Armenia's Automobile and Battery market analysis

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***Abstract*—The automotive sector in Armenia has changed in different ways because of global economic shifts, local policy changes, and technological advances. This paper presents a detailed market analysis focusing on the import and export patterns of cars and car batteries, correlating these trends with the demand and distribution of battery capacities. Utilizing data from Armenian Statistical Agency [1] and Car Selling Platform [2], we identify significant market shifts influenced by events such as the 2008-2009 financial crisis, recent tax adjustments, and the COVID-19 pandemic. The paper also explores the potential for setting up a new car battery retail store(s) in Yerevan, examining optimal store locations, inventory structure, and pricing strategies based on comprehensive market data and predictive analytics. The predictions of the market's future and geospatial analysis aim to support decision-making for stakeholders planning to invest in growing opportunities in the automotive battery landscape in Armenia.**

***Index Terms*—Car batteries, market analysis, import, export, Armenia, economic trends, predictive modeling.**

I. Introduction

A. Problem Statement

The automotive industry is complex because it's affected by economic conditions, changing regulations, and new technology. In Armenia, the car and car battery markets are particularly influenced by international trade dynamics and local consumer demand patterns. Understanding these factors is crucial for effective market entry and competitive strategy development.

B. Research Objectives

- To analyze the import and export characteristics of cars and car batteries in Armenia.
- To examine the demand for and proportions of batteries with different capacities.
- To evaluate the feasibility and strategic considerations for establishing a car battery store in Yerevan, including the best location, inventory management, and pricing strategies.

C. Methodology Overview

This study uses descriptive analytics and predictive modeling on data sourced from the National Statistical Service of Armenia and a local car trading platform. The analysis includes trend examination, correlation of car imports with battery demand, and geospatial analysis for store placement.

D. Significance of the Study

The insights from this research will help businesses, and investors with a deeper understanding of the Armenian car battery market's dynamics. This is important for handling market challenges and taking advantage of opportunities, especially with the growing move toward electric vehicles.

II. Data

A. Data Collection

The dataset of imports/exports volume and prices is sourced from the Armenian Statistical website, which provides information on cars, batteries, and tire imports/exports. These datasets include detailed records of product names, codes, overall weights, and overall volumes. Both imports and exports volumes are represented in tonnes and the overall prices are represented in 1000 US dollars. The data spans annual figures broken down into monthly periods starting from January 2007 to December 2023, with a cumulative column for the entire year. The datasets which were taken from Armenian Statistical Agency, were restructured by integrating the year and month columns of the dataset into a single date column. This transformation allows for a more granular examination of temporal trends and standardizes the format across all datasets from Armenian Statistical Agency. By using official amount of imports from the years 2022 and 2023, the import and export amounts are transformed into numbers by unit from the two columns that were in tonnes and 1000 dollars. The overall weight was divided by the number of official number of imports for the last years. This way the average weight for 1 car was identified. Then overall weight numbers of each months imports starting from 2007, were divided by the average weight of 1 car. This way the approximated number of each month's and each year's import amount was found. The datasets were transformed using the SAS programming language.

B. Historical Trends: Cars

The time-series data from 2007 to 2024 revealed significant fluctuations in car import and export volumes(Figure 2):

