Northeastern University
College *of* Engineering

Data Warehousing & Integration
IE 6750
FALL 2024

[Retail sales and Inventory Analysis]

AWS Project Report

Group 11

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Submission Date:_____12/07/24_____

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Problem Statement

The goal of this project is to analyze the Brazilian e-commerce dataset in sales, customer behavior, and operational efficiency. By implementing a data pipeline, we aim to process and analyze large volumes of retail data to identify trends, optimize inventory etc

The primary objective is to implement a cloud-based data pipeline using AWS services to process and analyze large volumes of retail data. This approach will enable the identification of trends, optimization of inventory management, and enhancement of overall business operations

The project utilizes various AWS services to create an efficient ETL (Extract, Transform, Load) pipeline. These services include AWS S3 for data storage, AWS Glue for data transformation, AWS Athena for data analysis, and AWS Step Functions for workflow orchestration

Here are the key KPIs and metrics that were analyzed.

Sales Performance Metrics
- Total sales value by product category
- Revenue per seller
- Product-wise sales volume
- Sales trends over time

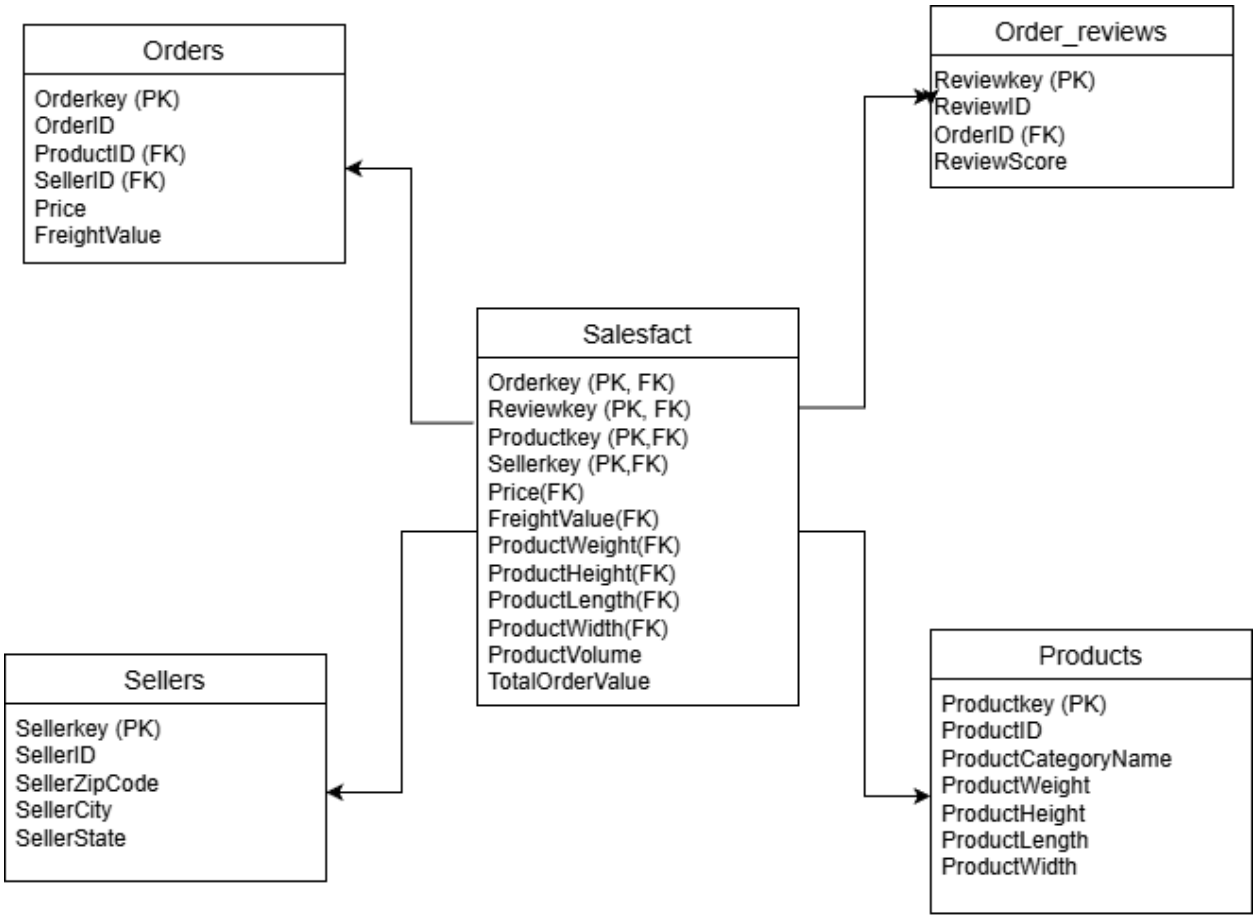
Customer Behavior Metrics
- Average review scores
- Review distribution across product categories

Operational Metrics
- Average freight costs per seller
- Seller performance by region

Product Analytics
- Product dimensions (average length, width, height)
- Product weight metrics
- Category-wise product performance
- Top products by total sales value

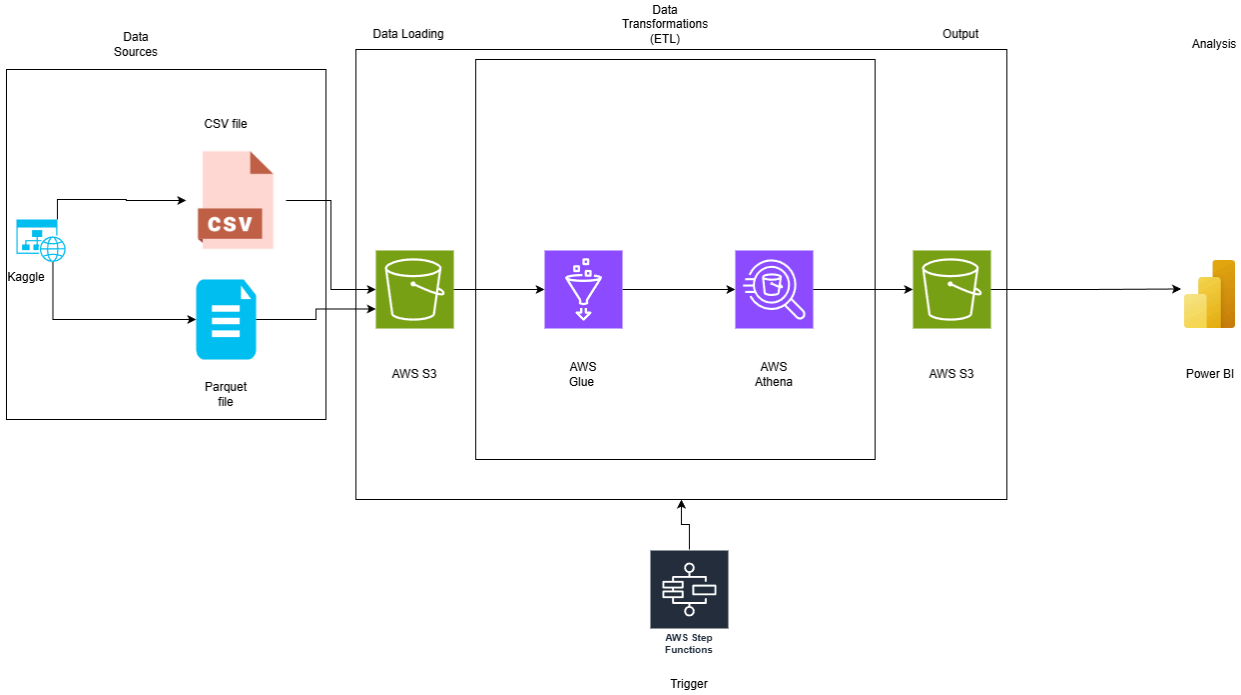
Seller Performance Metrics
- Total sales value by seller
- Geographical distribution of sales
- Average review scores by seller
- Seller efficiency by state/region

Logical Model



ETL Process

Data Architecture



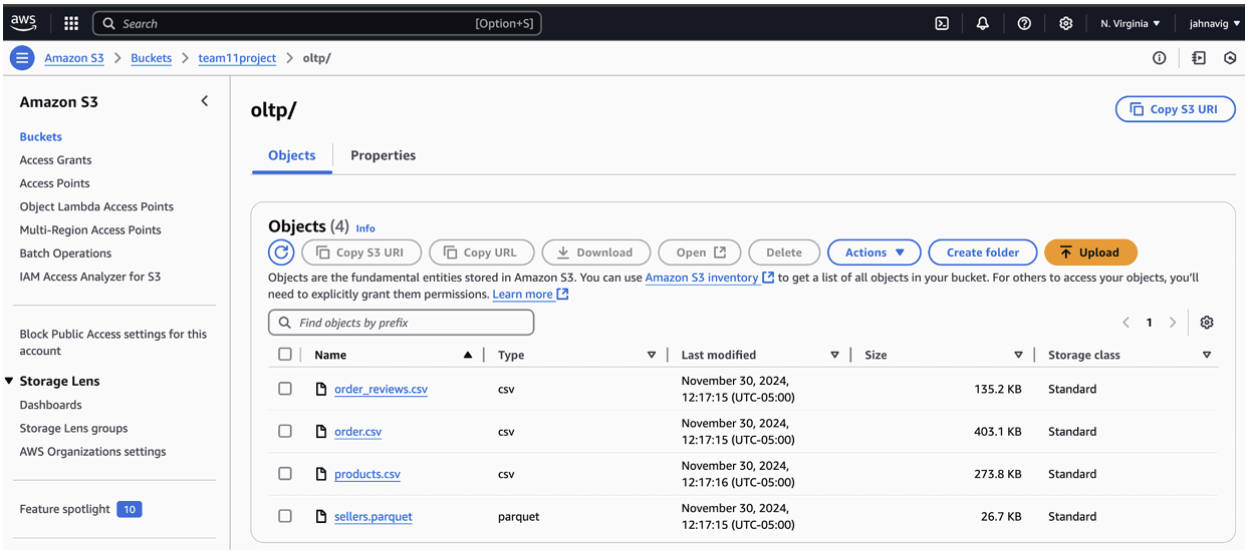
Data Sources

The pipeline processes multiple data files from the Brazilian e-commerce platform:
- Order Items (CSV format)
- Products (CSV format)
- Order Reviews (CSV format)
- Sellers (Parquet format)

