



Freight Flows and Regional Economic Growth

An analysis of how freight activity by mode, commodity, and geography connects to GDP and income, with implications for infrastructure and economic strategy.

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Introduction

This capstone analysis examines United States freight flows and their connection to state economic performance. By integrating comprehensive freight data with economic indicators, we reveal the complex relationships between transportation networks and regional prosperity.

My analysis links commodities, transportation modes, and freight consumption patterns to GDP and personal income, uncovering insights that can guide infrastructure planning and economic development strategies.

Motivation



Supply Chains

Networks of production, storage and distribution



Freight Networks

Physical movement of goods across regions



Economic Growth

GDP, employment, and personal income

Freight transportation is the backbone of modern supply chains and a critical driver of regional economic growth. By studying freight flows alongside GDP and income metrics, we can identify which transportation modes and commodity types most strongly correlate with economic prosperity.

Research Questions

1

Primary Question

Are there trends where certain transportation types and commodity freight paths correlate with more GDP growth?

2

Secondary Questions

- How do freight flows relate to regional economic indicators (GDP, employment, income)?
- Which transportation modes and commodities show the strongest relationships with economic growth?

These questions guide my analysis of the complex relationship between freight movement and economic indicators, helping to identify patterns that may inform infrastructure investment and economic strategy.

Data Sources and Scope

Freight Analysis Framework (FAF5)

Core flows by commodity, mode, and geography

Census Commodity Flow Survey (CFS)

Shipment survey that validates and enriches FAF.