[1] Armenian Statistical Agency - armstat.am
[2] Car Selling Platform - auto.am

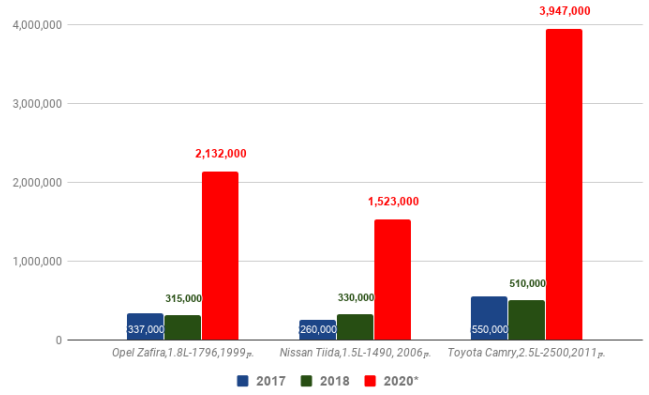

Fig. 1. Examples of Changes of tax amount on most Popular car models uic.am

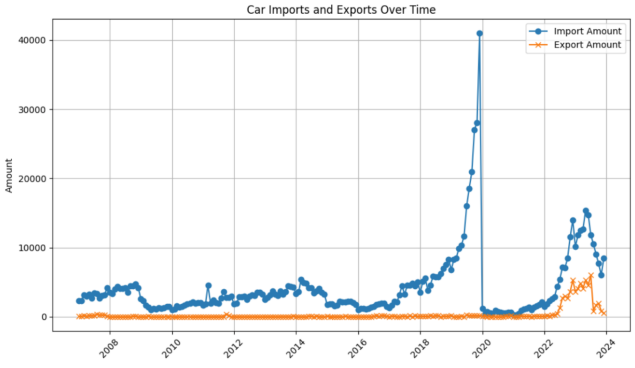

Fig. 2. Import/export amount of cars 2007-2024

- A marked decrease was observed during the 2008-2009 global financial crisis, with a recovery period extending until 2014, demonstrating the sector's resilience.
- In 2019, a surge in car imports occurred in anticipation of new taxation policies scheduled for 2020 (uic.am). The new taxation was going to be applied by the rules of the Eurasian Economic Union after nearly 5 years of Armenia's membership as a EEU member since 2015. The new policy disproportionately affected older vehicles (Figure 1). This preemptive increase in imports was aimed at circumventing higher future costs.
- In 2020, the global spread of COVID-19 and the outbreak of the Nagorno-Karabakh war profoundly impacted international trade and imports/exports. The pandemic, which began earlier in the year, led to a sharp decline in global demand and significant disruptions to supply chains. Governments imposed lockdowns and border closures, causing delays in cargo shipments, shortages of goods, and increased transportation costs. As these challenges were unfolding, the conflict in Nagorno-Karabakh further complicated the situation by disrupting trade routes. Together, these crises resulted in a marked downturn in trade volumes and import/export activities.
- By 2021, the market demonstrated resilience and adaptability, with a notable increase in exports, especially to the Eurasian Economic Union (EEU). This uptick was driven by several key factors, including favorable export policies implemented by countries within the EEU and changes in external demand. The latter was significantly influenced by international sanctions imposed on the Russian Federation, which altered trade dynamics and opened new opportunities for exporters in the region. These shifts allowed nations within the EEU to capitalize on redirected trade flows and enhance their economic engagements, thereby mitigating some of the adverse effects experienced in the previous year due to the pandemic and regional conflicts.

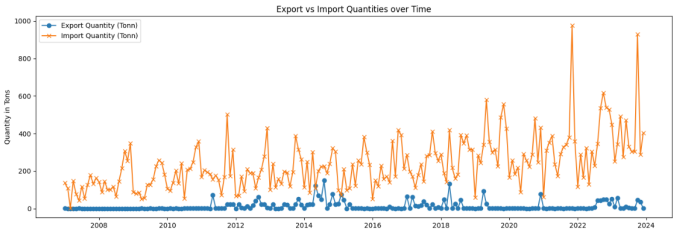

Fig. 3. Import/export values of batteries in tonnes

C. Historical Trends: Batteries

The battery import rates more or less stayed steady during the years. The import numbers of batteries were also influenced by the factors mentioned in the cars dataset. The battery import numbers were also influenced by the local production of batteries. ELBAT, established in 2007, began producing car batteries in 2011. Despite its contributions, the factory's output of 15,000 batteries per year for Armenia satisfies only about 12.5 percent of the estimated annual demand of 120,000 units, leaving a heavy reliance on imports to meet the remaining demand. They export most of their batteries to countries including Russia, Georgia, Iran, Syria, and the UAE.

D. Car Listings Dataset

The data is scraped as of January 2024. It includes car name, model, make year and description. Data from the listings website consists of 1000 rows. It is enriched through expert consultations and online resources to correlate each car model with its appropriate battery type, enabling a more refined analysis of the market needs (Figure 4). Two new columns are added. One shows the corresponding battery capacity in amps per hour the car needs to operate, and the other one indicates the type of that battery. The car batteries can have one of two types: AGM or regular lead acid.