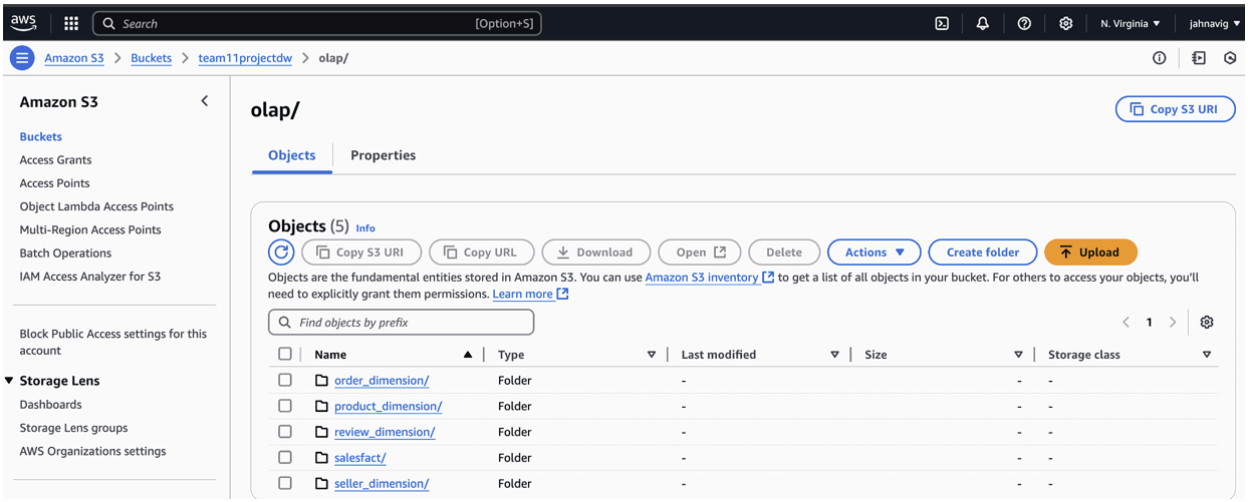
Data Loading Phase

AWS S3 Implementation
- Raw data files are uploaded to the initial S3 bucket
- AWS Step Functions orchestrates the entire ETL workflow

S3 Bucket



Data warehouse bucket (team11projectdw)



Data Transformation Phase

AWS Glue Job 1: Dimension Loading

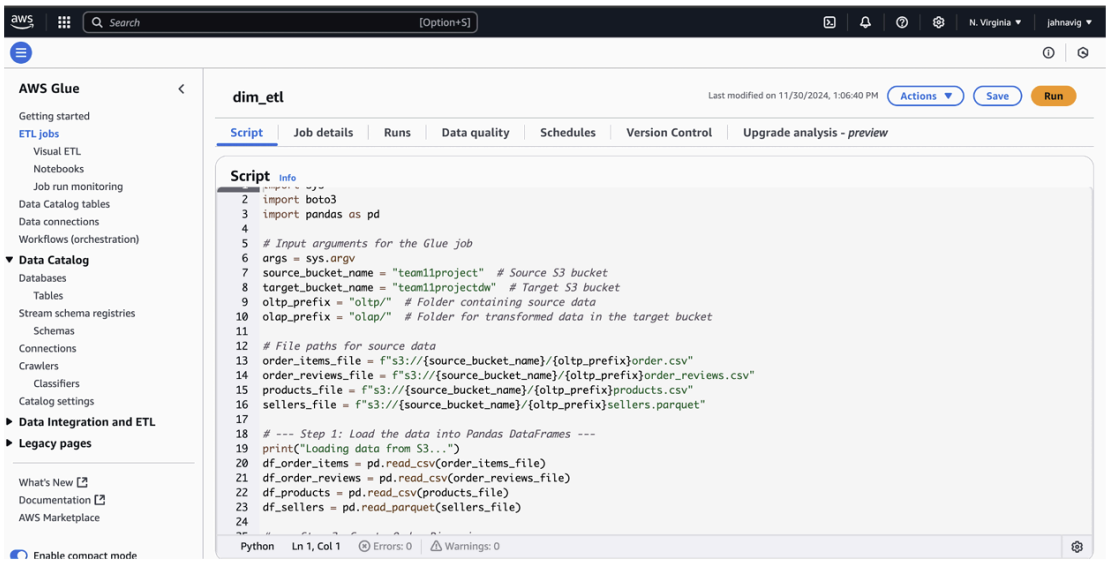
- Processes four key dimensions:
  - Order Items
  - Products
  - Reviews
  - Sellers
- Performs transformations:
  - Selects relevant columns
  - Removes duplicate entries

  - Assigns primary keys to dimensions
- Outputs transformed dimensions as CSV files to S3

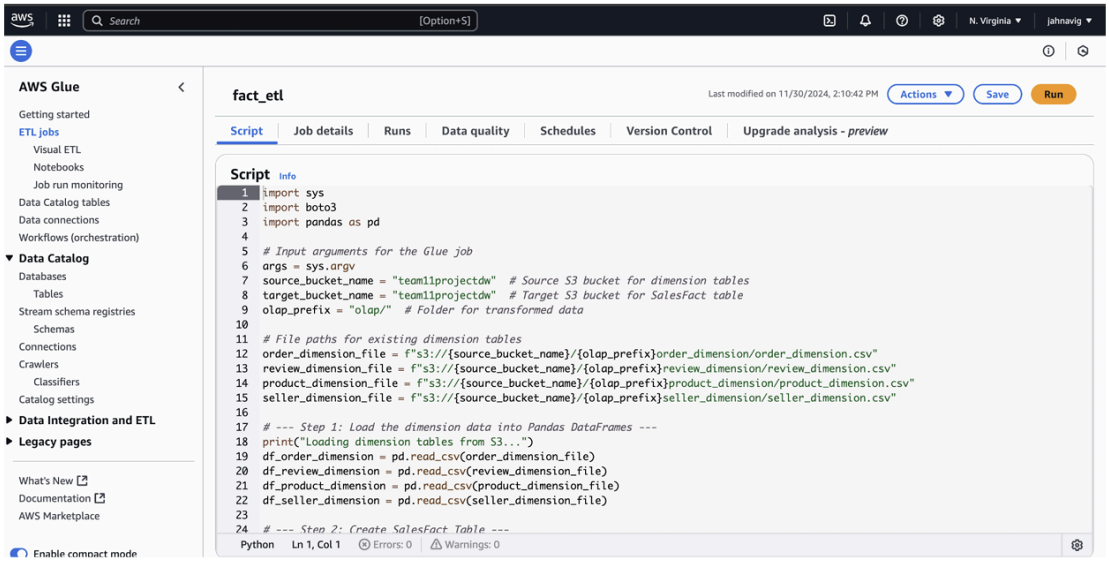
AWS Glue Job 2: Fact Table Creation
- Creates the sales fact table through:
  - Joining dimension data using keys
  - Calculating business metrics (order value, product volume)
  - Assigning primary keys to fact rows
- Stores fact table as CSV in output S3 bucket

AWS Glue

1) dim_etl - executes the loading data into the dimensions of the data warehouse



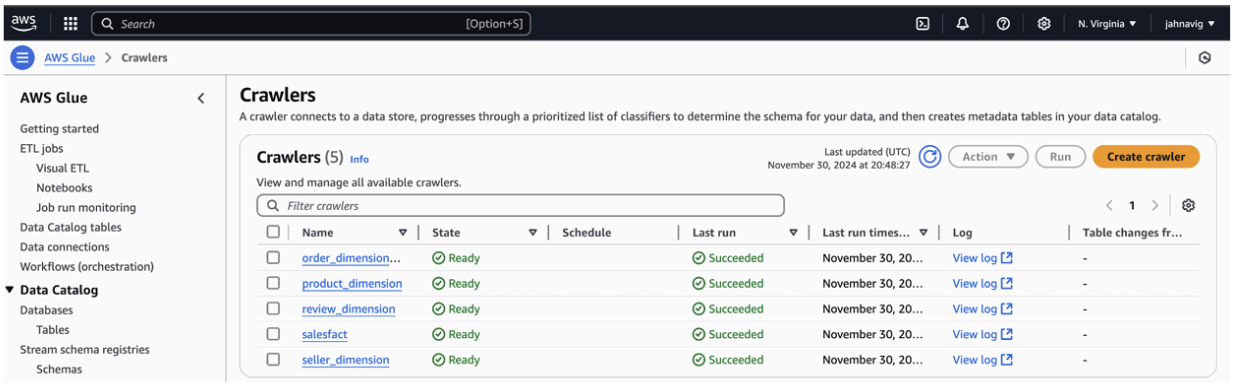
2) fact_etl - executes loading data into fact table of the data warehouse



Data Cataloging

- Implements Glue Crawlers for:
  - Products
  - Orders
  - Sellers
  - Order reviews
- Updates the AWS Glue Data Catalog automatically

AWS Crawler:



