Project Report

MAI-BB-1-WS2023 ILV Data Engineering

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1 Introduction

The automotive industry is integral to modern society. In Austria, the new car registrations market is a dynamic field, influenced by multiple factors including consumer behaviour, seasonal fluctuations, and economic stability. This study aims to explor this complex ecosystem, uncoverign valuable insights and responses to significant queries.

The Austrian automotive market harbours a wide range of car brands competing for market share. Volkswagen, a global automotive giant, holds a significant presence in Austria. It has consistently been a prominent player, not only as a standalone brand but also as the Volkswagen Group. The first hypothesis to be examined in this study is whether Volkswagen maintains its dominance in the Austrian market, consistently securing the highest market share in new car registrations.

Additionally, car registrations exhibit patterns that vary throughout the year. This seasonality is a matter of interest, as it can offer critical insights into consumer behavior and market dynamics. The second hypothesis under scrutiny asserts that new car registrations in Austria demonstrate seasonal fluctuations, with higher registration rates during the spring and summer months compared to the autumn and winter.

Furthermore, the health of the automotive industry is closely related to the overall economic conditions of a country. Austria's economic stability, as measured by GDP and the performance of the Austrian Traded Index (ATX), is expected to influence the number of new car registrations. The third hypothesis posits a positive correlation between economic conditions and car registrations, suggesting that periods of economic prosperity are associated with higher car registrations in Austria.

2 Data Exploration

2.1 Dataset Description

The dataset under analysis [2] contains information on the number of new passenger car registrations by brand in Austria. It is a time series dataset covering the period from January 2000 to September 2023. The dataset has 4 columns:

1. "Passenger car makes" - the brand of the car
2. "Time (monthly values)" - the month and year of the registration
3. "Vehicle type"
4. "Number of registrations of new vehicles" - the number of registrations for the given brand and month

The "Vehicle type" column is dropped from further analysis as it contains a constant value, "Passenger cars," which does not provide relevant information for the analysis.

2.2 Dataset Overview

- Number of rows: 12,612
- Number of columns: 4 (3 after dropping "Vehicle type")
- Number of unique brands: 105
- Total number of new car registrations: 7,213,112
- Car registration Mean: 571.92
- Car registration Minimum value: 1 (Note that there are no entries for no registrations)
- Car registration Maximum value: 7739
- Car registration Standard deviation: 842.73

2.3 Monthly Car Registrations

To address the high variations in the number of car registrations between brands, the "Number of registrations of new vehicles" column is aggregated by month. This is done to provide a more comprehensive overview of the data and to account for months where certain brands had no new registrations.

Figure 1 provides a visual summary of the monthly car registration data, displaying the median, quartiles, minimum and maximum values. It also shows that there are no significant outliers. The data appears to be moderately skewed, with some months having significantly higher or lower registrations compared to the median.

2.4 Car Companies

In order to conduct a more comprehensive analysis, the brands of the top car companies [5] [7] have been aggregated into specific groups. This grouping allows us to examine the performance and trends of these major car manufacturers more effectively. Table 1 shows the brand combinations that were made for further analysis.

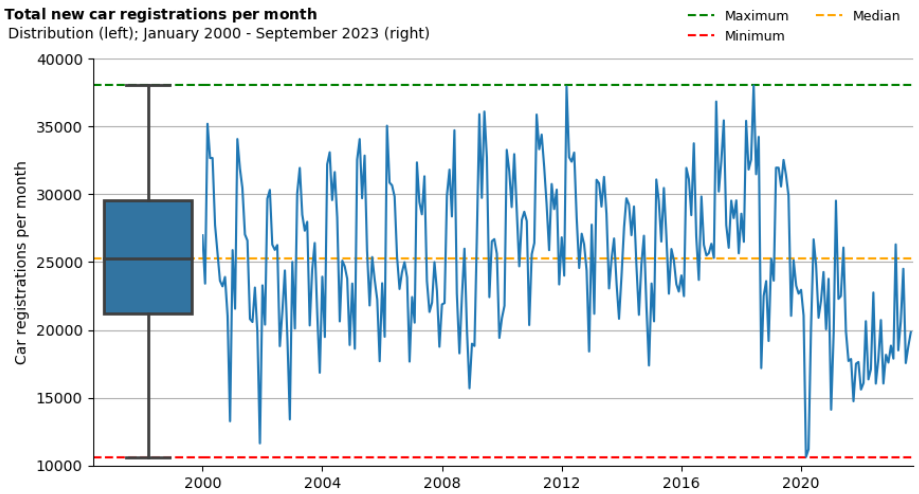

Figure 1: Total new car registrations per month.

