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Research article

An Analysis of the Relationship Between Production, Sales, and Export in the Indian Automobile Industry: Using Time Series

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ABSTRACT

This study examines how production, sales, and exports are related in the Indian auto industry using data from 1994 to 2023. The Augmented Dickey-Fuller (ADF) tests show that all the variables are not stationary at levels, but they do become stationary after the first difference. A Vector Auto Regression (VAR) model used to the differenced log-transformed data shows that variations in production considerably and positively affect exports at the 10% level, showing the importance of supply-side capacity in increasing international competitiveness. Sales, on the other hand, have no direct effect on exports, which highlights that domestic demand is not affected by external performance. These findings show that capacity of production, rather than sales expansion, is the primary factor influencing vehicle export trajectory of India, offering guidance for industry strategy and formulation of policy.

1) Introduction

India has one of the biggest and most important car industries in the world. It is an important part of industrial and economic growth of country. India's middle class is growing quickly. The cities are getting bigger, the population is getting younger, and people have more money to spend. The car market has grown because of all of these things. The fact that car companies are more interested in selling cars in rural areas has also helped the industry grow even more. Automobile Products of India was started in Bombay in 1949 by the British company Rooters Group. Later, M. A. Chidambaram from the MAC Group in Madras bought the company [6]. Mr. Pawan Goenka, who used to be the President of the Society of Indian Automobile Manufacturers (SIAM), said, "No one can ignore this market because the Indian auto industry and market have become important internationally." This shows how important India is becoming on the world stage.

1.1 Policy-Oriented and Institutional Perspectives on the Indian Automobile Industry:

The Indian car business started in 1897, when the first car hit Indian roads. But it was not until after independence in 1947 that domestic manufacturing really got going. Automobile products of India were founded in Bombay in 1949 by the British Rootes Group and later bought by M.A. Chidambaram of the MAC Group. It was an early step toward making cars in India. The First Tariff Commission was established in 1952, and it had a big impact on the institutional framework of industry. It made it harder to import fully completed units (CBUs) and easier to make things in the U.S. and work with other companies (IBEF, 2023).

After independence, there was a tight control on car industry, with high tariffs, output quotas, needs of licensing, and validations on foreign participation. This environment of policy, commonly related with the "license raj", limited competition, constrained technological adoption, and resulted in slow growth of industry with minimal contribution to overall development of economic [15]. The gradual deregulation started in the early 1980s, followed by partial deregulation in 1985 and comprehensive liberalization 1991, showed a transforming point for the sector [11, 12, 17].

The Maruti Udyog Limited's development in 1980, in partnership with Suzuki Motor Corporation of Japan, was a major change of policy. The popularity of Maruti 800 changed how Indian people move around by making automobiles more affordable for a larger group of people. After 1991, measures that opened the economy made it much easier for integration of global, foreign direct investment, and transfer of technology to happen. This drew in huge international firms such as Nissan and Toyota. The market of Indian car has become strategically important around the world, according to Mr. Pawan Goenka, who used to be the president of SIAM.

The recent governments programs like, make in India, the AMP 2026, the PLI Scheme from 2021, and the FAME program, have helped the sector grow over the long term by promoting domestic manufacturing, exports, and environmental sustainability [3, 4, 14]. These regulations have helped India become a significant global production centre, which makes almost 29 million automobiles a year from 2017 to 2018, with almost 4 million of them going to other countries [5]. In 2018, the European Automobiles Manufacturers Association said that India was the fourth largest car maker of the world [10].

Policy-oriented studies show that there are still problems, even though the economy is growing quickly. These problems consist of poor infrastructure, strict emissions standards, fluctuating fuel prices, and interruptions created by the COVID-19 epidemic. However, the consensus in policy-focused literature is that automobile industry of India has moved from being a protected local sector to one that competes globally and focuses on manufacturing and exporting.

1.2 Econometric and Empirical Analysis of Production, Sales, and Exports:

A lot of empirical research has looked at the performance of the Indian automobile sector using quantitative methods in addition to policy narratives. Initial research predominantly concentrated on production trends, sales expansion, and export success in isolation. According to empirical evidence, the economic changes of 1991 greatly improved competitiveness in the market, foreign direct investments inflows, and the operational efficiency of sector [8]. Other studies point to urbanization, building new infrastructure, and rising household income as important factors that lead to more cars being made and sold [16].

Econometric studies also represent that government actions like the Automotive Mission Plan have had a good effect on productivity, economies of scale, and technical modernization [3]. Studies that focus on exports suggest that exports of vehicles of India and auto parts are risking quickly. This is because automotive supply chains of India are becoming more

linked to the rest of the world [7]. Most of the people think that the growth of exports is a sign of how competitive India is on the world stage and how much better India-made cars are getting.

However, despite this substantial empirical literature, most of the current research evaluate production, sales, and exports in isolation, frequently use descriptive statistics or short-term econometric models. A significant deficiency persists in thorough time-series analysis that concurrently investigate the long-term linkages and dynamic interdependencies among these critical industry factors.