Data Analysis Phase

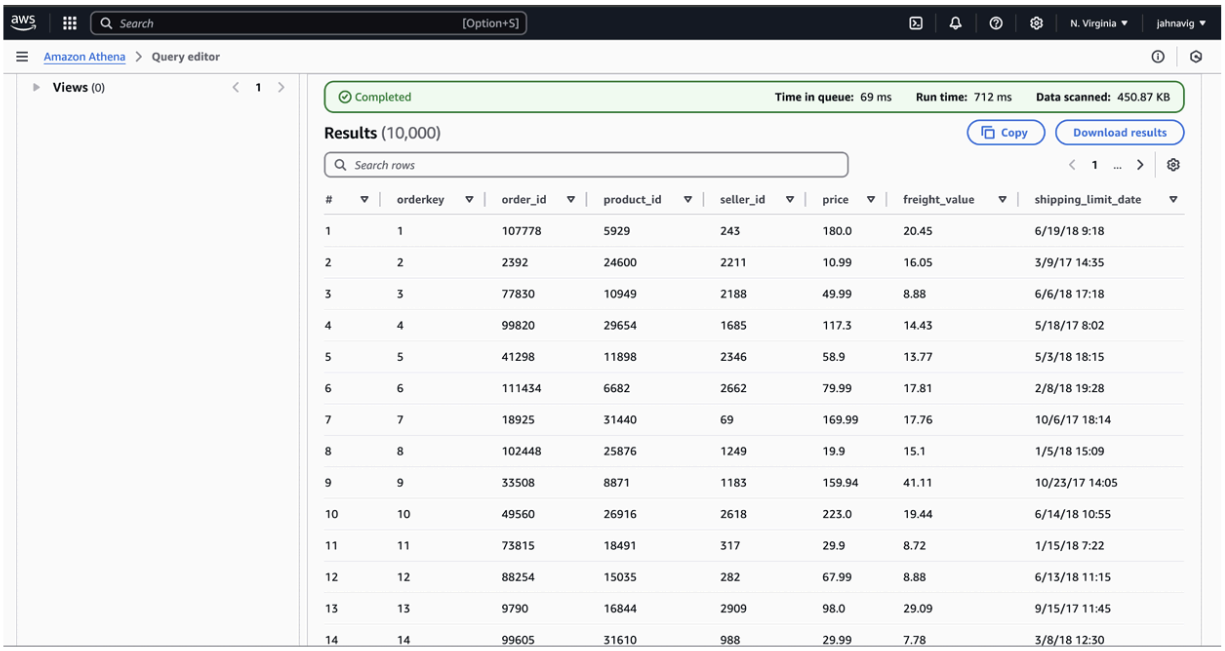
AWS Athena Implementation

- Executes SQL queries on the transformed data
- Generates insights on:
  - Sales trends
  - Seller performance
  - Product category metrics
  - Customer review analysis

AWS Athena

Select queries for dimensions & facts:

1) Order dimension



Amazon Athena > Query editor

Views (0)

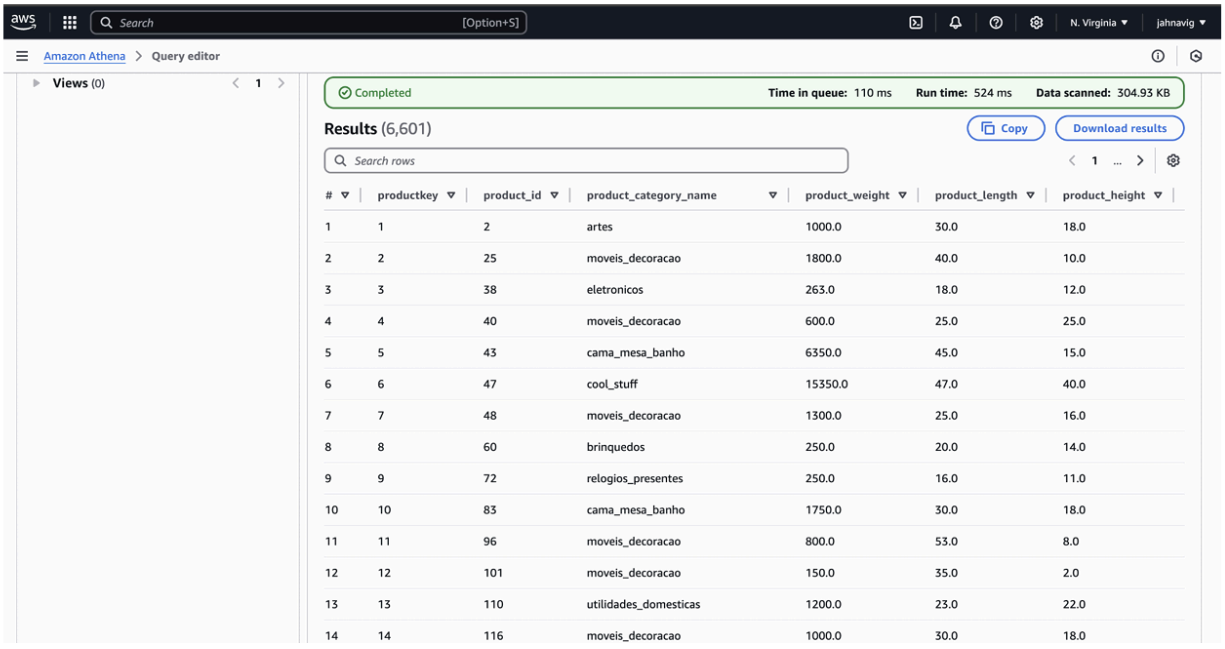
Completed — Time in queue: 69 ms — Run time: 712 ms — Data scanned: 450.87 KB

Results (10,000) — Copy — Download results

Search rows

#	orderkey	order_id	product_id	seller_id	price	freight_value	shipping_limit_date
1	1	107778	5929	243	180.0	20.45	6/19/18 9:18
2	2	2392	24600	2211	10.99	16.05	3/9/17 14:35
3	3	77830	10949	2188	49.99	8.88	6/6/18 17:18
4	4	99820	29654	1685	117.3	14.43	5/18/17 8:02
5	5	41298	11898	2346	58.9	13.77	5/3/18 18:15
6	6	111434	6682	2662	79.99	17.81	2/8/18 19:28
7	7	18925	31440	69	169.99	17.76	10/6/17 18:14
8	8	102448	25876	1249	19.9	15.1	1/5/18 15:09
9	9	33508	8871	1183	159.94	41.11	10/23/17 14:05
10	10	49560	26916	2618	223.0	19.44	6/14/18 10:55
11	11	73815	18491	317	29.9	8.72	1/15/18 7:22
12	12	88254	15035	282	67.99	8.88	6/13/18 11:15
13	13	9790	16844	2909	98.0	29.09	9/15/17 11:45
14	14	99605	31610	988	29.99	7.78	3/8/18 12:30

2) Product dimension



Amazon Athena > Query editor

Views (0)

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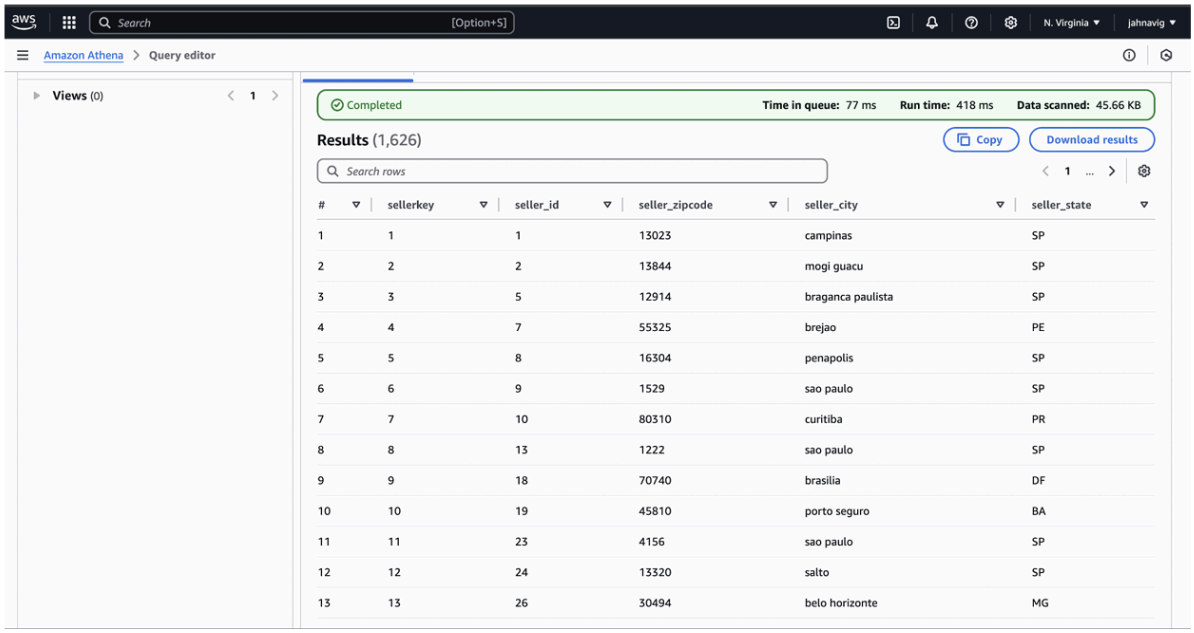
Results (6,601) — Copy — Download results