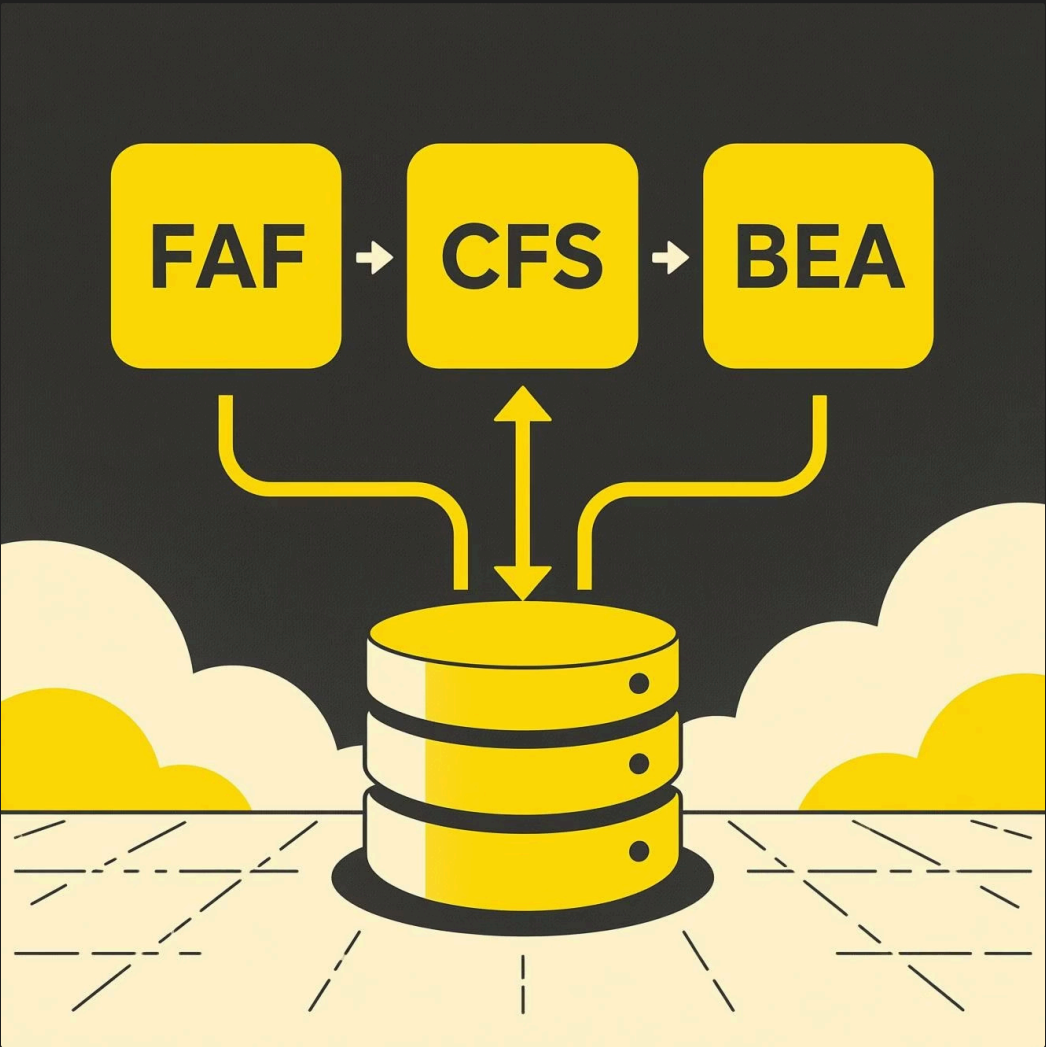
** Complete data until 2022*

Bureau of Economic Analysis (BEA)

Regional GDP and personal income data

Dataset Scale

The FAF5 file contains **2,663,287 rows** and **56 columns**, providing comprehensive national coverage across years and transportation modes.



Method and Workflow

Data Preparation

Clean and merge FAF with regions and BEA economic data

Exploratory Analysis

Identify patterns by state, transportation mode, and commodity

Economic Integration

Join freight flow data with GDP and income metrics

Correlation Analysis

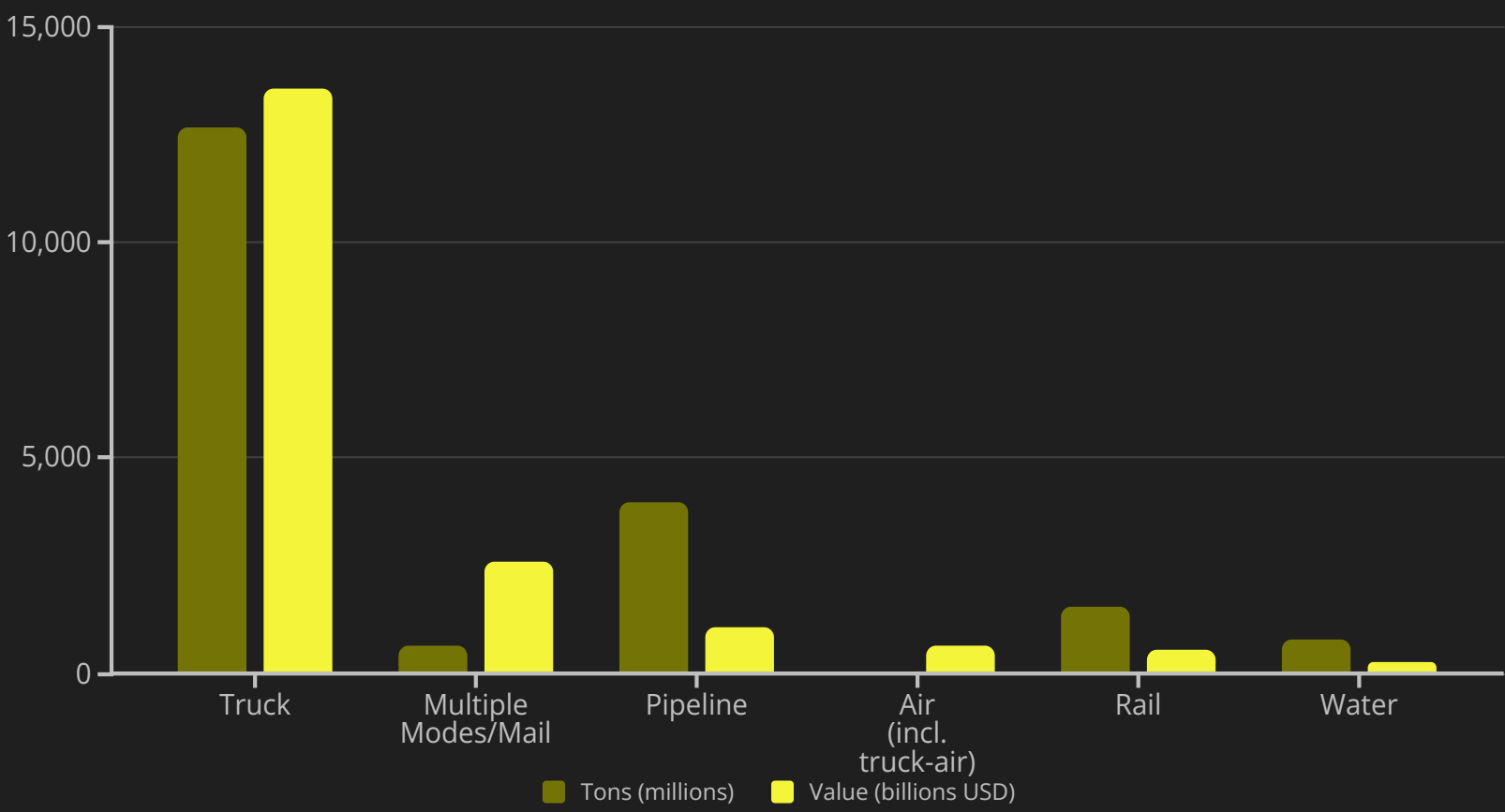
Measure strength of relationships between variables