The observed data of the car listings after enrichment indicates an increasing usage of AGM batteries in both electric vehicles and newer cars. The shift towards AGM batteries is supported by their enhanced durability and maintenance-free characteristics. The AGM batteries are particularly suited for the electrical demands of modern vehicles (Figure 5).

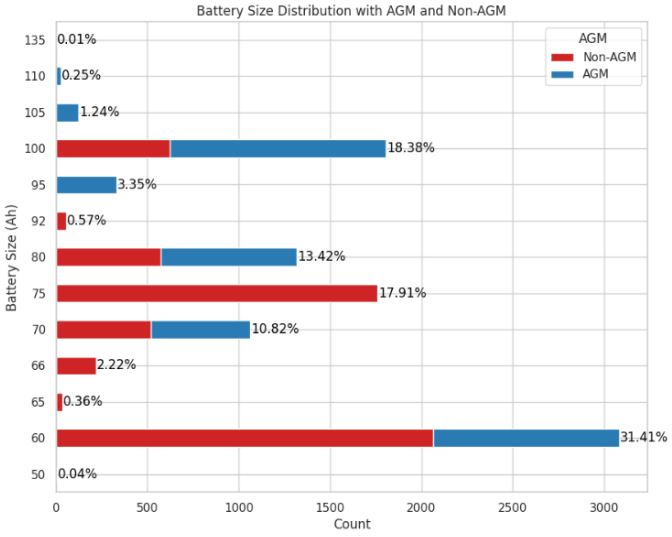

Fig. 4. Battery Capacity Distribution

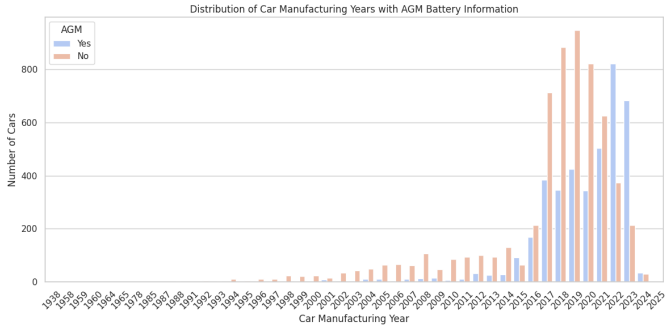

Fig. 5. Distribution of Production Years of Cars and AGM Battery Usage

E. Other Datasets

The data of car battery stores is taken from the website, spyur.am. The data includes the company name, location of the store and the longitude and latitude of the locations of each store. The dataset of house prices is scraped from the website, list.am. This dataset comprises data scraped from list.am, featuring 766 apartment listings uniformly distributed across the 10 districts of Yerevan. Each listing includes a direct URL, a title summarizing key details such as location, number of rooms, total area in square meters, and floor location within the building. The district name is also specified for geographical segmentation. Descriptions in each listing provide additional information on the apartment's condition, amenities, and other relevant characteristics. Prices are listed in dollars, offering insights into the property values and serving as an economic indicator of the residents' solvency in each district. The data of Yerevan districts and their population is changed and a new column is added. By doing calculations the density of the population is calculated. The density is calculated by dividing the population of a district by its area.

III. Methodology

A. Visualization of Datasets

Python programming language was utilized for creating visual representations of the data to understand trends and temporal changes in import/export volumes and to explore correlations between the car and battery markets. Visualizations were also used to see the proportions of battery capacities and car production years from corresponding datasets. Libraries such as `matplotlib` for time series plots and `seaborn` for correlation heatmaps were used.

B. Predictive Modeling

A Seasonal Autoregressive Integrated Moving Average with Exogenous Variables (SARIMAX) model was implemented to forecast future import volumes for cars and batteries. The choice of SARIMAX was due to its capability to handle seasonal variations and the impact of external variables, which are very important in economic time series data. SARIMAX is an extension of the ARIMA model.

The "Seasonal" aspect of SARIMAX enables the model to handle fluctuations that reoccur over regular intervals, addressing patterns that appear seasonally in monthly sales data or quarterly financial reports.