Search rows

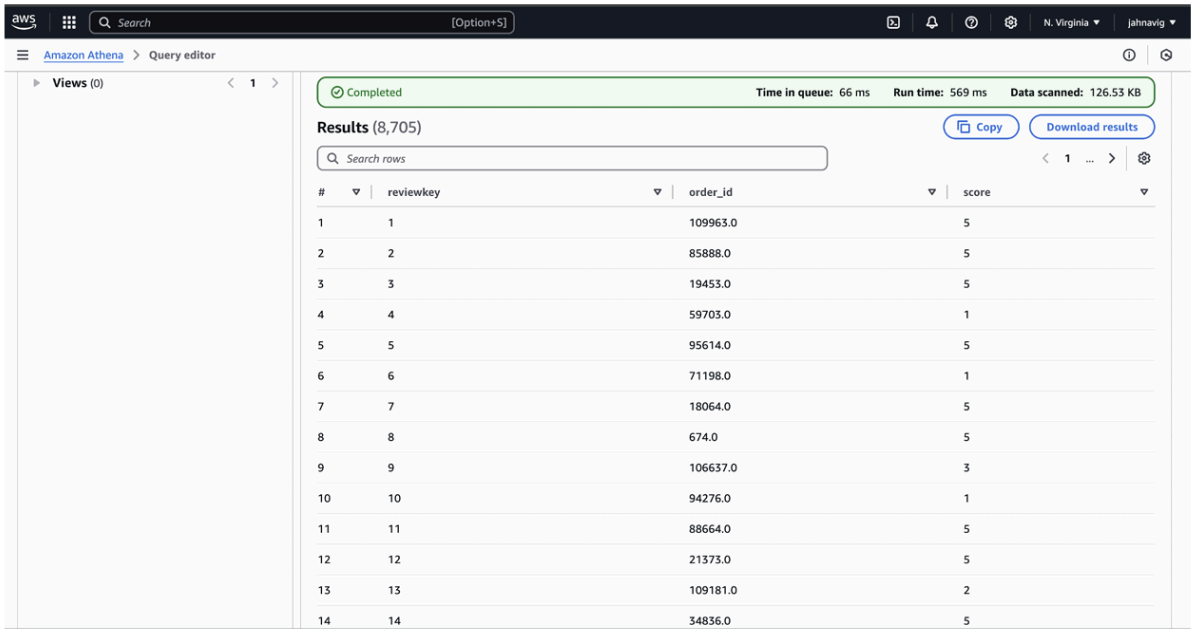
#	productkey	product_id	product_category_name	product_weight	product_length	product_height
1	1	2	artes	1000.0	30.0	18.0
2	2	25	moveis_decoracao	1800.0	40.0	10.0
3	3	38	eletronicos	263.0	18.0	12.0
4	4	40	moveis_decoracao	600.0	25.0	25.0
5	5	43	cama_mesa_banho	6350.0	45.0	15.0
6	6	47	cool_stuff	15350.0	47.0	40.0
7	7	48	moveis_decoracao	1300.0	25.0	16.0
8	8	60	brinquedos	250.0	20.0	14.0
9	9	72	relogios_presentes	250.0	16.0	11.0
10	10	83	cama_mesa_banho	1750.0	30.0	18.0
11	11	96	moveis_decoracao	800.0	53.0	8.0
12	12	101	moveis_decoracao	150.0	35.0	2.0
13	13	110	utilidades_domesticas	1200.0	23.0	22.0
14	14	116	moveis_decoracao	1000.0	30.0	18.0

3)Seller dimension



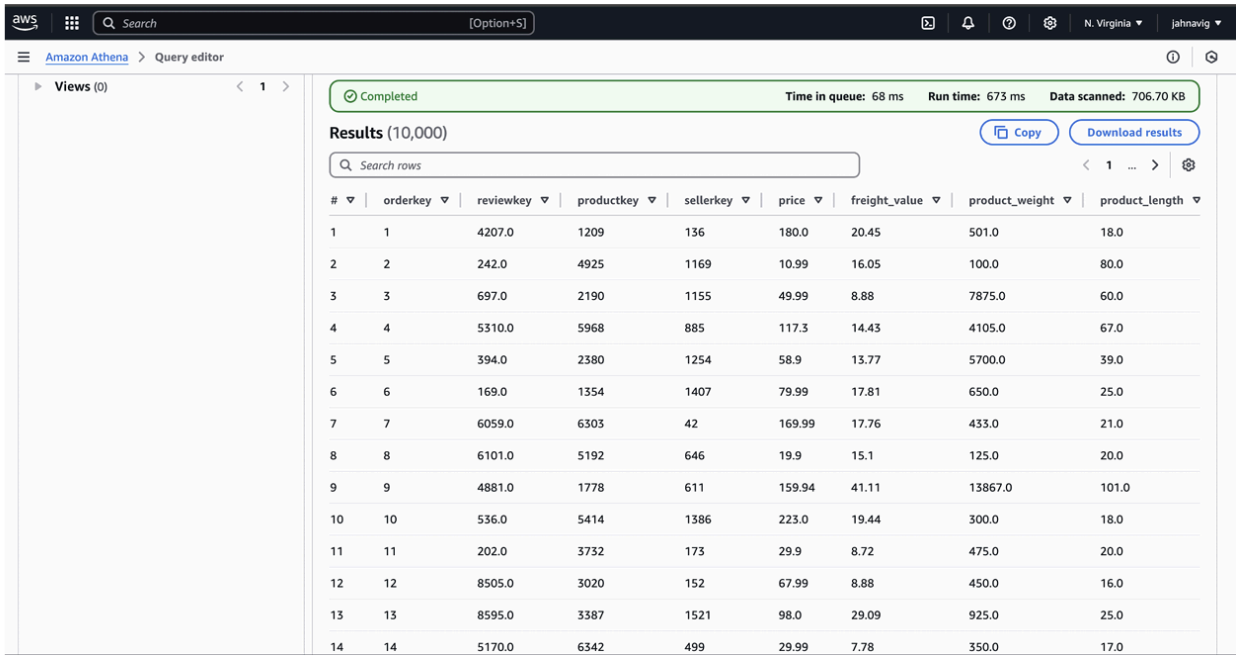
#	sellerkey	seller_id	seller_zipcode	seller_city	seller_state
1	1	1	13023	campinas	SP
2	2	2	13844	mogi guacu	SP
3	3	5	12914	braganca paulista	SP
4	4	7	55325	brejao	PE
5	5	8	16304	penapolis	SP
6	6	9	1529	sao paulo	SP
7	7	10	80310	curitiba	PR
8	8	13	1222	sao paulo	SP
9	9	18	70740	brasilia	DF
10	10	19	45810	porto seguro	BA
11	11	23	4156	sao paulo	SP
12	12	24	13320	salto	SP
13	13	26	30494	belo horizonte	MG

4)Review dimension



#	reviewkey	order_id	score
1	1	109963.0	5
2	2	85888.0	5
3	3	19453.0	5
4	4	59703.0	1
5	5	95614.0	5
6	6	71198.0	1
7	7	18064.0	5
8	8	674.0	5
9	9	106637.0	3
10	10	94276.0	1
11	11	88664.0	5
12	12	21373.0	5
13	13	109181.0	2
14	14	34836.0	5

5)Sales dimension



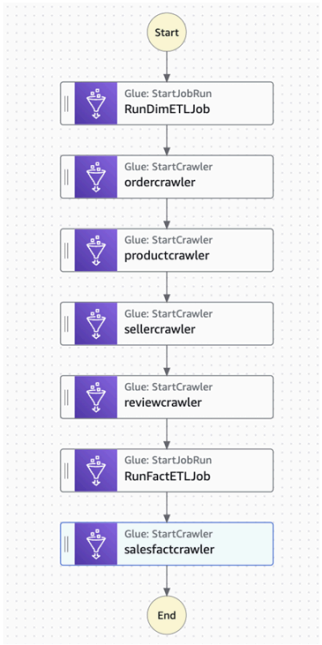
#	orderkey	reviewkey	productkey	sellerkey	price	freight_value	product_weight	product_length
1	1	4207.0	1209	136	180.0	20.45	501.0	18.0
2	2	242.0	4925	1169	10.99	16.05	100.0	80.0
3	3	697.0	2190	1155	49.99	8.88	7875.0	60.0
4	4	5310.0	5968	885	117.3	14.43	4105.0	67.0
5	5	394.0	2380	1254	58.9	13.77	5700.0	39.0
6	6	169.0	1354	1407	79.99	17.81	650.0	25.0
7	7	6059.0	6303	42	169.99	17.76	433.0	21.0
8	8	6101.0	5192	646	19.9	15.1	125.0	20.0
9	9	4881.0	1778	611	159.94	41.11	13867.0	101.0
10	10	536.0	5414	1386	223.0	19.44	300.0	18.0
11	11	202.0	3732	173	29.9	8.72	475.0	20.0
12	12	8505.0	3020	152	67.99	8.88	450.0	16.0
13	13	8595.0	3387	1521	98.0	29.09	925.0	25.0
14	14	5170.0	6342	499	29.99	7.78	350.0	17.0

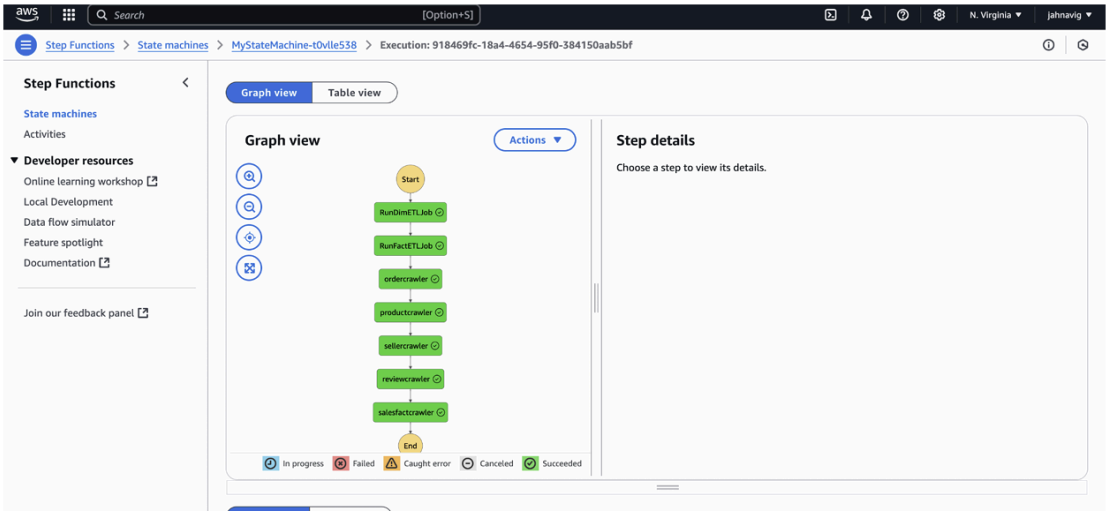
Workflow Orchestration

AWS Step Functions Process

1. Triggers dimension loading job
2. Executes fact table loading job
3. Runs Glue Crawlers for data catalog updates:
   - Product dimension
   - Review dimension