Trend Analysis

Examine growth alignment over time across regions

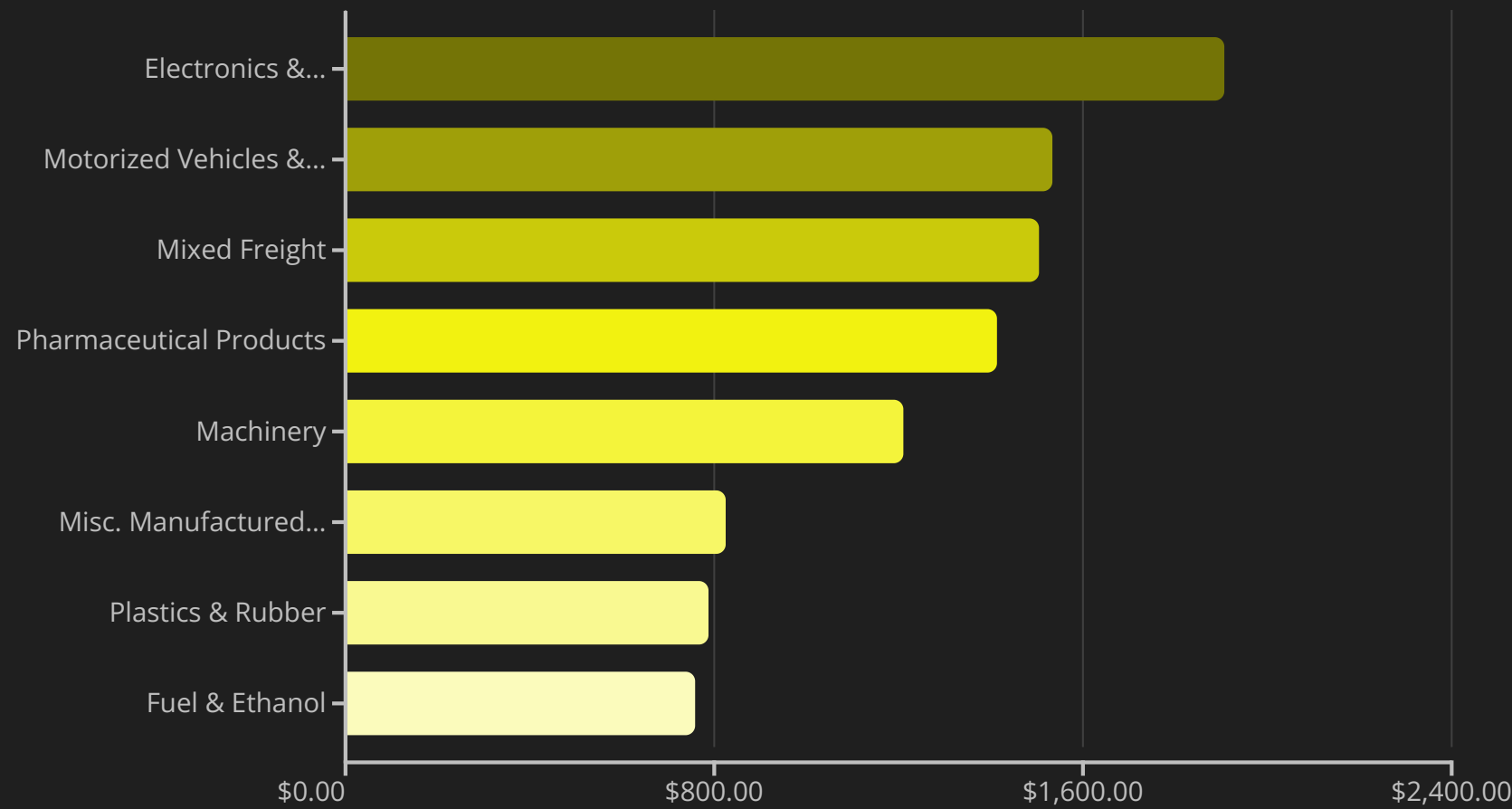
This systematic approach allows us to progressively build insights, from basic freight patterns to sophisticated economic relationships that reveal the interplay between transportation and prosperity.