To fill this gap, the current study uses time-series econometric approaches to look at trends in production, sales, and exports in the Indian vehicle industry from 1994 to 2023. The first step in the study is the ADF test, which is used for checking stationarity. Then, VAR model is evaluated using log-transformed data. The VAR framework help to look at production, sales, and export affect each other over time and how they are related to each other. This provides a better overall picture of how the industry works [2].

Even though there is a lot of research on how the Indian car industry has developed, various studies have studied at production, sales, and exports separately. Few people have used strong time series approach to carefully look at how they depend on each other over time. This study handles the research issue of discerning and evaluating the dynamic causal relationships among production, sales, and exports in the Indian automobile business from 1994 to 2023. The aim of this research is to explain the impact of variations in domestic production using ADF test and VAR modelling, consequently guiding industrial strategy and policy formulation.

Despite a substantial body of literature on the Indian automobile industry, most existing studies examine production, sales, and exports separately or rely on descriptive and static econometric approaches. Limited attention has been paid to the dynamic interdependence among these key variables within a unified time-series framework. This study contributes to the literature by jointly analyzing automobile production, sales, and exports in India using a Vector Autoregression (VAR) model over the period 1994–2023. By capturing the dynamic interactions among these variables, the study provides empirical evidence on whether export performance is driven primarily by domestic production capacity or demand-side factors. The findings offer policy-relevant insights into the effectiveness of supply-oriented industrial initiatives, such as production-linked incentives, in strengthening India's export competitiveness.

The rest of the study is set up like this, the next section talks about the data sources and research methods, further we discuss about the results, then we talk some discussion and then then we discuss about the study's limitations and policy implications; and the last sections give recommendations, conclusions, and directions for future research.

2) Methodology

The study implements a quantitative research design, using time series econometric methods to evaluate the interrelationship among production, sales, and exports in Indian automobile sector from 1994 to 2023. The Automotive Component Manufacturers Association of India (ACMA) database provided yearly secondary data on production, sales, and exports for the Indian automobile sector. To stabilize variance and lower heteroscedasticity, all of the variables were change to logarithmic form. The ADF test was utilized to see if the time series data was stationary. Because there was unit root ($p > 0.05$), first order differencing was used to make the data stationary. The autocorrelation test confirmed that suitability of model to detect residual serial correlation. Coefficients were analyzed according to their sign, magnitude and statistical

significance (p-values). We need to make sure that the order of the variables is the same, that our dataset is balanced, and that we usually use the Unit Root Test [9] before we use the VAR.

a) Analysis of ADF

The result of ADF highlights that the time series for production, sales, and exports in the Indian car sector are not stationary at first, with p-values more than 0.05. Implementing first-order differencing to the log-transformed data represents that all three variables are stationary, which means that they have unit roots in their original forms. This change makes the data ready for more econometric modelling, like VAR framework, by getting rid of trends and making variance more stable.

The ADF test was used to assess the stationarity of production variable. The production series appears non-stationary ($p > 0.05$), as demonstrated by the test statistic of −0.569426 and the p-value of 0.8749. Differentiating was therefore used to create stationarity.

According to the ADF test, SALES are likewise non-stationary (p > 0.05), which produced a test statistic of −1.16055 and a p-value of 0.6936 under the model with a constant. The resulting series retested after differencing was applied to log-transformed sales. The findings of ADF test for export confirmed that this series is also non-stationary ($p > 0.05$) with a test statistic of 2.1172 and an asymptotic p-value of 0.999999. Additional testing is required after differencing.

b) VAR Equation Model

A VAR model is used to look at the changing relationship between car exports, sales, and production in India. The VAR framework considers all variables as endogenous, articulating each variable as a function of its own lagged values and the lagged values of other variables within the system. This method is especially good for looking at time series data where variables are expected to affect each other and depend on each other.

This study estimates the VAR model using first-differenced and log-transformed series to guarantee stationarity, as validated by the Augmented Dickey-Fuller (ADF) test. The model with one lag(VAR(1)) is defined as follows:

VAE Model Specification

$$\Delta Export_t = \beta_{0,1} + \beta_{1,1}\Delta Export_{t-1} + \beta_{1,2}\Delta Sales_{t-1} + \beta_{1,3}\Delta Production_{t-1} + \epsilon_{1t}, \quad (1)$$

$$\Delta Sales_t = \beta_{0,2} + \beta_{2,1}\Delta Export_{t-1} + \beta_{2,2}\Delta Sales_{t-1} + \beta_{2,3}\Delta Production_{t-1} + \epsilon_{2t}, \quad (2)$$

$$\Delta Production_t = \beta_{0,3} + \beta_{3,1}\Delta Export_{t-1} + \beta_{3,2}\Delta Sales_{t-1} + \beta_{3,3}\Delta Production_{t-1} + \epsilon_{3t}. \quad (3)$$