AWS STEP FUNCTION





-

Seller dimension
- Order dimension
- Sales fact

Output Storage
- All transformed files are stored as CSV format
- Successfully created tables:
  - Dimension tables: Products, Sellers, Reviews, Orders
  - Fact table: Sales
- Data is made available for querying through AWS Athena

Power BI is used to analyze all of this

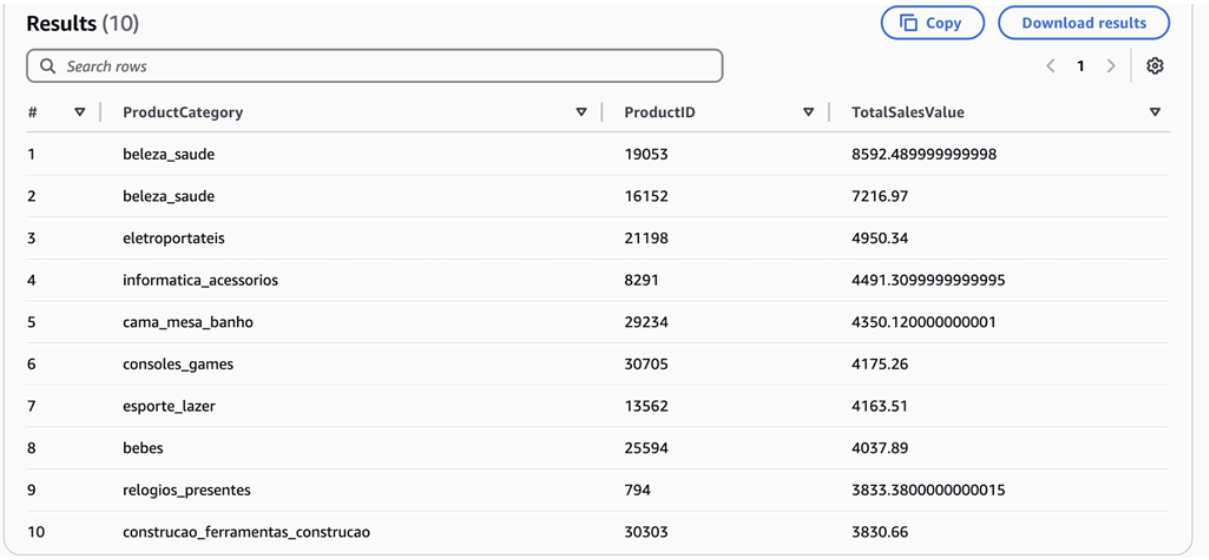
This ETL pipeline ensures efficient data processing, transformation, and analysis of the e-commerce dataset while maintaining data integrity and enabling comprehensive business insights.

Analyzing Trends

Analysis using AWS athena

1. Top Products by Total Sales Value

```
SELECT
    p.product_category_name AS ProductCategory,
    p.product_id AS ProductID,
    SUM(sf.totalordervalue) AS TotalSalesValue
FROM
    salesfact sf
JOIN
    product_dimension p ON sf.Productkey = p.Productkey
GROUP BY
    p.product_category_name, p.product_id
ORDER BY
    TotalSalesValue DESC
LIMIT 10;
```



Results (10)

Copy | Download results

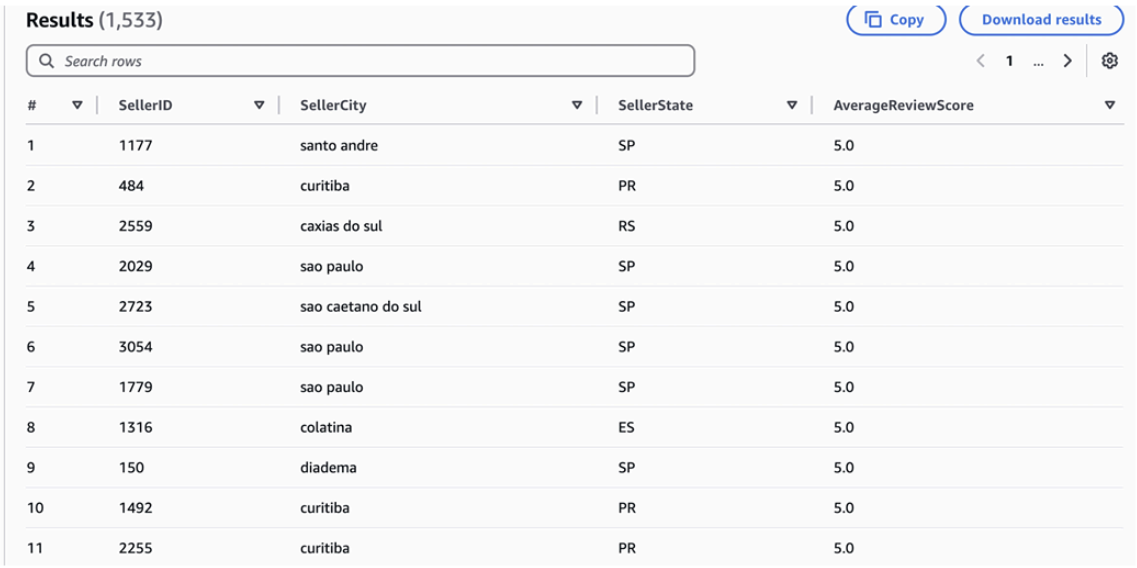
Search rows

1

#	ProductCategory	ProductID	TotalSalesValue
1	beleza_saude	19053	8592.489999999998
2	beleza_saude	16152	7216.97
3	eletroportateis	21198	4950.34
4	informatica_acessorios	8291	4491.3099999999995
5	cama_mesa_banho	29234	4350.120000000001
6	consoles_games	30705	4175.26
7	esporte_lazer	13562	4163.51
8	bebes	25594	4037.89
9	relogios_presentes	794	3833.3800000000015
10	construcao_ferramentas_construcao	30303	3830.66

2. Average Review Score by Seller

```
SELECT
    s.seller_id AS SellerID,
    s.seller_city AS SellerCity,
    s.seller_state AS SellerState,
    AVG(r.score) AS AverageReviewScore
FROM
    salesfact sf
JOIN
    seller_dimension s ON sf.Sellerkey = s.Sellerkey
JOIN
    review_dimension r ON sf.Reviewkey = r.Reviewkey
GROUP BY
    s.seller_id, s.seller_city, s.seller_state
ORDER BY
    AverageReviewScore DESC;
```



Results (1,533)

Copy | Download results

Search rows

1 ...

#	SellerID	SellerCity	SellerState	AverageReviewScore
1	1177	santo andre	SP	5.0
2	484	curitiba	PR	5.0
3	2559	caxias do sul	RS	5.0
4	2029	sao paulo	SP	5.0
5	2723	sao caetano do sul	SP	5.0
6	3054	sao paulo	SP	5.0
7	1779	sao paulo	SP	5.0
8	1316	colatina	ES	5.0
9	150	diadema	SP	5.0
10	1492	curitiba	PR	5.0
11	2255	curitiba	PR	5.0

3. Distribution of Product Dimensions

```
SELECT
    p.product_category_name AS ProductCategory,
    AVG(p.product_length) AS AvgProductLength,
    AVG(p.product_width) AS AvgProductWidth,
    AVG(p.product_height) AS AvgProductHeight,
    AVG(p.product_weight) AS AvgProductWeight
FROM
    salesfact sf
JOIN
    product_dimension p ON sf.Productkey = p.Productkey
GROUP BY
    p.product_category_name
ORDER BY
    ProductCategory;
```

#	ProductCategory	AvgProductLength	AvgProductWidth	AvgProductHeight	AvgProductWe
2	agro_industria_e_comercio	30.705882352941178	22.0	22.88235294117647	3371.0588235
3	alimentos	19.05128205128205	14.871794871794872	12.41025641025641	650.46153846
4	alimentos_bebidas	22.11111111111111	17.333333333333332	17.40740740740741	1460.1851851
5	artes	44.705882352941174	33.588235294117645	9.705882352941176	1320.5882352
6	artes_e_artesanato	18.666666666666668	13.666666666666666	9.666666666666666	866.66666666
7	artigos_de_festas	29.666666666666668	24.166666666666668	19.833333333333332	1908.3333333
8	artigos_de_natal	34.4	27.7	14.3	1955.0
9	audio	20.115384615384617	15.653846153846153	8.923076923076923	1593.7692307
10	automotivo	33.44638403990025	24.98004987531172	16.01995012468828	2700.6059850
11	bebes	34.96989966555184	28.535117056856187	20.240802675585286	3255.8361204
12	bebidas	21.318181818181817	18.045454545454547	19.84090909090909	969.77272727
13	beleza_saude	23.944380069524914	18.11239860950174	14.16106604866744	1045.5191193
14	brinquedos	30.329479768786126	23.973988439306357	20.77456647398844	1577.1127167
15	cama_mesa_banho	36.94449950445986	31.00792864222002	12.786917740336968	2050.3310208
16	casa_conforto	45.84375	37.65625	16.0	3217.1875