Freight by Transportation Mode (2022)



Trucks dominate freight transport by both tonnage and value, reflecting their flexibility and reach across the supply chain. Air transport moves relatively small tonnage but carries extremely high-value goods, highlighting its role in high-value supply chains. Pipeline and rail systems primarily handle bulk commodities that are critical operationally but show less direct alignment with GDP growth in my analysis.

Top Commodities by Value (Billions USD) (2022)



High-value manufactured goods lead in dollar value, with electronics, vehicles, and pharmaceuticals at the top. While bulk energy and food products dominate in volume, they are not as strongly indicative of GDP alignment as these higher-value commodities. This suggests that economies specializing in high-value manufacturing may experience stronger economic benefits from their freight networks.

Top 5 Freight Consuming States (2022)

State	Freight Value Received (billions USD)
Texas	2,378.8
California	2,034.8
Illinois	980.6
New York	930.6
Florida	871.7

Texas and California lead as the largest freight destinations by value, reflecting both the scale of their economies and their critical positions in national supply chains. These states serve as major import gateways and distribution hubs, processing enormous volumes of domestic and international freight.



Production and Consumption Views

States such as New York, Illinois, Florida, and New Jersey produce more freight than they consume, reflecting their strong manufacturing, port, and distribution roles. Other States tend to consume more than they produce, aligning with service-oriented or population-driven economies.

These relationships highlight how **freight flows mirror economic specialization** across regions.

Key Findings



Strong Economic Link

Very high positive correlation ($r > 0.91$) between freight activity and state-level economic performance, confirming freight's role as an economic indicator.



Mode Differentiation

Transportation modes vary significantly in their economic relationships, with truck and multimodal transport showing the strongest GDP alignment.