In the above equations, Δ represents the first-difference operation that captures the changes in the respective variable over time. $\Delta Export_t, \Delta Sales_t,$ and $\Delta Production_t$ highlight the differenced export, sales, and production series in time t. $\Delta Export_{t-1}, \Delta Sales_{t-1},$ and $\Delta Production_{t-1}$ represents the one-period lagged values of the differenced variables. $\beta_{0,i} (for\ i = 1,2,3)$ are the intercepts that captures the constant effects in each equation. $\beta_{i,j}$ shows the coefficient that measures the lagged variable's impact j on the current value of variable i. $\epsilon_{i,j}$ represents the stochastic error term at time t, considered to be white noise with zero mean, constant variance, and non-serial correlation. Equation (1) represents the export equation, that explains the change in automobile exports as function of past changes in exports, sales, and production. This extracts how previous domestic market conditions and capacity of production that influence export performance. Equation (2) known as sales equation that predicts how domestic car sales will change on the basis of how they have changed in the past and how exports and production have changed in the past. This shows how domestic

demand, supply-side dynamics, and international trade, all affect each other. Equation (3) discusses about how changes in production of car are affected by past exports and sales, as well as changes in the production itself that have happened in the past. This equation presents how production decisions change based on both demand and export opportunities. Because it doesn't necessitate rigid theoretical presumptions about the relationships between the variables, the VAR model is very beneficial. Rather, it allows the data to display changes in exports, sales, and production over time. Forecast error variance decomposition (FEVD) and impulse response functions (IRFs) can also be examined using the VAR framework. These provide additional details about the long-term effects of shocks to one variable on the system as a whole.

3) Results

This section displays the study's practical outcomes. First, descriptive statistics provide an overview of the production, sales, and export figures of the Indian auto industry. The predicted outcomes of the VAR model will then be discussed to demonstrate how the variables vary over time.

3.1 Summary Statistics (1994-2023)

Table 1 presents the descriptive statistics of automobile production, sales, and exports for the period 1994–2023. The time period was selected to represent how the Indian auto sector has change over the long term. Begin in the middle of the 1990s, the industry saw a lot of deregulation, foreign investment, and changes to policies that changes how goods were made and traded. By extending the research to 2023, we may look at current events such as the Production Linked Incentive (PLI) scheme, the Automotive Mission Plan 2026, and the effects of the COVID-19 epidemic. This time period provides a full picture of trends before and after liberalization, cyclical changes, and current policy changes.

Table 1: Summary Statistics

Variable	**Mean**	**Median**	**Minimum**	**Maximum**
Production	1.1808×10^7	9.9322×10^6	1.3125×10^5	2.5064×10^7
Sales	1.3046×10^7	1.1202×10^7	5.6498×10^5	3.0910×10^7
Export	1.6908×10^6	9.1600×10^5	41,248	5.0352×10^6
Variable	**Std. Deviation**	**Coefficient of Variation**	**Skewness**	**Excess Kurtosis**
Production	8.3369×10^6	0.70601	0.02517	−1.4180
Sales	8.3775×10^6	0.64213	0.35740	−0.92937
Export	1.6345×10^6	0.96670	0.58893	−1.2313
Variable	**5th Percentile**	**95th Percentile**	**Interquartile Range**	**Missing Observations**
Production	1.4606×10^5	2.4170×10^7	1.6094×10^7	0
Sales	1.6519×10^6	2.9911×10^7	1.4801×10^7	0
Export	79,542	4.5188×10^6	3.1928×10^6	0

The descriptive statistics represent that production, sales, and exports changed a lot and grew a lot during the study. The standard deviations for production and sales are high, which shows that they can change a lot. The coefficient of variation (0.997) for exports, on the other hand shows that they are very different from their mean. The skewness values highlight that

the distributions for production and sales are roughly the same on both sides, or somewhat left-skewed. This shows that there are some high export values. All of the variables show negative excess kurtosis, which means that the distributions are platykurtic. This states that the data is flatter than a normal distribution. The descriptive statistics show that production of vehicle has the largest mean and variability of the three variables. This shows that the sector is the main driver of the development on the supply side. Sales have a lower range of values, meaning domestic demand is steadier than the volatility of exports. India is more sensitive to changes in the global market and external shocks, like financial crises and the pandemic, because its exports have a higher standard deviation. The skewness and kurtosis values show that output and sales are more evenly spread out, whereas exports have thicker tails, which is what you would expect during times of rapid growth or decline. These statistical characteristics correspond with the dual structure of industry, a comparatively stable home market and a more unpredictable, opportunity-driven export sector.

Overall, the summary statistics show that the Indian car industry is always changing because of both domestic demand and conditions in the internation market.

3. 2 Equation interpretation of VAR Model

To make sure that the data is stationary, a VAR is estimated using first-differenced, log-transformed values of car exports, sales and production. The Akaike Information Criterion (AIC) showed that a VAR (1) specification was the best lag structure.

Model Selection Criteria

- Log-likelihood: −19.5689
- AIC: −1.6835
- HQC: −1.7417
- BIC: −1.8738

These information criteria values indicate an adequate model fit.