Volkswagen [4]	Toyota	Stellantis [10][12]	Daimler [9]	General Motors	Renault-Nissan-Mitsubishi Allianz [11]	Ford	BMW	Hyundai Motor Group [8]
VW	Toyota	Abarth	Mercedes	GMC	Renault	Ford	BMW	Hyundai
Skoda	Lexus	Alfa Romeo	Smart	Chevrolet	Nissan	Lincoln	Mini	Kia
Seat	Daihatsu	Chrysler	Maybach	Buick	Infiniti		Rolls Royce	Genesis
Cupra		Citroen		Cadillac	Mitsubishi			
Audi		Dodge			Dacia			
Lamborghini		DS			Alpine			
Bentley		Fiat			Lada			
Ducati		Jeep						
Porsche		Lancia						
Bugatti		Maserati						
MAN		Opel						
		Peugeot						
		Ram						
		Vauxhall						

Table 1: Car companies and their brands.

2.5 Seasons

To analyze the presence of seasonality in the dataset, the months have been grouped into four distinct seasons: autumn, spring, summer, and winter, following the definition from WetterOnline [6]. This seasonal grouping facilitates a more structured examination of the data and allows for a comprehensive assessment of the influence of seasonality on new car registrations.

2.6 Economic Indicators

To gain insights into the potential impact of economic factors on new car registrations, the dataset has been extended to include GDP data provided by Statistik Austria [1] and the ATX index data provided by Wiener Börse [3]. This expansion allows for a thorough analysis of whether economic indicators, such as GDP and stock market performance, are associated with variations in the number of new car registrations.

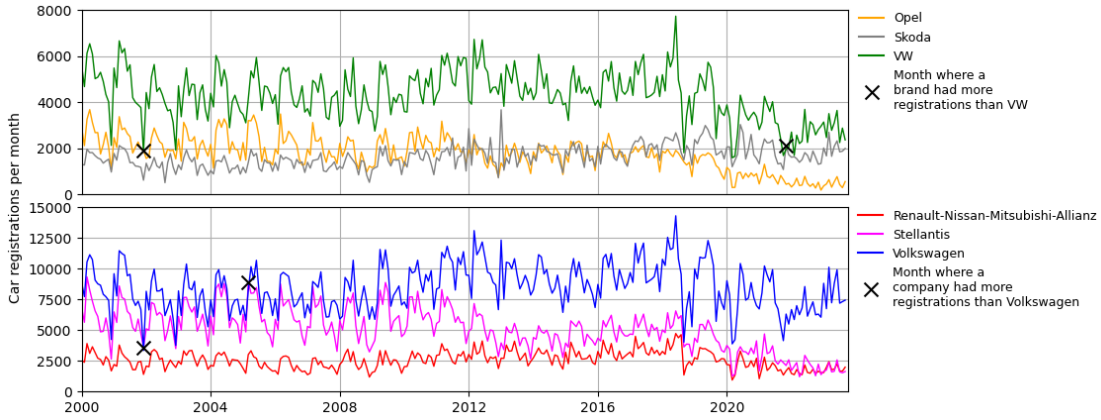

Figure 2: Comparison of Volkswagen to their two next best competitors.
Top Brands **Bottom** Companies

3 Analysis and Results

3.1 Hypothesis 1: Volkswagen Dominance

Since January 2000, Volkswagen has stood as an automotive giant, maintaining its dominance in the Austrian automotive market as both a brand and the flagship of the Volkswagen Group. The data as seen in Figure 2 reveals a remarkable and almost unbroken reign of Volkswagen, with only a couple of exceptions worth noting.

Volkswagen, as a brand, has been an undisputed leader in new car registrations in Austria. Over the course of more than two decades, it has consistently held the highest market share. Remarkably, there have been only two instances when another brand managed to surpass Volkswagen in new car registrations. In December 2001, Opel briefly overtook Volkswagen, and in November 2021, it was Skoda's turn to claim the top spot. Interestingly, Skoda is a member of the Volkswagen Group, and its moment of triumph indicates the strength of the Volkswagen Group as a whole.

In the most recent past, the data suggests that the Volkswagen brand may not appear as dominant as it once was. The rise of Skoda, a subsidiary of the Volkswagen Group, foreshadows a potential shift in the balance of power in the Austrian new car registration market. The data invites us to speculate whether Skoda's ascent could result in a more competitive landscape in the near future.

