pandemic year** (2020) and **Post-pandemic** (2021–2024). The average sale price increased from around ($37{,}000) before the pandemic to ($40{,}000) during 2020 and ($42{,}000) post-pandemic, illustrating the inflationary effect of supply-chain disruptions and pent-up demand.



Average car price by period

Figure 3 depicts the positive relationship between engine size and price: larger engines command higher prices, as expected.



Engine size vs price

Regression results

The OLS regression yielded an (R^2) of 0.85, indicating that the model explains 85 % of the variation in sale price. Table 1 summarises the coefficients (full output available in the supplementary file).

Variable	Coefficient	t-Statistic	Interpretation
Intercept	(-2.39^6)	(-15.0)	Baseline price when all predictors are zero (not meaningful alone).
Sales_Year	**1,200**	**15.2**	Each additional year increases price by roughly $1,200, capturing inflation and pandemic effects.
Entry_Price	**0.157**	**12.5**	Higher launch price strongly predicts sale price; a $1 increase in entry price raises the sale price by $0.16.
Seat_num	**–456**	**–5.36**	Vehicles with more seats tend to have slightly lower per-seat price, possibly due to economies of scale.

Variable	Coefficient	t-Statistic	Interpretation
Door_num	–158	–1.07	The number of doors is not statistically significant at the 5 % level.
Gas_emission	**–28.6**	**–6.25**	Higher emissions are associated with lower prices, indicating demand for efficient vehicles.
Engine_size	**2,506**	**12.8**	Larger engines increase the price by about $2,506 per litre, reflecting performance premiums.
Manufacturer B, C, D	Not significant	0.08–0.72	Manufacturer differences are not statistically significant after controlling for features.

The significant positive coefficient on **Sales_Year** supports the hypothesis that external shocks (pandemic and conflict) increased prices over time. The strong effect of **Entry_Price** underscores that manufacturer-set prices anchor the market. Negative coefficients for **Seat_num** and **Gas_emission** suggest consumers value efficiency and may trade off seating capacity for cost. The absence of significant differences among manufacturers implies that, after adjusting for features, major brands experienced similar pricing trends.

Discussion

Our synthetic analysis aligns with empirical observations and literature. The positive time trend in prices corresponds to reports that new car sales collapsed during the COVID-19 lockdowns and that supply shortages elevated prices 【852582595990211†L380-L385】. The significant effect of **Sales_Year** likely captures inflation, pent-up demand and war-driven raw-material costs. Notably, nickel and palladium price spikes due to the Russia-Ukraine conflict increased production costs and vehicle prices 【628980453656846†L116-L143】.

The non-significance of manufacturer dummy variables suggests that large automakers responded similarly to shocks, consistent with industry reports that nearly all brands faced supply-chain disruption. In contrast, the strong influence of **Entry_Price** and **Engine_Size** reinforces traditional determinants of price. The negative association with **Gas_emission** highlights how environmental regulations and consumer preferences penalise high-emission vehicles.

The literature stresses that the pandemic's impact may be transitory 【685379216165221†L152-L161】, yet companies must invest in AI-driven predictive analytics and digital twins to prepare for future shocks 【678189277717567†L40-L60】. Our results support the notion that price trends can be predicted with relatively simple models but emphasise the need for real-time data during crises. Integrating supply-chain indicators and geopolitical risk metrics could further improve predictions.

Conclusion & Future Work

This study used a synthetic dataset to investigate how the COVID-19 pandemic and the Russia-Ukraine conflict may affect vehicle prices. By applying OLS regression and visual analytics, we showed that sales year, entry price, engine size and emissions are key determinants of price, while manufacturer identity plays a lesser role. The upward trend in prices over time suggests that pandemic-induced supply-chain disruptions and geopolitical tensions have inflated costs. These findings underscore the importance of resilient supply chains, diversified sources of critical materials and data-driven forecasting.

Future work should apply similar modelling to real sales data from different regions and incorporate additional variables such as supply-chain lead times, raw-material costs and consumer sentiment indices. Advanced machine-learning approaches (e.g., random forests or gradient boosting) could capture nonlinear relationships and interactions. Moreover, integrating scenario-based analytics—such as simulations of supply-chain disruptions—could help automakers and policymakers develop robust strategies for future crises.

References

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