Analyzing the Relationship Between Economic Indicators and Crime Rates

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1 Introduction

Crime rates and economic conditions have long been subjects of sociological and economic research. Understanding how economic factors influence crime rates can help policymakers develop more effective interventions to improve public safety and economic stability. This study explores the relationship between key economic indicators and crime categories across U.S. states, leveraging advanced visualization techniques to make patterns accessible to policymakers designing interventions, law enforcement agencies optimizing patrols, and researchers testing socioeconomic theories. By addressing gaps in prior visual analysis methods, we aim to empower these users to derive actionable insights from complex datasets.

1.1 Initial Research Directions

Before deciding to proceed with this topic, we initially attempted to develop our project around the COVID-19 pandemic. However, we could not find a dataset that complemented the existing COVID dataset (COVID-19, 2025). Our findings were constrained to a brief time frame of just a few months, excluding key COVID-19 peak periods.

After deciding to focus on crime rates in the US, we initially considered analyzing the relationship between crime and gun possession. However, we were unable to find a suitable dataset for this analysis. Although several studies have explored the relationship between economic indicators and crime rates, we found that few have leveraged advanced data visualization techniques to analyze and communicate these patterns effectively. This gap motivated us to pursue our research in this direction.

2 Related Work

For our project, we drew inspiration from existing visualizations and techniques discussed in class. One key reference was the Banda UltraLarga (BUL) Italia interactive map, which provides a clear and intuitive representation of broadband coverage across Italy. This visualization influenced our approach to displaying geographical data, particularly in terms of color-coding regions based on performance metrics and implementing interactive elements like zooming and filtering.

Additionally, examples demonstrated in class helped shape our design choices. For instance, we adopted best practices for **color contrast and accessibility** after analyzing case studies on effective color schemes in data visualization. Interactive dashboards shown during lectures also guided our decisions on **user interaction** (e.g., tooltips, clickable items) and **layout organization** to ensure clarity and usability.

3 Design Requirements

The design requirements were derived from user needs (policymakers, researchers, journalists) and the analytical questions to be explored.

3.1 Analytical Questions

The system must enable users to answer:

- Does the number of robberies increase with unemployment rates?
- Do states with higher weekly earnings experience more financial crimes, such as money laundering?

- Are sudden income changes linked to spikes in welfare fraud?
- Do low-income states have higher rates of prostitution and/or drug-related offenses?
- Is there a lag between GDP drops and crime surges?

3.2 User Tasks

To answer these questions, users should be able to:

- Compare multiple crime rates across states;
- Visualize temporal trends of crimes and economic indicators;
- Identify correlations through data overlays (e.g., crime maps + unemployment heatmaps);
- Filter specific crimes/indicators (e.g., only "homicides" and "state GDP");
- Drill down into state-specific data (tooltips, bar charts).

4 Data Sources and Processing

Our analysis combines crime statistics with economic indicators through an extensive data processing pipeline.

4.1 Data Collection

The data used for the chosen analysis came from two main sources:

- **FBI Crime Data**: Crime statistics were collected from the FBI database (FBI, 2025), requiring manual retrieval of individual crime reports for each jurisdiction.
- **Urban Institute Economic Data**: Economic indicators (weekly earnings, state GDP, unemployment rates, and housing price indices) were sourced from the Urban Institute's State Economic Monitor (Urban, 2025).

4.2 Data Processing

4.2.1 Crime Data Consolidation

The crime data required extensive preprocessing due to its fragmented initial structure. The raw dataset consisted of 72 separate CSV files for each jurisdiction (50 states plus the District of Columbia), with each file representing a distinct crime category.

To create a workable dataset, we developed a Python script that systematically consolidated these files through several key operations. The script first standardized the file names by removing date stamps and extensions, then extracted the first row from each crime category file while replacing column values with cleaned crime category names. This process was repeated across all jurisdictions, ultimately aggregating the data into single, state-specific files while preserving the categorical structure of the original crime reports.

The transformation reduced the original 3,672 individual files (72 categories $\times$ 51 jurisdictions) to 51 consolidated state files, enabling efficient cross-state analysis while maintaining granular crime category information.

4.2.2 Economic Data Transformation

The economic indicators required significant transformation to create a unified time-series dataset. The raw data arrived in mixed frequencies as some metrics were reported quarterly while others came as monthly or irregular multi-month values.

To enable consistent temporal analysis, we implemented a Python processing pipeline that harmonized all indicators to monthly resolution. For quarterly data, values were evenly distributed across three months (with each monthly value calculated as one-third of the quarterly total). Irregular multi-month indicators were linearly interpolated to estimate monthly values. The script automatically detected each metric's native frequency through date pattern recognition, then applied the appropriate transformation while preserving the original state-level relationships.

The final output maintained the complete set of state-level economic measurements while standardizing the time intervals for direct comparison with crime patterns.

5 Design

5.1 Midterm Interface Description

This project introduces an interactive tool designed to visualize and analyze the relationship between economic indicators and crime rates across US states. The interface is divided into two main pages.