Looking at the Volkswagen Group as a whole, the picture is slightly different. The company has exhibited remarkable resilience and dominance. Similar to the brand-level analysis, there have been only two instances where another company surpassed the Volkswagen Group in new car registrations. Stellantis, a major automotive corporation, achieved this feat in December 2001 and then again in March 2005.

Despite occasional challenges at the brand level, the Volkswagen Group, as a conglomerate of brands, remains a force to be reckoned with in the Austrian market. Recent data indicates that the Volkswagen Group is more dominant than ever. This highlights

the strength and synergy of the group's various brands and suggests that even when individual brands face competition, the collective strength of the group continues to excel.

In conclusion, Volkswagen's position as a brand and the Volkswagen Group as a company in the Austrian new car registration market is one of enduring significance. While the brand-level data may suggest shifts in dominance, the group's overall performance remains formidable, underlining the enduring influence of this automotive behemoth. The future dynamics of this market are poised to be an exciting narrative to watch as competition intensifies, driven by both internal and external forces.

3.2 Hypothesis 2: Seasonality

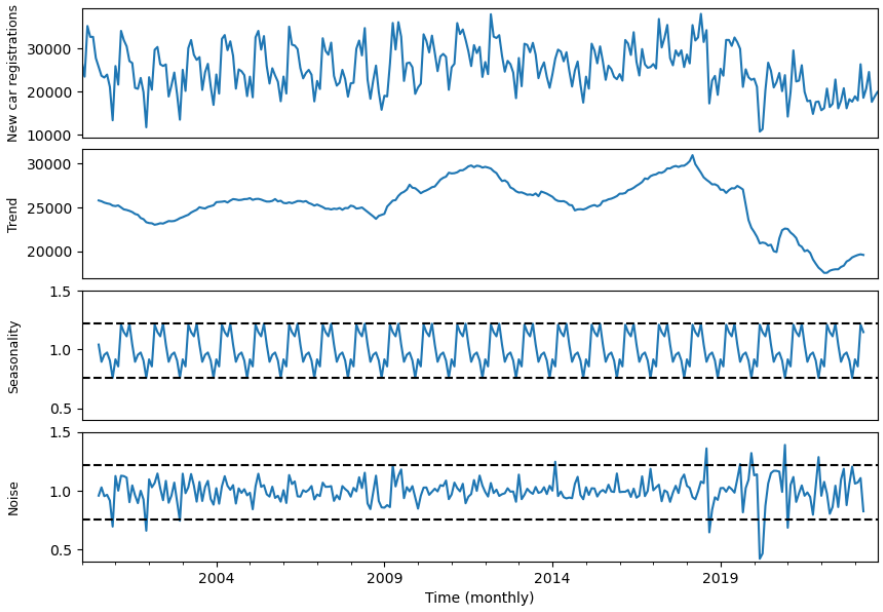

Figure 3: Visualization of Trend, Seasonality and Noise of monthly new car registrations.

Figure 3 showcases the decomposition of the data into trend, seasonality, and noise components. It is evident that the data demonstrates strong seasonal fluctuations. In most years, the seasonality component surpasses the noise component, signifying the robust seasonal pattern in new car registrations. It's worth noting that a deviation from this pattern occurred from 2019 onwards, possibly influenced by the global pandemic, COVID-19, which disrupted typical consumer behavior and economic conditions.

Figure 4 visually represents the seasonal changes in new car registrations per month. It offers a clear illustration of the seasonal pattern, with a marked increase during the spring and summer months and a decline during the autumn and winter. Notably, in every month of the winter and autumn seasons, there is a negative seasonal change, indicating reduced car registrations compared to the average. Conversely, in almost

every month of the spring and summer seasons (with the exception of August), there is a positive seasonal change, demonstrating a surge in new car registrations.

These two figures provide compelling evidence supporting the second hypothesis. The seasonality in new car registrations is a prominent feature of the Austrian automotive market, with consumers showing a consistent preference for registering new cars during the warmer months. This observation is in line with common consumer behavior, influenced by factors such as weather conditions, holidays, and the desire for new vehicles in preparation for summer travel.