Table-2: According to the Portmanteau test, the model fits well, which showed no discernible

Variable	Co-efficient	Std. Error	T-ratio	P- value
Constant	0.0466512	0.112893	0.4132	0.6831
$\Delta Export$	0.0595912	0.225182	0.2646	0.7935
$\Delta Sales$	0.00897312	0.205974	0.04356	0.9656
$\Delta Production$	0.330264	0.183889	1.796	0.0851 *

The constant terms in Table 2 are not statistically significant ($p = 0.6831$), which means that there is no fixed trend component in export growth after differencing. The lagged differenced export variable doesn't have a big effect on current exports ($p = 0.7935$), which means that exports don'ts stays the same for very long. Lagged sales also don't have a statistically significant effect on export growth ($p = 0.9656$). At the 10% level of significance ($p = 0.0851$), however, lagged production growth has a small but positive effect on export growth. This suggests that a rise in automobile production leads to a rise in exports. This shows the importance of production capacity and supply-side strength are to increasing exports of India. There is a genuine, if weak, relationship in the Indian auto industry between the quality of products made in India and their international sales.

4) Discussion

The empirical finding represents how production, sales, and exports in the Indian auto sector are always changing. The VAR results show that delayed adjustments in production have a favourable and statistically significant effect on export growth. This result highlights how import supply-side capacity is, when manufacturers from India increase their outputs, they are better able to meet foreign demand, which makes India more competitive in global markets. On the other hand, lagged scales don't have a big effect on exports, which means that how much people in the country by does not have much to do with how well exports do. This distinction shows that while rising incomes and urbanization increase internal demand, export growth is more strongly linked to how efficiently and on a larger scale goods are made than to changes in local sales.

The lack of persistence in export growth, where historical changes in exports do not substantially predict present exports, suggest that shocks to external demand don't last long and that car exports of India are very susceptible to change in the global market. The results show that the best way to enhance the car exports of India is to improve production capacity. So, policymakers should put expanding manufacturing infrastructure, encourage technological upgrades, and support supply-chain resilience at the top of their list of things to do. The Production Linked Incentive (PLI) scheme and the AMP 2026 are two programs that fit this need perfectly because they focus on improving production efficiency and making the business more competitive across the world. On the other hand, policies that only attempt to boost domestic sales, like consumer subsidies or demand-side incentives, may not lead to more exports because there is not a strong statistical correlation between sales and exports. Instead, it is better to have a dual-track approach, with one set of measures to keep domestic demand and prices stable and another set to improve the quality and scale of production for internation markets. Lastly, the fact that export performance is so unpredictable shows how important it is to diversify export markets and engage in flexible tactics to deal with sudden changes in global demand.

This section of the study looks at how India's car sales, production, and exports have changed over time. ACMA gets its information from its Figures 1 through 4. The paper adds that the Indian auto sector has risen over time, but it has also had its ups and downs due of changes in government legislation, economic shocks, and things that happen throughout the world.

Figure 1 depicts how the Indian auto sector has changed for different car and truck types between 1994 and 2023. The number of passenger automobiles built progressively rose from 720,969 in 1994 to over 4 million in 2018. This happened because more people desired it, cities got bigger, and prices went down. The economy slowing down and the adoption of Bharat Stage VI (BS-VI) emission limitations were the key reasons for the drop from 2019 to 2020. These changes made cars more expensive, but they also made them better for the environment and more fuel-efficient over time. The COVID-19 pandemic

made this decline even worse. There were 4.02 million units made in 2018. That number had reduced to 3.06 million by 2020.