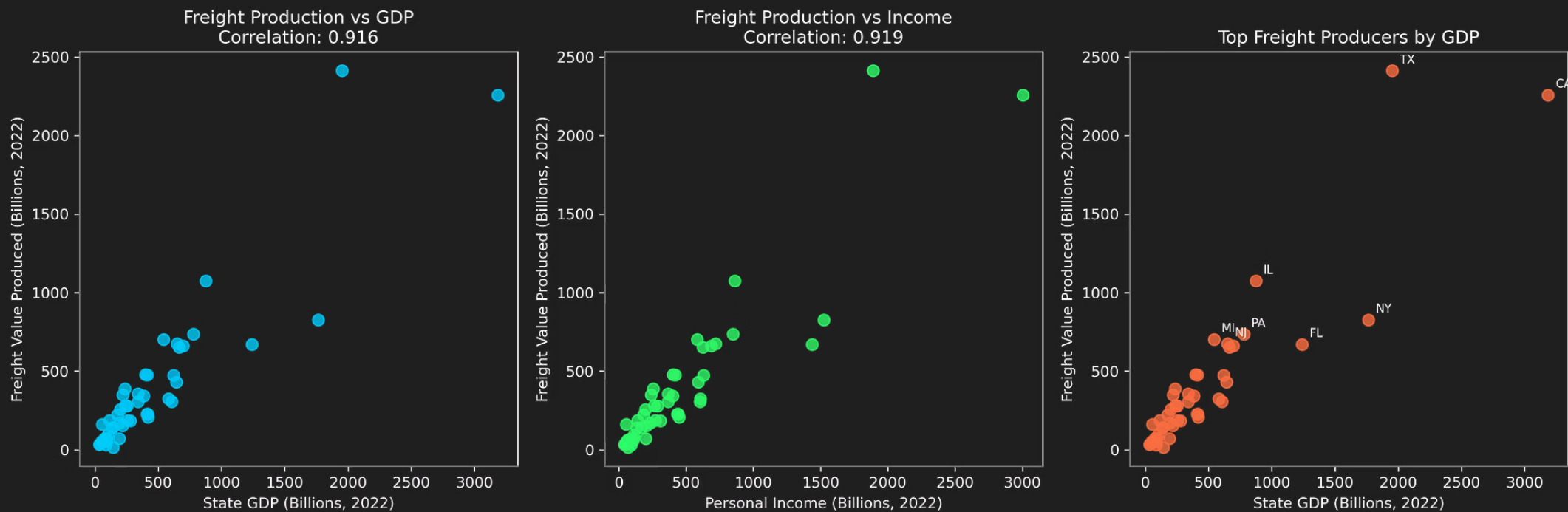


Commodity Indicators

High-value demonstrate the strongest correlation with economic prosperity.

Correlation of Freight Production with Economic Performance

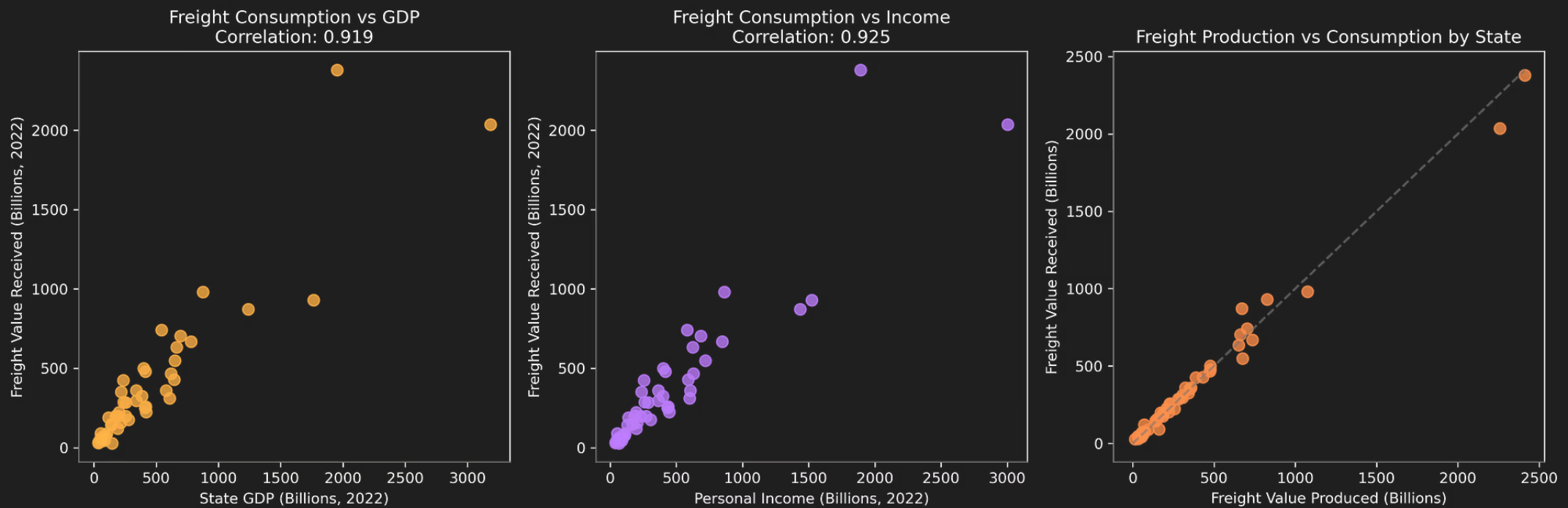
My analysis reveals a compelling relationship between freight production originating from a state and its overall economic health. The following correlations highlight freight's significant role as a leading economic indicator.



These high correlation coefficients ($r > 0.91$) underscore the vital connection between a state's industrial output, logistical infrastructure, and its economic prosperity.