The "AutoRegressive" component posits that current values in a series can be predicted based on previous values, suggesting a direct linkage between past and future data points within the time series. This part involves using past values of the time series to predict future values. The formula for the AR component of order p is:

$$\phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \cdots + \phi_p Y_{t-p}$$

where ϕ_i (i ranges from 1 to p) are the coefficients of the autoregressive terms. Y_{t-i} represents the value of the series at time $t-i$. The subscript $t-i$ on Y indicates the lag i. The ellipsis ($\cdots$) indicates that the pattern continues up to p terms.

The "Integrated" part focuses on rendering the time series stationary. This is achieved through differencing the data, a method that helps stabilize the series' mean by eliminating trends and cyclical elements. This represents differencing the series to make it stationary (i.e., to have constant mean and variance over time). Differencing involves subtracting the previous observation from the current observation. If the series is differenced d times, it is denoted as:

$$\nabla^d Y_t$$

where ∇^d denotes the d-th difference of the time series. Y_t is the value of the time series at time t. The superscript d on ∇ indicates the order of differencing.

"Moving Average" deals with the model's error term, where forecasts are adjusted based on the inaccuracies of past predictions. This component is crucial for smoothing out the noise within the data. This component models the error of the model as a linear combination of error terms that occurred

contemporaneously and at various times in the past. The MA part of order q is:

$$\theta_1\epsilon_{t-1} + \theta_2\epsilon_{t-2} + \cdots + \theta_q\epsilon_{t-q}$$

"Seasonal Components" are similar to the non-seasonal components but involve backshifts of the seasonal period. For example, for a seasonal period *s*, the seasonal AR of order *P* and MA of order Q can be written as:

$$\Phi_1 Y_{t-s} + \Phi_2 Y_{t-2s} + \cdots + \Phi_P Y_{t-Ps}$$

$$\Theta_1\epsilon_{t-s} + \Theta_2\epsilon_{t-2s} + \cdots + \Theta_Q\epsilon_{t-Qs}$$

These represent the seasonal autoregressive (SAR) and seasonal moving average (SMA) parts of a SARIMAX model, where Φ_i (where i ranges from 1 to P) are the coefficients of the seasonal autoregressive terms. Θ_i (where i ranges from 1 to Q) are the coefficients of the seasonal moving average terms. Y_{t-is} represents the value of the series at time $t - is$ for the SAR part, and ϵ_{t-is} represents the error term at time $t - is$ for the SMA part. The ellipsis $(\cdots)$ indicates that the pattern continues up to P or Q terms.

Finally, the inclusion of *eXogenous variables* allows SARIMAX to account for external influences that impact the series but are not inherently part of it, such as economic indicators or weather conditions. This feature renders SARIMAX exceptionally versatile and effective in scenarios where these external factors significantly influence the forecasts. These variables might affect the response variable *Y* but are not affected by *Y*. They are included in the model as follows:

$$\beta_1 X_{1,t} + \beta_2 X_{2,t} + \cdots + \beta_k X_{k,t}$$

This formula represents the combination of k exogenous variables $(X_{1,t}, X_{2,t}, \ldots, X_{k,t})$ with their respective coefficients $(\beta_1, \beta_2, \ldots, \beta_k)$.

The complete SARIMAX model can be represented as:

$$Y_t = c + \text{AR part} + \text{MA part} + \text{Seasonal AR part}$$

$$+\text{Seasonal MA part} + \text{Exogenous Variables} + \epsilon_t$$

In this equation Y_t represents the value of the time series at time t. c is a constant term or intercept. "AR part", "MA part", "Seasonal AR part", "Seasonal MA part", and "Exogenous Variables" denote the respective components of the SARIMAX model as described earlier. ϵ_t represents the error term at time t.

C. Geospatial Analysis

Geospatial analysis was conducted using `Folium` in Python to optimize the placement of a new battery store. This analysis involved mapping potential locations and key surrounding features, such as, neighborhood density, and competitor presence, which were derived from the local directory website `spyur.am`. The map also uses a geojson file which is created with the help of the website, `geojson.io`. The geojson file marks the borders of all the districts of Yerevan and helps to identify the locations of competitor stores. The density is derived from the dataset of districts and population. This factor can help to find locations with high densities for potential high sales. Another factor to look for is the solvency of the population. To be able to use this factor, apartments' data was scraped from `list.am`. The logic is that apartment prices are a great way to measure a district's solvency. Visualization shows the exact way the solvency levels are distributed among the districts of Yerevan.