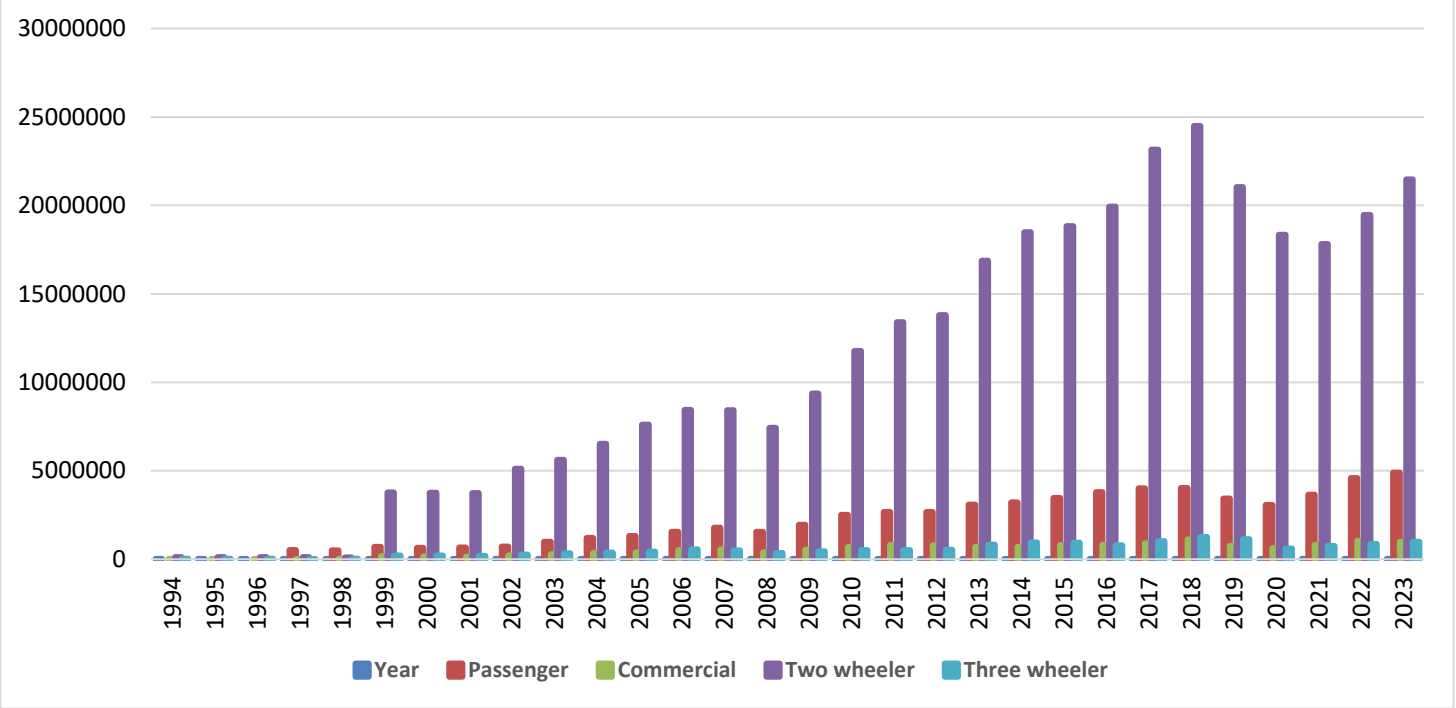

Figure 1: Trends in Production of passenger vehicles, commercial vehicles, two-wheelers, and three-wheelers in India from 1994 to 2023, showing long-term growth with notable declines during the 2008 financial crisis, 2019 slowdown, and COVID-19 pandemic, followed by recovery supported by policy initiatives.

But from 2021 to 2023, things got a lot better because of pent-up demand, government incentives, and greater exports. By 2023, there were a record 4.9 million passenger cars on the road. India's commercial vehicle production followed trends that shifted as infrastructure and industry expanded. Because of the slowing economy and shifting regulations, it increased significantly between 1999 and 2010, peaked in 2018, and then declined in 2019 and 2020. By 2023, it had recovered strongly thanks to more industrial activity. Two-wheelers grew the fastest and the most, making them the most important part of the Indian car market. After the late 1990s, production rose quickly, peaked in 2018, fell during the pandemic because of low demand, and then rose strongly again after 2021. The number of three-wheelers made stayed the same until it peaked in 2018. After that, it fell sharply because of the pandemic and then slowly recovered thanks to urban mobility and last-mile logistics. There were times of growth from 2001 to 2007, 2011 to 2018, and 2021 to 2023. There were also times of decline during the financial crisis in 2008, the slowdown in 2019, and COVID-19 in 2020. The PLI scheme from 2021 and other policy support helped the recovery even more, especially in the electric vehicle market.

Figure 2 shows that car sales in India grew steadily in all segments until 2018. Then, from 2019 to 2020, they fell sharply because of the COVID-19 pandemic and the economy slowing down. After that, they slowly started to recover. Sales of passenger cars went up steadily from the middle of the 1990s until they peaked in 2018. They then fell sharply in 2020 but started to rise again in the years that followed. Sales of commercial vehicles closely followed infrastructure and industrial activity. They rose sharply until 2018, fell to a multi-year low in 2020, and then slowly rose again by 2022–2023. Sales of two-wheelers showed the most long-term growth and resilience, even though they fell for a short time during the pandemic. Three-wheeler sales grew at a moderate rate until 2018, when they fell sharply because of the pandemic. They have been

slowly recovering since 2021. Overall, the trends show that car sales, the economy, and outside shocks are all closely related. There is a clear recovery across all segments after the pandemic.