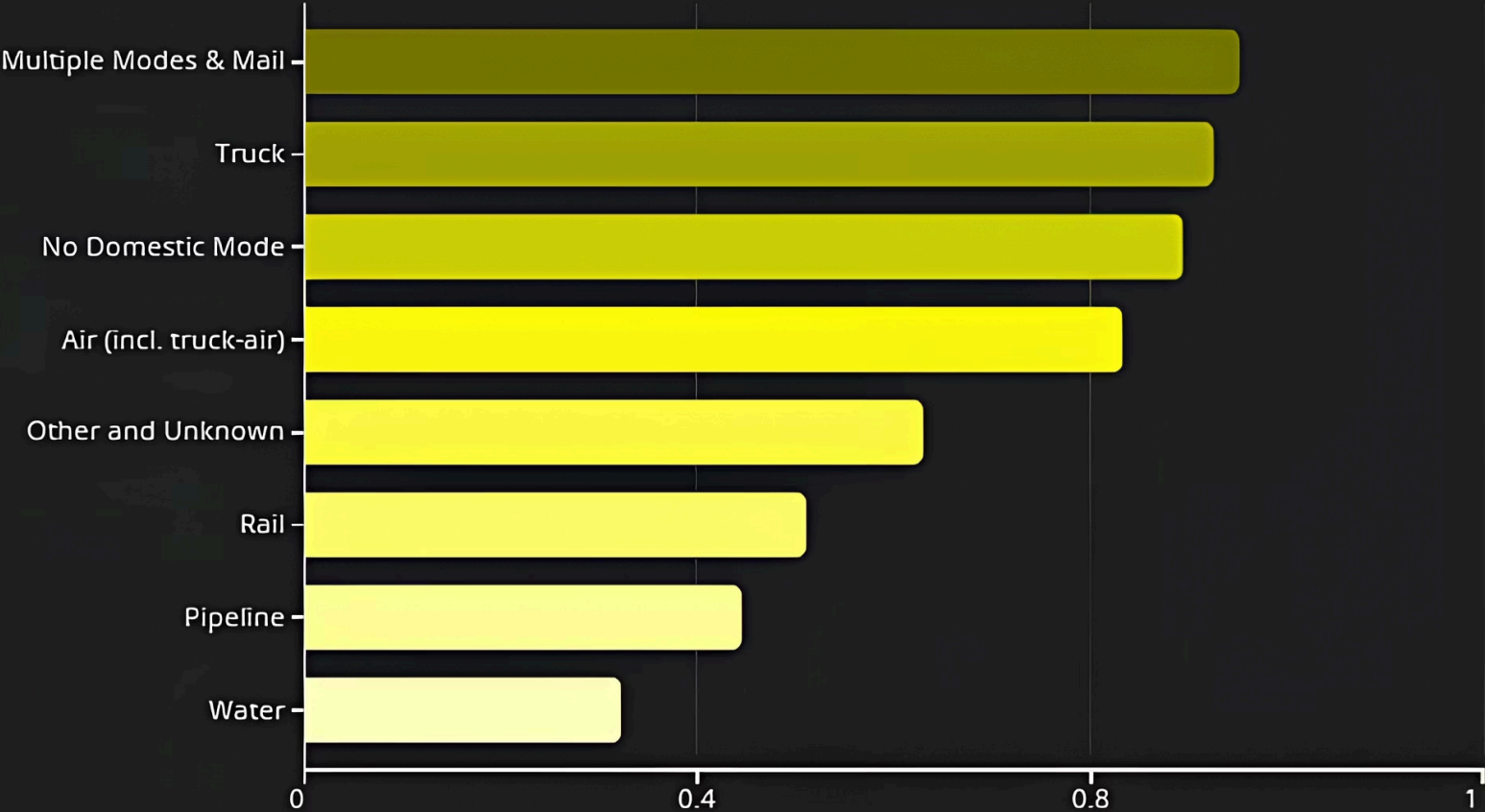
Correlation of Freight Consumption with Economic Performance

My analysis reveals a striking correlation between a state's freight consumption and its economic performance, underscoring the vital role of transportation in regional prosperity. Freight value at its destination acts as a robust indicator of economic activity.