IV. Results

A. Prediction Trends

- **Batteries:** The exogenous variables for the batteries import volume prediction are:*impact_financial_crisis', 'impact_preemptive_imports', 'impact_war_pandemic', 'impact_recovery', 'impact_domestic_production'*. In the prediction we are able to see a similar trend happening similar to the previous years. Overall it shows that the imports will be high until the end of 2025 then it will drop and start to gain momentum again during the year. We can see the same trend happening for almost every year. This finding shows that the model predicted quite well and accurately. The import numbers will follow the trends and the market will be stable if there will not be new external factors (Figure: 6).
- **Cars:** The exogenous variables for the cars dataset are: *financial_crisis, taxation_policy, war_pandemic, and market_adaptation*. The prediction model was run without the exogenous variables at first and the results were different and the import was predicted to be higher. The exogenous variables changed the model. The model understood that the big changes in the import rates happened because of different external factors. Then the model identified the average demand of Armenia and predicted a very normalized prediction (Figure:7).

B. Future Outlook

- **Battery Market:** In the business plan, the potential for increased self-sufficiency in battery production within local market should be considered. Exploring opportunities in emerging battery technologies and recycling programs is very important to be able to adapt easily and quickly. These changes might also be favored by new regulations.
- **Car Market:** The business plan for cars should take into account the potential shifts in consumer preferences, possibly towards electric vehicles. Regulatory changes may likely favor vehicles with lower emissions, which could transform the nature and volume of car imports, which will play their part in the demand of car batteries.
- **Adaptability:** Given the impact of exogenous variables on both markets, developing a flexible storage organization and purchase strategy that can quickly adapt to crises and policy shifts will be critical.
- **Innovations:** Innovation in product design and quality could position a product favorably. That is why it is important to follow the innovations and make sure the store storage is up to date.

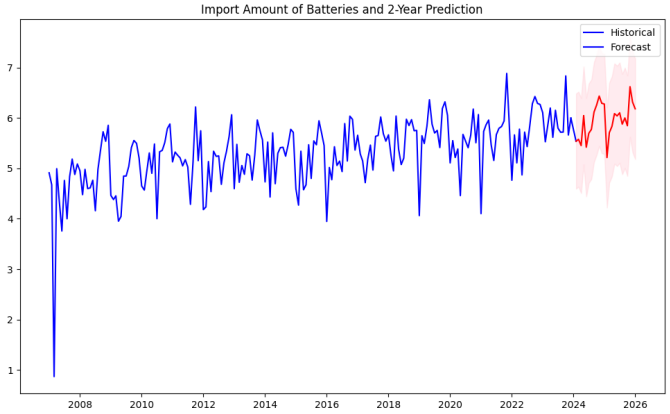

Fig. 6. Historic data and 2 year prediction(Battery imports)

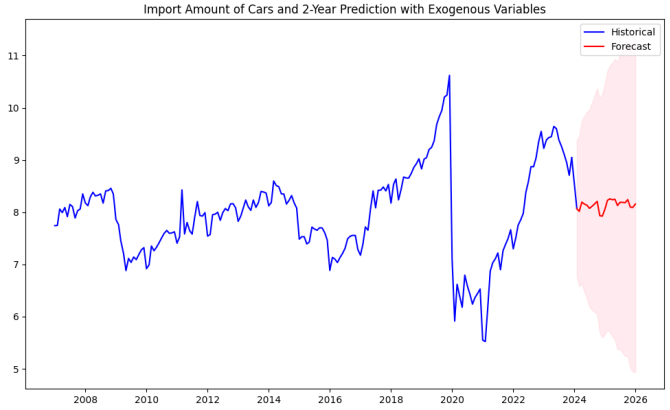

Fig. 7. Historic data and 2 year prediction(Car imports)

- **Local vs. Global Dynamics:** Balancing between supporting local production and engaging in global trade will be a key challenge, requiring careful monitoring of policy changes and market signals.