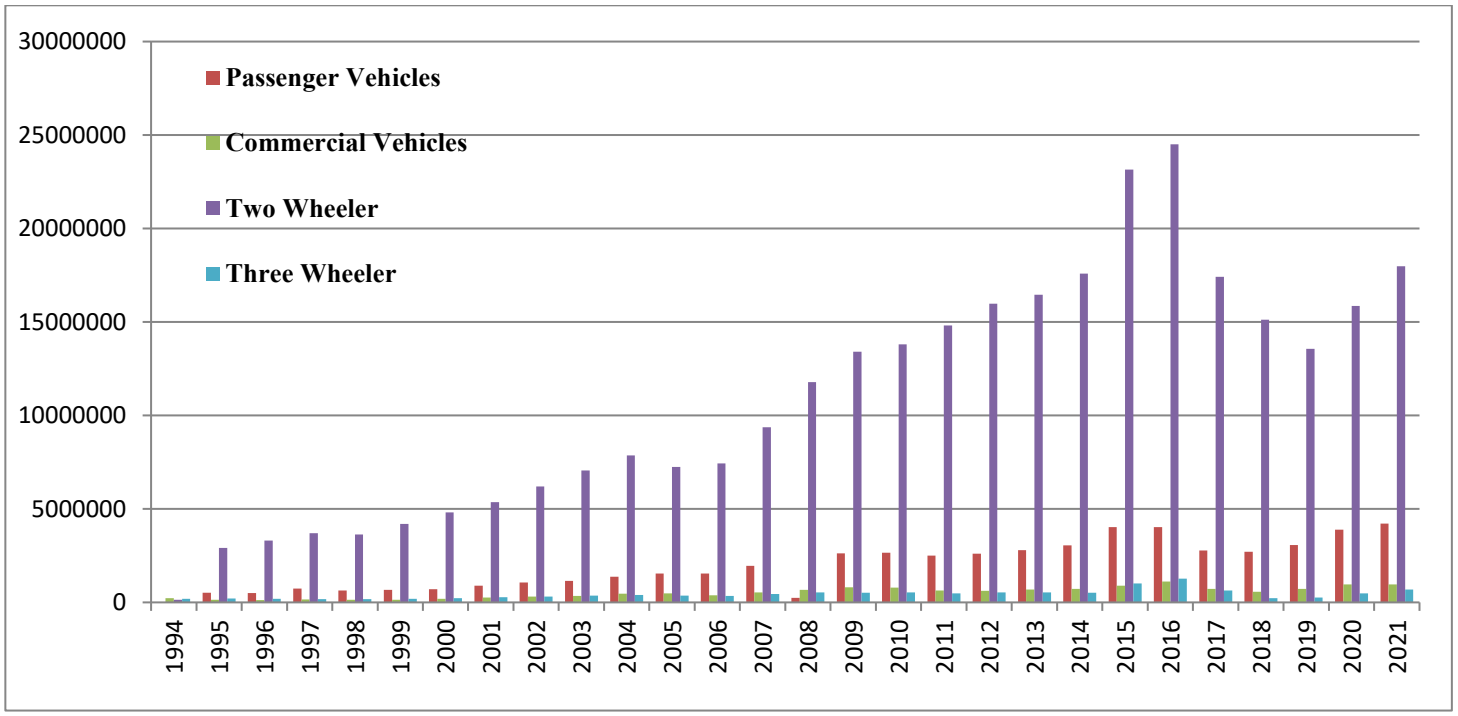

Figure 2: Annual sales of passenger vehicles, commercial vehicles, two-wheelers, and three-wheelers in India between 1994 and 2023, that highlights steady growth until 2018, sharp declines in 2019-2020, and gradual recovery thereafter.