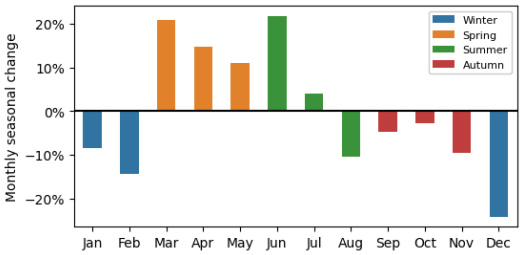

Figure 4: Seasonal change in new car registrations per month.

The existence of seasonality in new car registrations has practical implications for both the automotive industry and policymakers, as it can inform decisions regarding production schedules, marketing campaigns, and policy initiatives aimed at regulating the automotive market. Proceeding with this analysis, the influence of seasonality on new car registrations will be a key factor to consider when interpreting the data and its implications for future trends in the Austrian automotive market.

3.3 Hypothesis 3: Correlation with Economic Conditions

To explore this hypothesis, a correlation matrix was constructed, encompassing the following variables: yearly new car registrations, GDP per capita, disposable income per capita, and the yearly mean of the Austrian Traded Index (ATX). These variables are considered essential indicators of economic conditions that could influence car registrations. The correlation matrix was developed to assess the relationships between these variables.

The correlation matrix in Figure 5 provides insight into the relationships between the variables. Notably, it reveals that yearly new car registrations exhibit a slight negative correlation with the economic indicators (GDP per capita, disposable income per capita) and the ATX index. This finding suggests that, contrary to the hypothesis, new car registrations are not positively correlated with economic prosperity.

To further understand these relationships, Figure 5 also displays the relative development of each variable, with the year 2000 as the base year. This relative development offers a historical perspective on how these factors have evolved over time. The data suggests that new car registrations have experienced fluctuations, but their trend is not markedly aligned with the economic indicators or the ATX index.

The results challenge the third hypothesis, indicating that economic conditions, as measured by GDP, disposable income, and the ATX index, do not appear to have a strong positive correlation with new car registrations in Austria. While economic factors undoubtedly play a role in consumer decisions regarding car purchases, the data suggests that other influences, such as seasonality, consumer preferences, and environmental

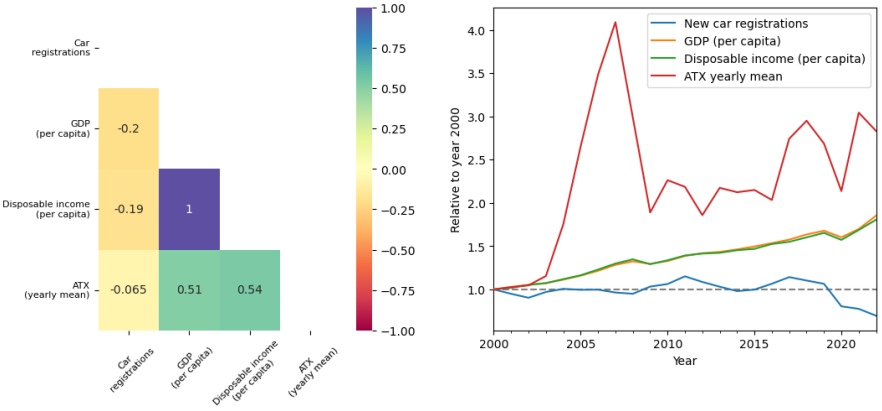

Figure 5: Correlation of new car registrations vs. economic conditions.
Left Correlation Matrix **Right** Relative development with 2000 as base year

considerations, may also be significant drivers of new car registrations.

This observation underscores the complexity of the automotive market and the multifaceted factors influencing consumer behavior. Policymakers, industry stakeholders, and researchers should consider this nuanced relationship between economic conditions and new car registrations when formulating strategies, policies, and forecasts for the Austrian automotive market.

4 Conclusion

This investigation revealed the remarkable dominance of Volkswagen, both as a brand and within the Volkswagen Group, in the Austrian new car registration market. While some fluctuations and challenges have arisen, the brand and the group have demonstrated a resilient and enduring influence.

Additionally, the exploration of seasonality underscored the significant impact of seasonal factors on new car registrations. The data clearly showed higher registration rates during the spring and summer months, followed by declines in the autumn and winter. This observation reflects consumer preferences and market dynamics strongly influenced by external factors.

Because the data challenged the third hypothesis, it was not possible to confirm a positive correlation between economic conditions and new car registrations. Future research could focus on the factors that influence new car registrations. Expanding the dataset with additional information would offer deeper insights. Promising directions for future research include used car registrations, electric car percentage and a geographic distribution of car registrations.

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