C. Potential of the Car Listings Dataset

Continuously scraping car listing data from the car listings website enables us to track market trends and anticipate shifts in battery demand corresponding to the distribution of vehicle types. This ongoing data collection provides valuable information that can make the inventory management significantly better. By understanding these market dynamics, store managers can optimize their stock levels and ensure a diverse selection of batteries is available to meet the needs of various car models. This approach improves the efficiency of storage management and enhances customer satisfaction by reliably meeting consumer demands(Figure 5).

D. Interdependence of Car Imports and Battery Market Dynamics

Within the scope of the Car Batteries Market Analysis and Business Plan, an essential facet of the market dynamics is the

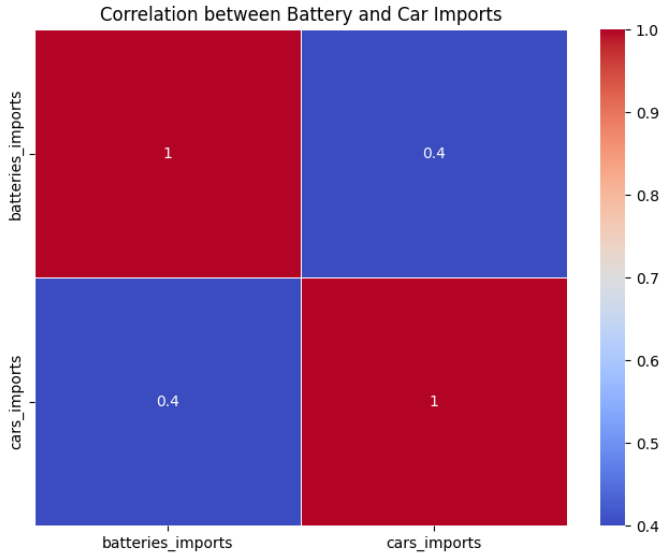

Fig. 8. Cars and Batteries Import Correlation

interdependence between the import of cars and the demand for car batteries. The analysis of import data over the last four years reveals a consistent pattern: as car imports fluctuate, so too do the imports of batteries, with a correlation coefficient of 0.4 indicating a moderate positive relationship (Figure: 8).

This relationship is particularly pronounced in scenarios where imported vehicles need battery replacements — a common requirement for cars that have experienced accidents and are in need of significant refurbishment. Such conditions are usual in the automotive industry and result in a predictable demand for batteries with the arrival of imported vehicles. This pattern is more than a statistical correlation. It reveals the big impact that automotive trends have on the battery market. When car imports increase, so does the need for batteries, suggesting that car import levels could be a leading indicator for battery import demand.

E. Importance of Interdependence for Business Strategy

For stakeholders in both the automotive and battery sectors, these findings are critical for strategic planning. By aligning inventory and supply chain management with the observed import trends, companies can optimize their operations to respond proactively to market demands. For instance, a surge in car imports can signal to battery suppliers the need to ramp up their inventory in anticipation of increased demand.

On the other hand, a decline in car imports should prompt a reassessment of battery stock levels to avoid overcapacity. Through a thorough market analysis and by following the correlations between these two industries, businesses can craft a more agile and responsive business strategy, ensuring that the supply of batteries can keep up with the demand created by car imports.

In conclusion, the correlation between car imports and battery demand over the previous four years demonstrates a

connection that businesses in the relevant sectors should look out for. As part of our Car Batteries Market Analysis and Business Plan, it is recommended that companies consider these market dynamics in their logistical and operational planning to capitalize on this identified trend and in order to have an approach that can withstand the flow of import activities and the possible changes in it.

V. Conclusion and Market Implications

A. Pricing and Storage

Two of the most important factors include pricing strategy and storage distribution. To determine appropriate pricing, it is important to investigate the solvency of the area where the store will be located. To address this, house prices in Yerevan's districts are analyzed, as they are a direct indicator of a district's financial strength. In areas with high solvency, it is expected that residents may own more expensive cars, thus requiring more batteries for these vehicles. This means that the store will need to accommodate a higher inventory of batteries for luxury cars. Additionally, pricing strategies can vary based on solvency: in wealthier areas, a higher margin can be justified for the same product, whereas in less wealthy areas, prices should be more competitive.