4. Seller Performance by Region

```
SELECT
    s.seller_state AS State,
    s.seller_id AS SellerID,
    SUM(sf.totalordervalue) AS TotalSalesValue
FROM
    salesfact sf
JOIN
    seller_dimension s ON sf.Sellerkey = s.Sellerkey
GROUP BY
    s.seller_state, s.seller_id
ORDER BY
    s.seller_state, TotalSalesValue DESC;
```

#	State	SellerID	TotalSalesValue
1	rio grande do sul	552	90.03999999999999
2	BA	902	15577.240000000002
3	BA	2686	706.58
4	BA	875	531.84
5	BA	2454	510.22
6	BA	2288	392.59
7	BA	19	343.58
8	BA	1971	224.45000000000002
9	BA	406	223.44
10	BA	2602	217.84

5. Review Distribution Across Product Categories

```
SELECT
    p.product_category_name AS ProductCategory,
    r.score AS ReviewScore,
    COUNT(r.score) AS ReviewCount
FROM
    salesfact sf
JOIN
    product_dimension p ON sf.Productkey = p.Productkey
JOIN
    review_dimension r ON sf.Reviewkey = r.Reviewkey
GROUP BY
    p.product_category_name, r.score
ORDER BY
    p.product_category_name, r.score;
```

Categories with Poor Ratings:

Results (282)

Copy | Download results

Search rows

1 ...

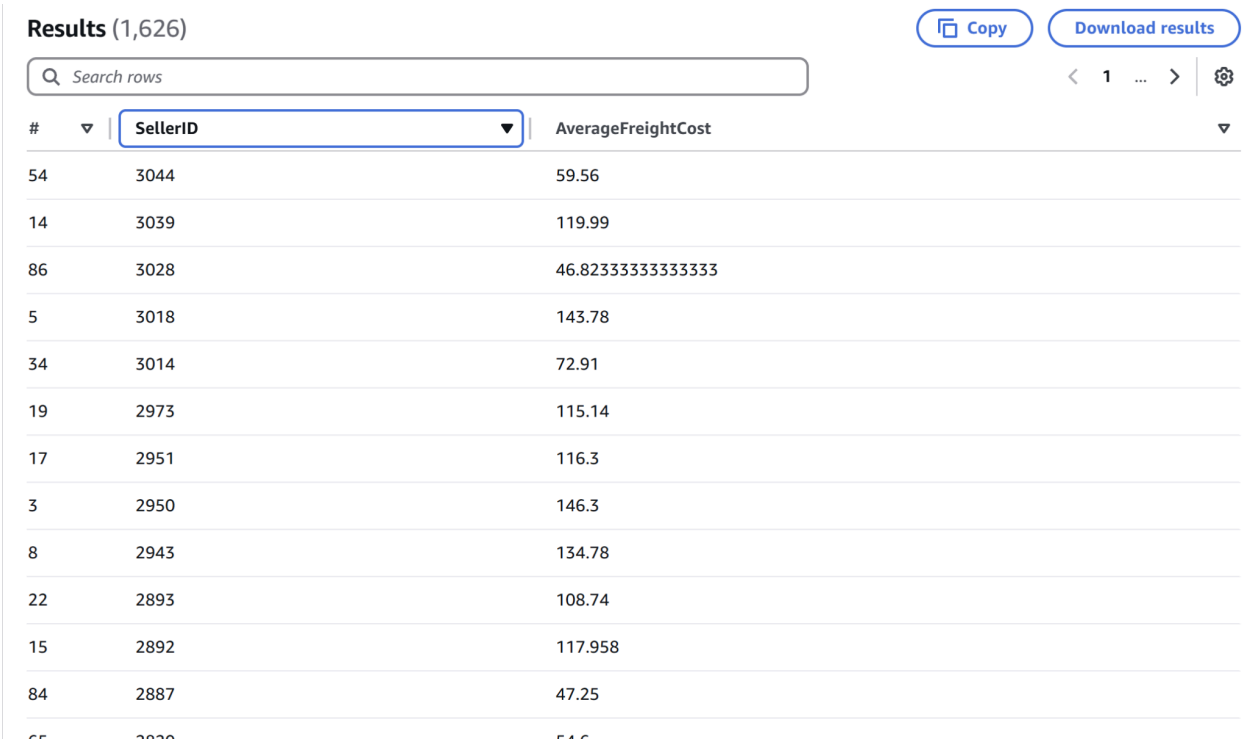
#	ProductCategory	ReviewScore	ReviewCount
99	construcao_ferramentas_jardim	1	2
100	construcao_ferramentas_jardim	2	1
94	construcao_ferramentas_iluminacao	1	2
95	construcao_ferramentas_iluminacao	2	3
96	construcao_ferramentas_iluminacao	3	2
97	construcao_ferramentas_iluminacao	4	7
98	construcao_ferramentas_iluminacao	5	9
92	construcao_ferramentas_ferramentas	4	1
93	construcao_ferramentas_ferramentas	5	4
88	construcao_ferramentas_construcao	1	5
89	construcao_ferramentas_construcao	3	7
90	construcao_ferramentas_construcao	4	11
91	construcao_ferramentas_construcao	5	40

For construcao_ferramentas_jardim, there are 2 reviews with a score of 1 and 1 review with a score of 2. This suggests products in this category might need improvement.

Categories with Mixed Reviews:
For construcao_ferramentas_iluminacao, there are varying review scores (e.g., 1, 2, 3, 4) with differing counts. This indicates a mix of customer satisfaction levels.

6. Avg freight costs of sellers

```
SELECT
   s.seller_id AS SellerID,
   AVG(sf.freight_value) AS AverageFreightCost
FROM
   salesfact sf
JOIN
   seller_dimension s ON sf.Sellerkey = s.Sellerkey
GROUP BY
   s.seller_id
ORDER BY
   AverageFreightCost DESC;
```



Results (1,626)

Copy | Download results

Search rows

1 ...

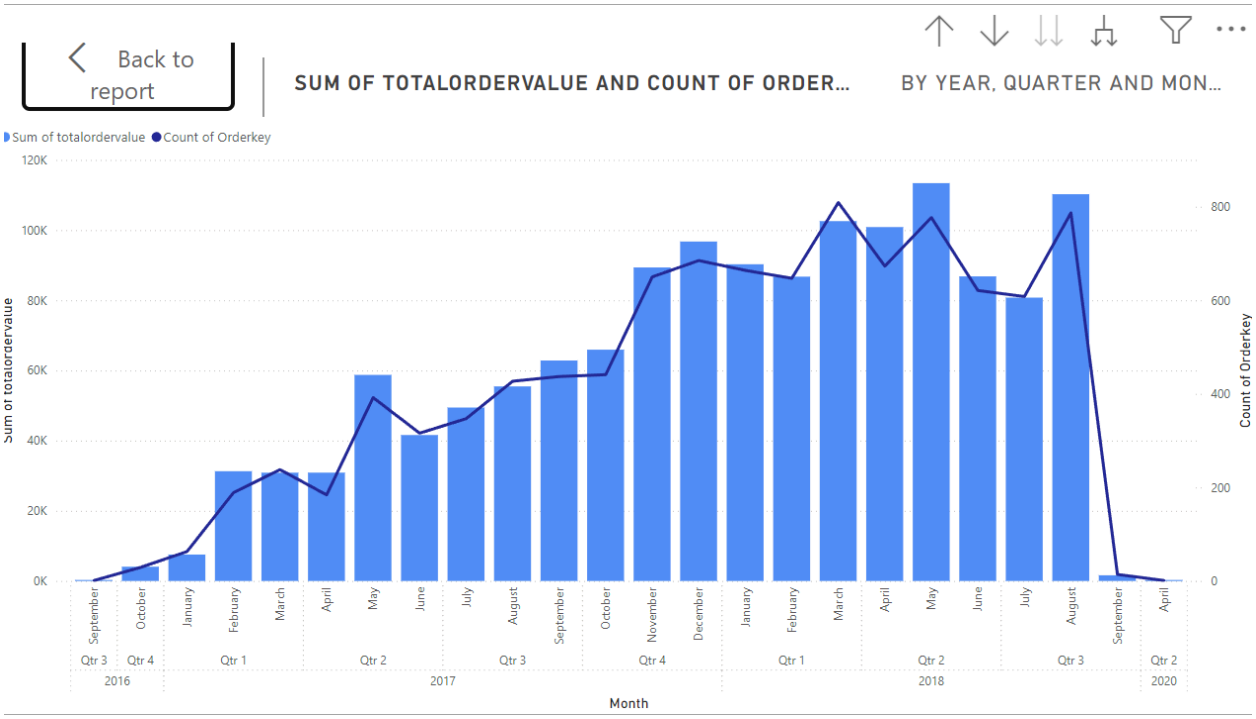
#	SellerID	AverageFreightCost
54	3044	59.56
14	3039	119.99
86	3028	46.82333333333333
5	3018	143.78
34	3014	72.91
19	2973	115.14
17	2951	116.3
3	2950	146.3
8	2943	134.78
22	2893	108.74
15	2892	117.958
84	2887	47.25

Based on the results of average freight costs by seller, there is a significant variation among sellers, ranging from efficient operations like Seller 3028 (with a low average of 46.82) to high-cost sellers such as 2950 (with an average cost of 146.3).

Analysis Using Power BI

1. Sales Performance Analysis
- From Sales Fact Table: Orderkey, price, totalordervalue
- From Order Dimension Table: shipping_limit_date (if available)
- X-axis: Time (daily, weekly, or monthly depending on date range)
- Primary Y-axis: Total Sales Value (sum of totalordervalue)
- Secondary Y-axis: Number of Orders (count of Orderkey)
- Use a line for Total Sales Value and bars for Number of Orders

Analysis: This will show sales trends over time, allowing you to identify peak sales periods and overall growth.