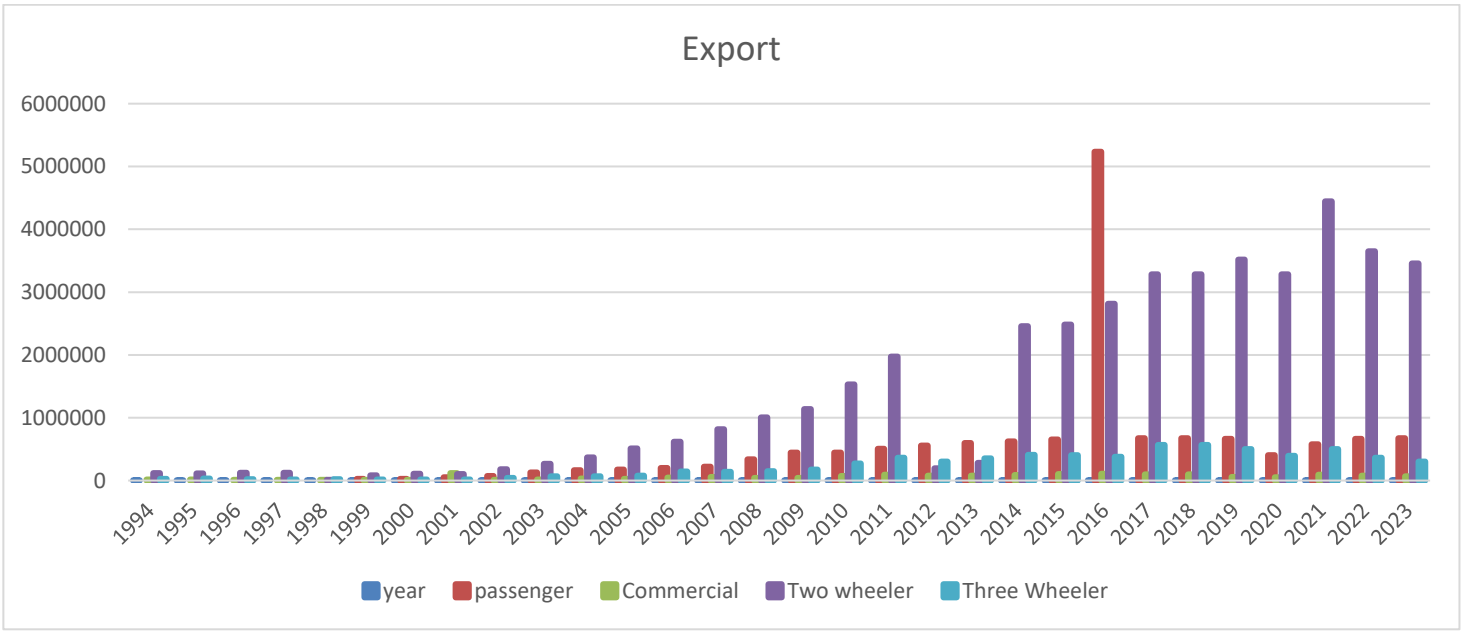

Figure 3: Export volumes of various automobiles segments from 1994 to 2023, showing India's enhancing integration into global supply chains, sensitivity to external shocks, and post-pandemic rebound in passenger car exports.

Figure 3 shows how India's car exports have changed over time, which shows how much more connected India is to the rest of the world. After 2000, exports of passenger cars rose steadily until they peaked in 2017–2018. They fell sharply in 2020 because of problems around the world, but by 2023 they had recovered strongly. Exports of commercial vehicles grew slowly until the middle of the 2010s, fell during the pandemic, and then slowly recovered, but they fell again in 2023, showing that there are still problems in foreign markets. Exports of two-wheelers grew the most over time, reaching their highest point in 2019, falling in 2020, rising again briefly in 2022, and then falling again in 2023 because of changes in global demand. Three-wheeler exports were very unstable. They peaked in 2017–2018, then fell sharply because of the pandemic and stayed weak after that. Overall, exports show that Indian vehicles are becoming more popular around the world and that they are very sensitive to changes in the global economy.

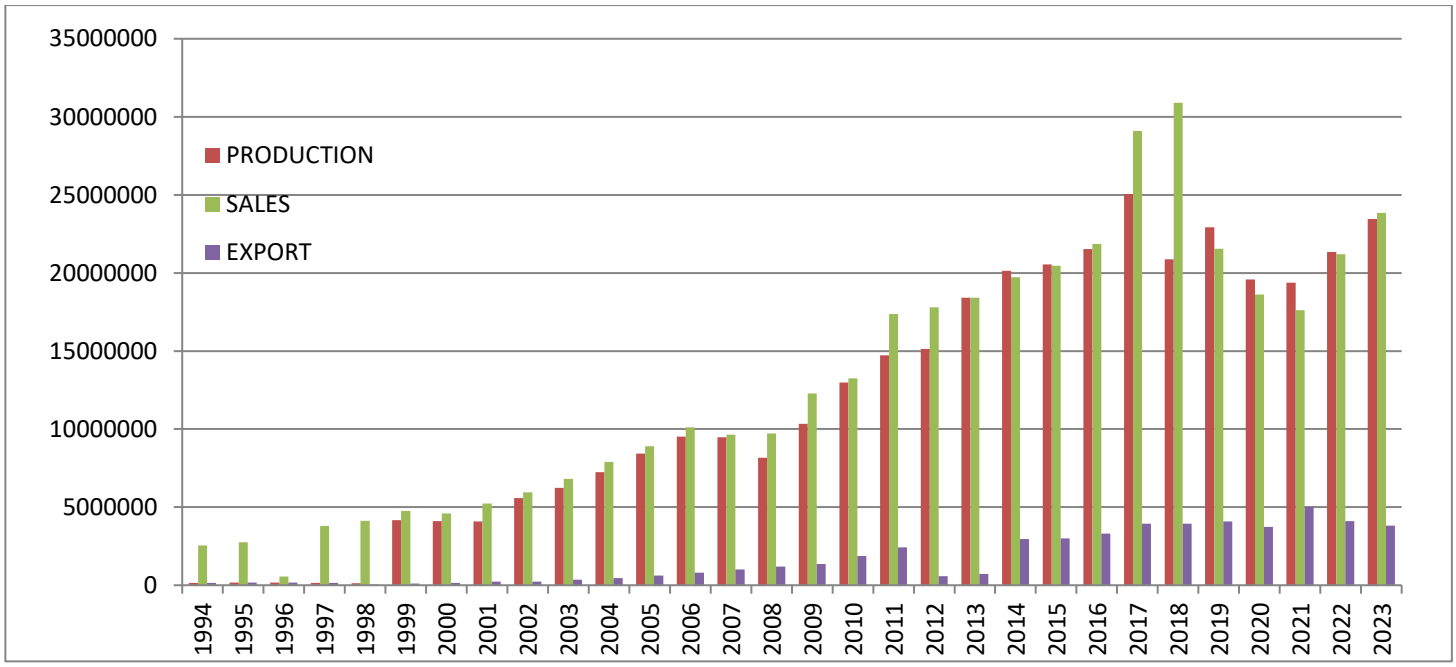

Figure 4: Trends in total automobile production, domestic sales, and exports in India (1994–2023).