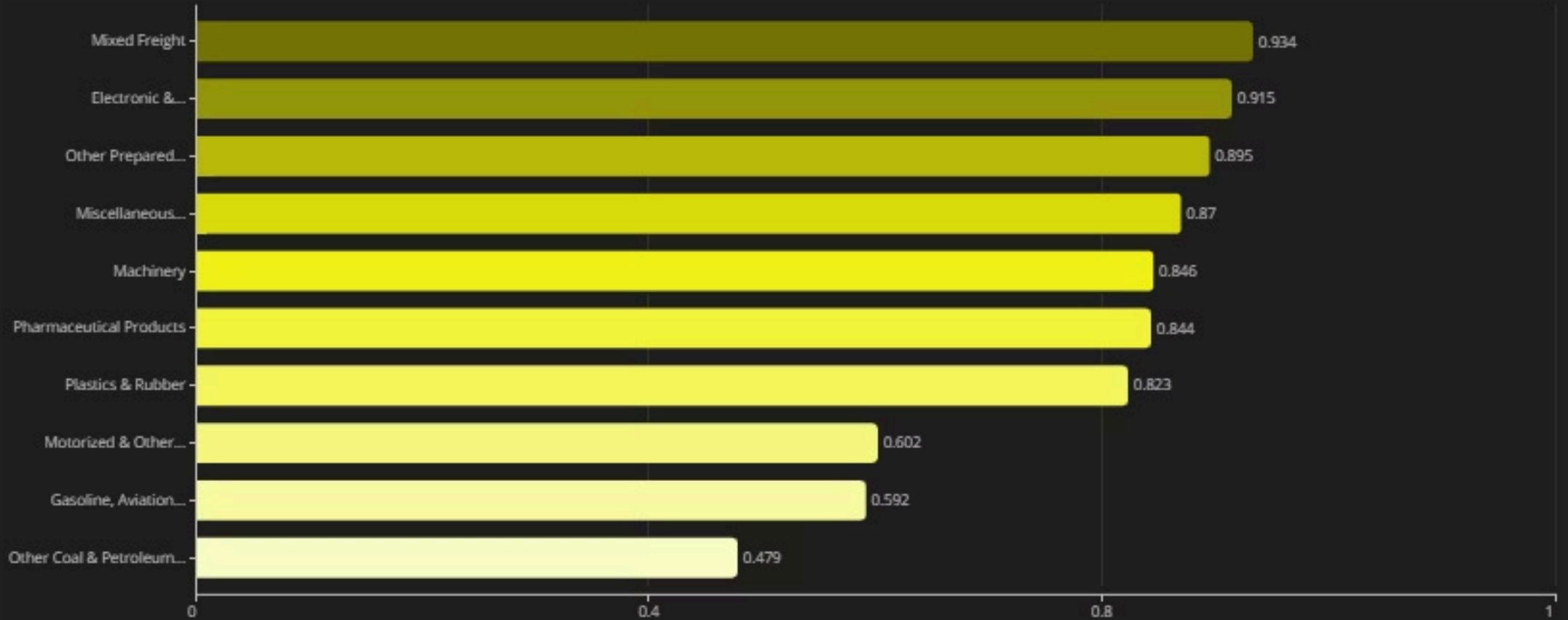
These high correlation coefficients indicate that states receiving higher volumes of freight tend to exhibit greater economic output and higher personal income levels, positioning freight consumption as a key economic indicator.

Correlation of Freight Modes with Economic Performance



My analysis reveals a strong positive correlation between freight activity and state-level economic performance, especially for modes like **truck and multimodal transport ($R > 0.9$)**. This highlights their direct impact on economic vitality due to their flexibility and reach across various supply chains. Conversely, modes primarily handling bulk commodities, such as pipeline and water, show a lower correlation with overall GDP growth.

Commodity Correlation with Economic Performance



High-value manufactured goods and mixed freight show the strongest positive correlations, indicating their freight movements are closely tied to overall economic health. Conversely, bulk commodities like fuels and raw materials exhibit lower correlations, suggesting their transport is less directly reflective of broader economic performance.