Key Performance Points

Peak Performance

- Highest revenue point: ~120K (April-May 2018)
- Most consistent high-performance period: Q1-Q2 2018

Growth Rate

- 2016-2017: Gradual upward trend
- 2017-2018: Steeper growth with higher volatility

Business Cycles

- Monthly fluctuations show consistent patterns
- Order volume (blue line) closely tracks revenue trends
- Sharp decline after Q3 2018 indicates potential business disruption

2. Product Category Performance
Fields:
- From Product Dimension Table: product_category_name
- From Sales Fact Table: price, Productkey

Design:
- Size of rectangles: Total Sales Value per category
- Color of rectangles: Number of products sold per category

Analysis: This visualization will quickly show which product categories are driving the most revenue and which are most popular in terms of units sold.

Major Categories by Revenue

Top Revenue Generators:

- "relogios_presentes" (Watches/Gifts) shows the largest rectangle, indicating highest total sales value
- "esporte_lazer" (Sports/Leisure) represents the second-largest revenue category
- "utilidades_domesticas" (Household Utilities) ranks third in revenue generation

Category Distribution

Mid-Range Categories:

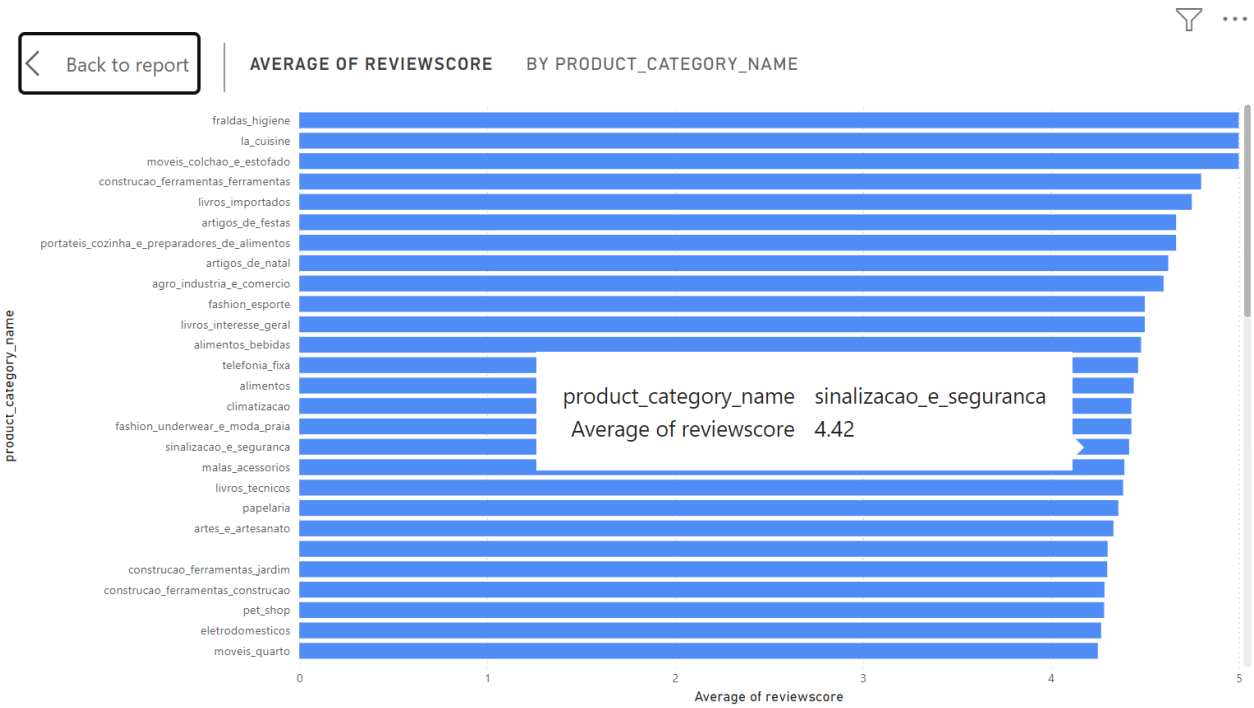
- "perfumaria" (Perfumes)
- "telefonia" (Telephony)
- "moveis_escritorio" (Office Furniture)
- "eletroport" (Small Appliances)

Notable Insights:

- "cool_stuff" category shows a value of 47,766.18, visible in the tooltip

3. Customer Satisfaction Overview

Analysis: This will provide an at-a-glance view of customer satisfaction levels and the overall sentiment towards your products



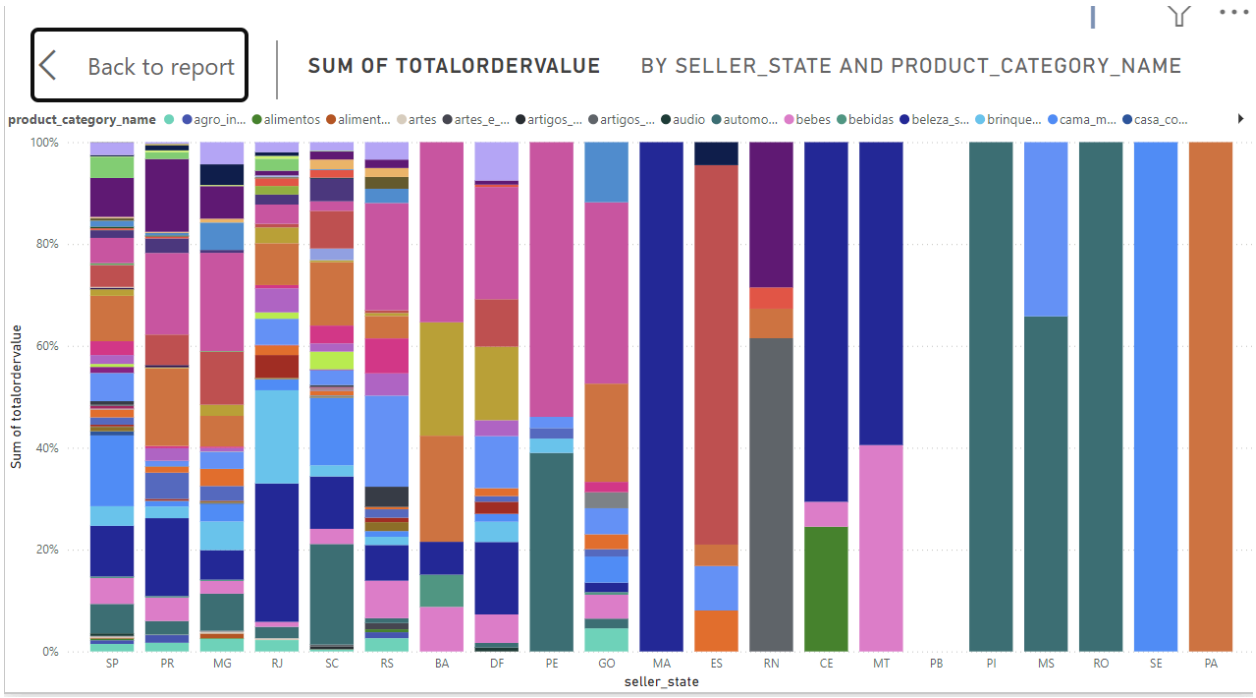
- Review Score Distribution:

- 5-star ratings: ~58% (dominant)
- 4-star ratings: ~19%
- 3-star ratings: ~8%
- 2-star ratings: ~3%
- 1-star ratings: ~11%

Category Performance by Reviews

- Highest Rated Categories:
  - Fraldas_higiene
  - La_cuisine
  - Chao_e_estofado
- Most Reviewed Categories:
  - Utilidades_domesticas
  - Esporte_lazer
  - Moveis_decoracao