B. Geospatial Analysis

The location of a car battery store is crucial for its success. Several factors influence a store's success, including storage organization, pricing strategy, and the presence of competitors in the area (Figure: 9). It is essential for business owners to be adaptable in order to thrive in a competitive market.

Geospatial analysis is utilized to visually examine competitors' store locations. The red and blue circles are battery stores. When clicked on they display the company name and address. Separate pins are also set on the map for districts' information. By clicking on a pin of a district the name of the district, the level of solvency and population density will pop up. They are both set in grades from 1 to 10. For both density and solvency 1 means low and 10 means high. This analysis helps to identify areas where competitors are absent and where there is potential market demand for a new store. Specifically, in Yerevan, we can observe that there are almost no battery stores on the eastern and southeastern sides of the city. Nor Nork is a great starting location for a business. The population density is high at 9, however the solvency is low at 2. Important to mention that there are no battery stores in the central part of the district Nor Nork. The new store will have storage management corresponding to the solvency of the area. As for the start the store will have more batteries for cheaper cars. Over time the store can grow and adapt, potentially increasing its profit margin.

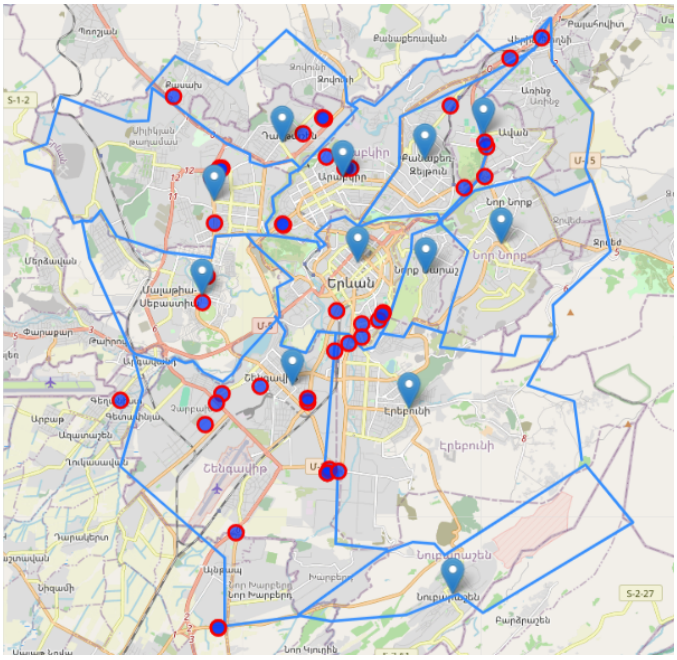

Fig. 9. Car Battery Stores and Information on Districts

C. Future Integration of AGM Batteries in Storage

As the automotive industry continues to evolve, with a greater focus on electric vehicles and advanced automotive technologies, the demand for AGM batteries is expected to rise. Although these batteries are more expensive, their longer lifespan and reliability justify the higher cost. This trend suggests a gradual shift in the battery market dynamics, where the increased adoption of AGM batteries will likely influence inventory and pricing strategies.

The main factors influencing storage distribution are cars' variety and their specific battery requirements. The inventory of a battery store can be constructed by analyzing a dataset of car listings and their corresponding battery types, including whether a car uses an AGM or a regular lead-acid battery. The data shows, for example, that the most commonly used battery is the 60Ah battery. Therefore, recommend over 30 percent of battery stock be 60Ah batteries, with 60 percent being regular lead acid and 40 percent AGM batteries (Figure 4). These proportions could vary based on the other factors previously mentioned.

In summary, these findings point to an active and adaptive automotive and battery market within Armenia, shaped by policy, economic forces, and consumer preferences. The insights provided here are critical for those involved in car sales, battery retail, and related services, to make strategic decisions aligned with market dynamics.

This methodological framework combined data transformation, visualization, predictive modeling, and geospatial analysis to understand the dynamics of the Armenian car and battery markets, thereby supporting informed business strategy development.

The analysis provided a strategic foundation for decision-making in launching a new battery store. The predictive models also offered insights into future market trends, essential for inventory and marketing strategy planning.

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