Conclusion and Next Steps

Key Conclusions

- Freight activity and economic performance show **remarkably strong correlation** at the state level
- Different transportation modes and commodities have varying economic implications
- Consumption patterns slightly outweigh production as economic indicators
- Regional variations exist despite strong national patterns

Future Work

My next steps will include:

- Deeper analysis of corridor and metropolitan patterns
- Leveraging FAF projections to 2050 for scenario planning
- Explore additional economic indicators (e.g., real estate, housing market, stock market) to find correlations with freight activity
- Analyzing resilience metrics in relation to freight diversity

Deliverables

Integrated Datasets

Cleaned and merged datasets combining FAF, CFS, and BEA data, ready for further analysis and application.

Analytical Pipeline

Comprehensive Jupyter notebook documenting the full analytical process, from data preparation through correlation analysis to visualization.

Interactive Dashboards

Tableau dashboards featuring interactive maps by mode and commodity, dynamic scatterplots, and trend visualizations.

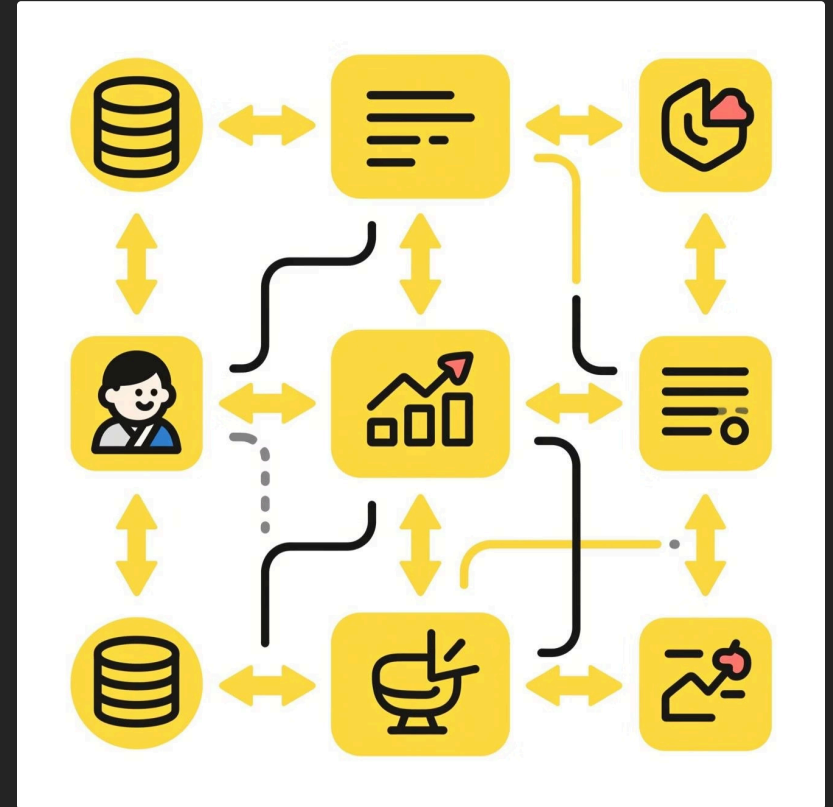
Appendix: Data Integration

The analysis combined multiple datasets:

- FAF flows linked to BEA GDP and income data using state abbreviations
- Derived standardized metrics in billions and millions for readability
- Combined tables with dimensions of 51×58 (states \times variables)

The analytical pipeline includes:

- Data cleaning and normalization procedures
- Correlation computations for both origin and destination analyses
- Visualization generation for maps, ranked bars, and scatterplots



Appendix: Detailed Methods

Data Preparation

The FAF dataset (2,663,287 rows × 56 columns) was cleaned by:

- Standardizing state codes and names
- Converting values to consistent units
- Filtering for completeness and accuracy
- Creating aggregated views by mode, commodity, and geography

Integration Approach

Economic data integration involved:

- Matching BEA regional identifiers with FAF geographic codes
- Temporal alignment of annual metrics
- Creation of derived variables for per capita analysis
- Development of growth metrics for longitudinal study

Analytical Methods

Statistical techniques applied:

- Correlation for relationship strength
- Time series analysis for trend identification



Freight connects the dots between supply chains and state prosperity

The data shows the connection clearly enough to guide planning, logistics, and investment.

Thank You!

I appreciate your time and attention today.



Questions?