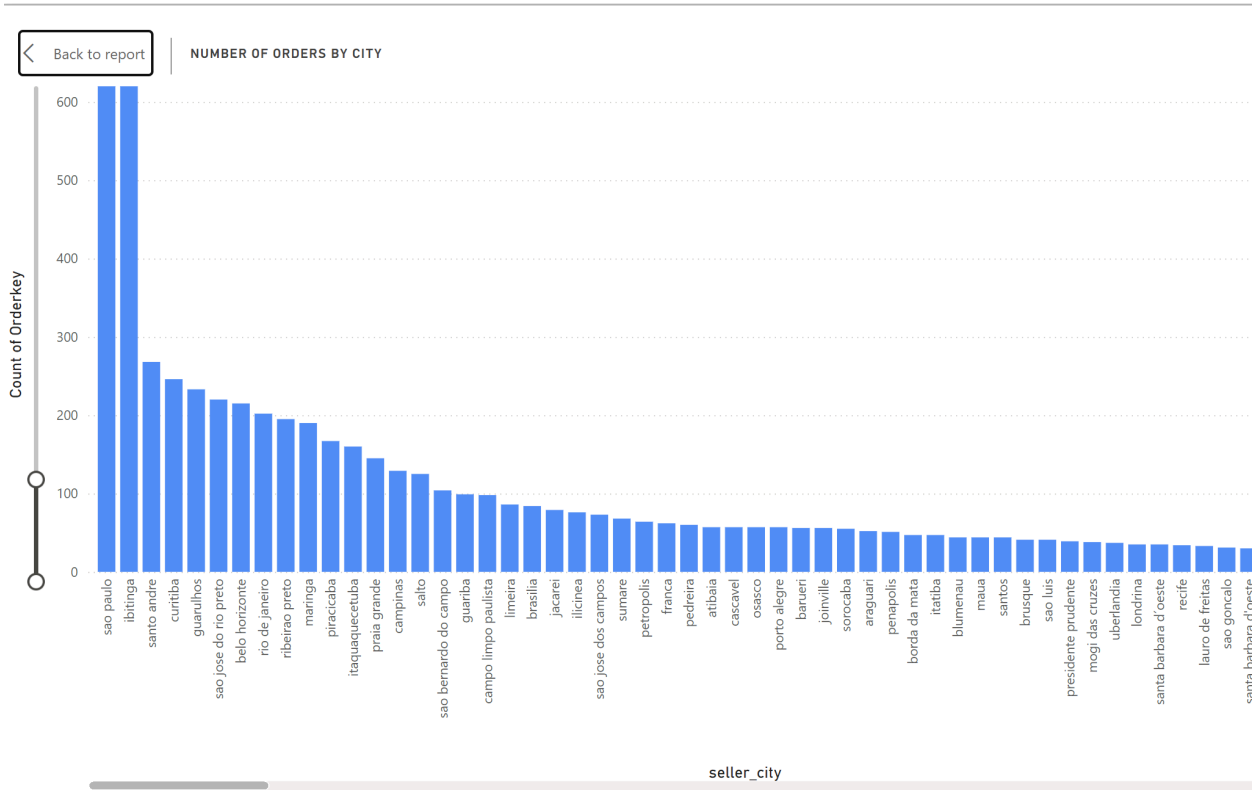
4. Geographical Sales Distribution



Regional Distribution

State-wise Performance

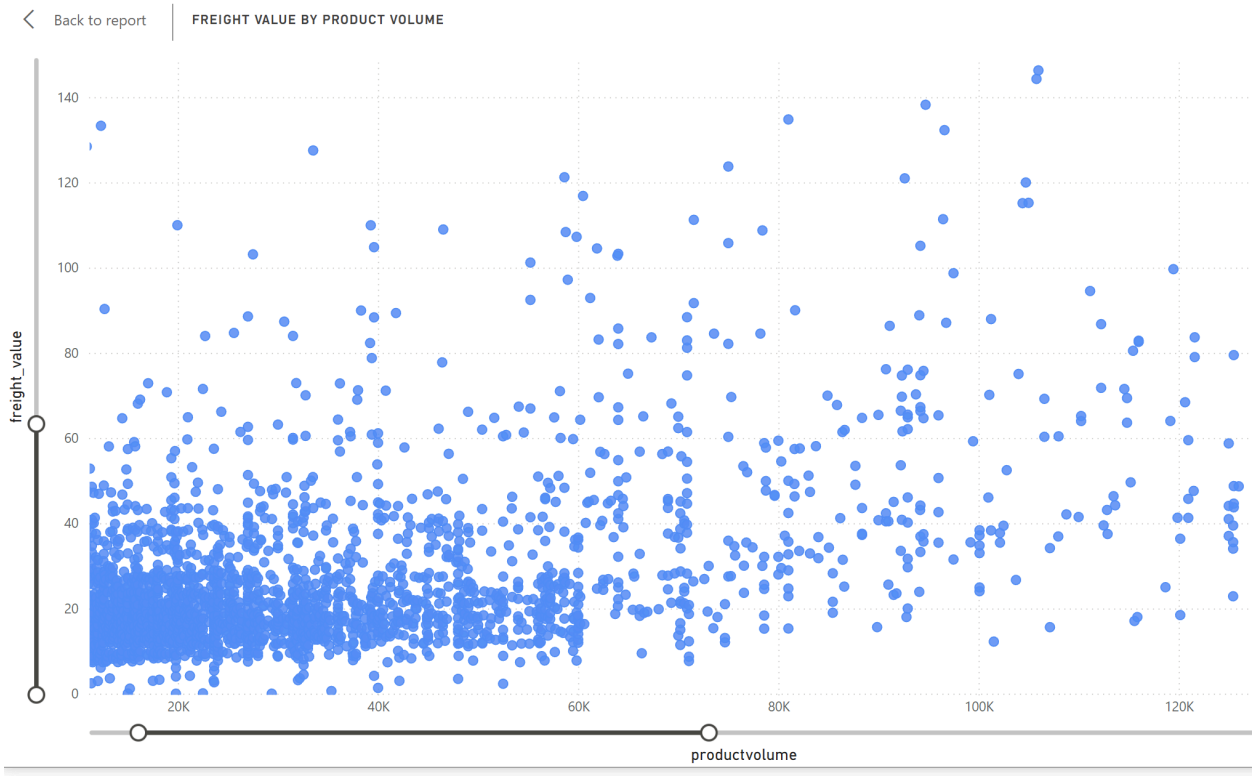
- SP (São Paulo) dominates the market
- PR (Paraná) and MG (Minas Gerais) show strong performance
- Smaller states like SE and PA have limited but focused category presence



Order Distribution by City

- São Paulo and Ibiruba lead with the highest number of orders, both exceeding 600 orders.

- There's a significant drop after the top two cities, with the third-ranking city having less than half the orders of the leaders.
- The distribution shows a long tail, indicating a wide spread of orders across many cities with lower volumes.

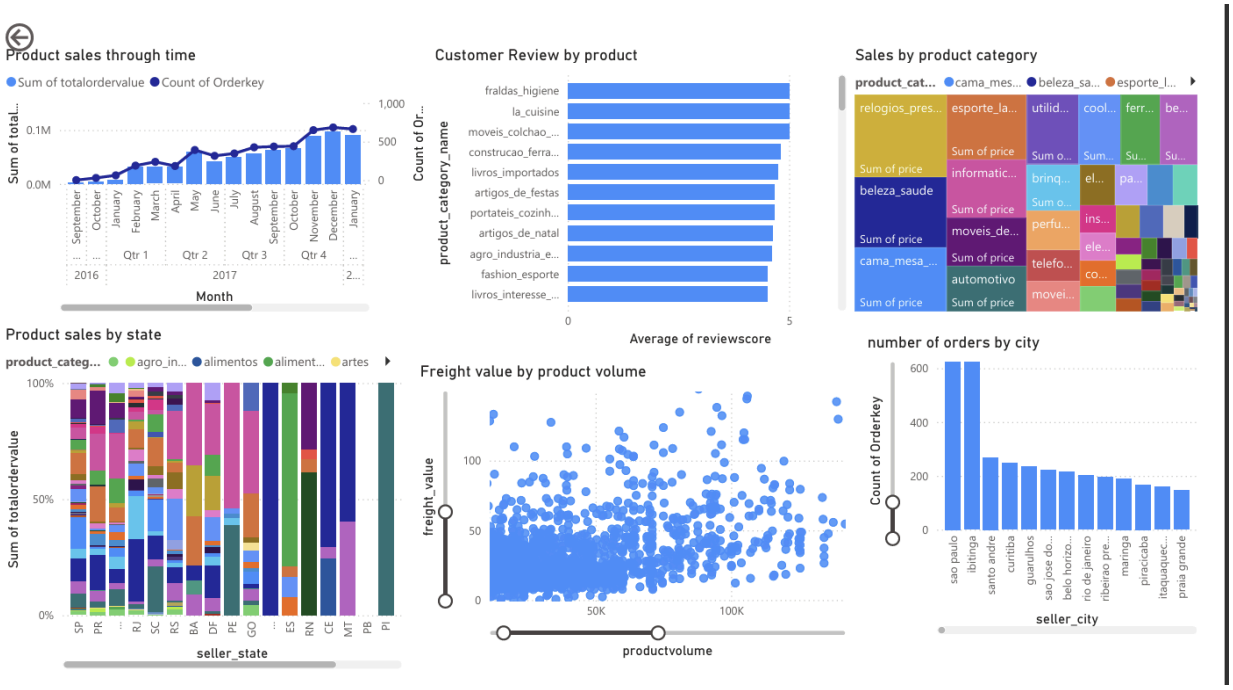


Product Volume and Shipping Costs

Freight Value Analysis

- Strong correlation between product volume and freight costs
- Majority of products cluster in 40K-80K volume range
- Freight values generally range from 20-60 units
- Several outliers with high freight costs (140+ units) for larger volumes
- Dense concentration of orders in lower volume range (40K-60K)

Dashboard(Power BI)



Conclusion

Thishis data warehousing project leveraged AWS cloud services to analyze the Brazilian e-commerce platform's performance. The project successfully implemented a comprehensive ETL pipeline, efficiently utilizing multiple AWS services, including S3, Glue, Athena, and Step Functions.

A data lake was established using AWS S3, providing a secure and scalable storage solution for both raw and processed data. Automated ETL processes were implemented using AWS Glue, facilitating seamless data transformation. The use of Glue Crawlers enabled efficient data cataloging, while AWS Athena offered advanced SQL analytics capabilities. The entire workflow was orchestrated using AWS Step Functions, ensuring a streamlined and coordinated data processing pipeline.

The project's key achievements include the successful processing and transformation of multiple data sources, such as CSV and Parquet files. Dimensional and fact tables were created to support efficient querying, and automated data processing workflows were established to enhance operational efficiency. Through detailed SQL analysis, actionable business insights were generated, highlighting the platform's performance and opportunities for improvement.

From a business perspective, the data warehouse solution provided crucial insights. São Paulo emerged as the leading market with the highest sales concentration, while top-performing product categories such as Fraldas_higiene, la_cuisine, and chao_e_estofado were identified. Customer satisfaction patterns revealed a 3.43% rate of 5-star ratings, and regional sales distribution and shipping cost patterns were mapped. Additionally, the project identified expansion opportunities in emerging markets, paving the way for strategic growth.

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1. Brazillian e-commerce Dataset
2. Amazon Web Services
3. Amazon S3
4. AWS glue
5. AWS crawler
6. AWS Athena
7. AWS Step Function
8. Power BI