Figure 4 shows a general upward trend with some ups and downs in production, sales, and exports all at once. In 1994, 1.58 million cars were produced. By 2023, the number had increased to 23.45 million. This represents that the industry is still robust and has a lot of space to develop. In some years, such as 1998 and 2018, sales were higher than output. Changes to inventory or imports could have caused this. But sales shown that there was a lot of demand within US, which was quite similar to what was happening with production. The number of exports went from 158,452 units in 1994 to 3.82 million units in 2023. India is a growing more and more important in the car business around the world. Various items were sent abroad in 2021, when 5.03 million pieces were sent. There was a lot demand for this from nations such as the US, South Africa, and Mexico. All in all, the patterns represent that the Indian sector of auto is strong and can adapt. The COVID-19 pandemic and the downturns of economy made things hard for the business, but it has done well since 2020. This shows that the future of the industry looks promising due to that there are more chances to export, the government is establishing rules that support, and demand at home is going up.

The findings of this study are broadly consistent with existing empirical literature on the Indian automobile industry. Previous

studies such as Mukherjee and S. T. (1996) and Narayanan (2001) emphasize the role of production capacity, technological upgrading, and economies of scale in improving international competitiveness [8, 11]. Similarly, Miglani (2019) finds that export growth in the Indian automobile sector is driven more by supply-side factors than by domestic demand conditions [7]. The present study reinforces this evidence by demonstrating that growth in production has a statistically significant positive effect on exports, while domestic sales do not directly influence export performance.

5) Limitation of the Study

This study might miss out on seasonal and short-term dynamic effects because it uses yearly data. Changes in exchange rates, gas costs, and policy are some of the important outside factors that could modify the variables that are not taken into account. The VAR model does not account for systemic alterations like as the 2008 financial crisis and the COVID-19 pandemic. We only look at relationships that are straight. Differences eliminate long-term trends; therefore, the research can only look at short-term consequences. The analysis employs industry statistics instead than concentrating on specific automotive categories. Finally, the impacts of various government programs have not been looked into.

6) Policy Implications

The results of this study represent that automobile industry of India needs to keep building more factories in order to improve its export performance. So, government programs such as the PLI scheme should keep focusing on scale, efficiency, and upgrading technology. This is because growth of manufacturing and performance of export are closely related. Making the supply chain more efficient, lowering the input cost, and using more advanced technologies can all help make exports more competitive. Policy makers should actively encourage the diversity of market to lower dependence on a limited number of export markets. Indian vehicle exports can find new customers by strengthening economic relations and regional agreements with new markets in Africa, Latin America, and Southeast Asia. At the same time, more money requires to be spent on making and enhancing the infrastructure and product capacity for electric vehicles. This is due to that more individuals are selecting to travel in ways that are good for the environments. If India invests like this, it might become a competitive worldwide hub for environmentally friendly transportation solutions. Long-term competitiveness also relies on getting more money for research and development (R&D), notably for technologies that make electric and fuel-efficient cars. Empowering public-private partnerships (PPPs) can help workers gain new skills, make it easier to share technology, and speed up the process of coming up with new ideas. Finally, a stable and clear set of regulations and policies that do not change would stimulate long-term investment, help businesses plan, and keep exports growing.

7) Future Recommendations

Future research may extend the present analysis by incorporating external macroeconomic variables such as exchange rates, global oil prices, and international demand conditions to better capture global linkages. Segment-wise analysis of the automobile industry may also provide deeper insights into heterogeneous dynamics across vehicle categories. In addition, future studies could examine the role of electric vehicle adoption and sustainability-focused policies, particularly in the context of recent initiatives such as PLI and FAME. Extending the dataset beyond 2023 would further enhance the robustness of empirical findings.

8) Conclusion

The study examined the stationarity of productions, sales, and time of export of series data using ADF test. It was ascertained that all variables were initially non-stationary but subsequently achieved stationarity at the time of process of differencing. The VAR models provide a full picture of how the data on exports, sales, and production are all related. To make smart choices in fields like the auto industry, it's important to estimate these equations to determine how these economic elements evolve over time. The liberalization of the market and improvements in legislation have helped the Indian auto sector grow a lot. It is an important part of the economy right now since it creates a lot of jobs and money. According to the statistical analysis, export performance and output levels are closely related. This represents how important it is to keep investigate in manufacture skills. Plans should focus on making production more efficient and looking into markets outside the US to keep growth going. This because more people are interested in electric cars and sustainability.

Authors' Contributions:

Conceptualization, J.Y. and A.; Methodology, J.Y.; Software, J.Y.; Formal Analysis, A.; Investigation, A.; Writing Original Draft Preparation, J.Y.; Writing – Review & Editing, J.Y. and C.K.; Visualization, C.K.

Data Availability Statement:

The data is available on the open sources as mentioned within the article.

Conflicts of Interest:

The authors declare no conflict of interest.

Finding:

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