5.1.1 Home Page

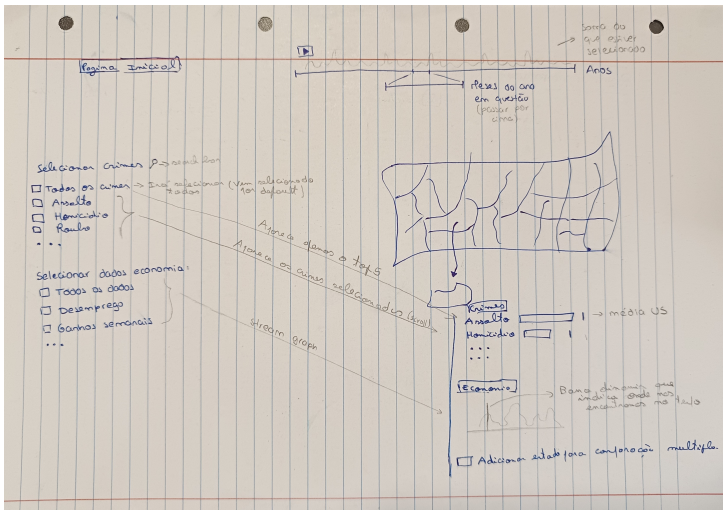

Figure 1: Sketch of the Home Page Interface

This page allows the user to select different crimes and economic indicators for analysis and visualize trends over time.
The **Main Elements** are listed below:

- **Crime Selection:**

  All crimes

  Assault

  Homicide

  Robbery

  ... (Other crimes)

  The system dynamically visualizes the relationships between the selected crimes. **Search Bar:** Allows users to search for specific crimes within the list.

- **Economic Data Selection:**

  All data

  Unemployment

  Weekly Earnings

  ... (Other indicators)

  Search Bar: Allows users to search for specific economic data indicators within the list.

- **Visualizations and Graphs:**
  - **Interactive Timeline**: Allows users to select specific time periods for a more detailed temporal analysis.
  - **Interactive US Map**: Enables the selection of individual states for in-depth analysis.
  - **Bar Graph**:
    * If all crimes are selected, it shows the top five most common crimes in the chosen state.
    * If specific crimes are selected, it ranks them from most to least frequent.
    * A scroll feature will be included to accommodate a large number of selected crimes.
  - **Stream Graph**: Visualizes the variation of economic data over time for a previously selected state.

- **Comparison with National Average:**
  - An indicator bar displays how the selected state's crime rate compares to the US average for that specific crime.

- **Multiple Comparison Option:**
  - A checkbox enables the addition of multiple states for comparison. When selected, the second page opens in a separate tab.

5.1.2 Comparison Page

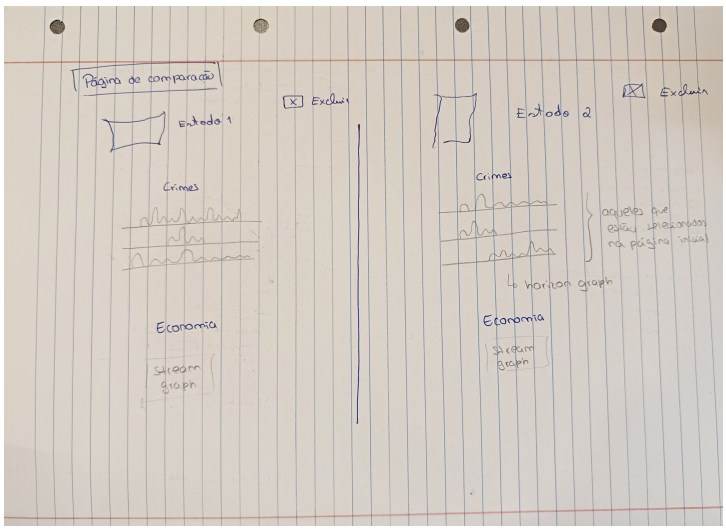

Figure 2: Sketch of the Comparison Page Interface

This page enables a side-by-side analysis of two or three states selected by the user.
The **Main Elements** are listed below:

- **State Selection:**
  - Users can select up to three states for side-by-side comparison.
  - Each state can be individually removed by clicking the cross icon above.
- **Crime Visualization:**
  - Display of trends for the crimes selected on the Home Page.
  - **Horizon Graphs:** Used to compare crime trends between states.
- **Economic Data Visualization:**
  - **Stream Graphs:** Used to show economic variations between states.

5.2 Development Challenges and Scope Adjustments

As outlined in **Section 6 (Midterm Interface Description)**, we initially developed a mockup to guide our implementation. However, certain elements posed technical challenges or proved incompatible with our dataset, necessitating modifications.

5.2.1 Home Page

- **Interactive Timeline:**

In the midterm mockup, we proposed an **interactive timeline** with a hover-based tooltip system, where users could select a specific month by navigating through yearly dropdowns. However, this implementation proved overly complex due to technical constraints. After evaluating alternatives, we simplified the design to a slider-based timeline along an x-axis, where users select a year directly by dragging the slider to the desired position. This approach retained the core functionality while improving usability and reducing development overhead.

- **Stream Graph:**

While we retained the core functionality of visualizing economic data over time, we ultimately abandoned the initial **stream graph** approach. This decision was driven by two key factors:

- **Dataset Complexity:** The presence of both positive and negative values would have required dual input streams (separate treatments for each polarity), doubling implementation overhead.
- **Visual Clarity:** The resulting superposition of positive/negative layers would have obscured trends, contradicting our goal of intuitive data interpretation.

We then considered a **bidirectional area chart** as an alternative, where positive values would be displayed above the zero axis and negative values would be shown below the zero axis. However, this approach also proved ineffective because:

- The mirrored layout created visual fragmentation, making it difficult to assess overall trends.
- Simultaneous interpretation of opposing directions added cognitive load without providing analytical value.

For the final solution we implemented a **heatmap** with standardized values using Z-score normalization, featuring color encoding:

- Red hues for values above historical averages.
- Blue hues for values below historical averages.
- Intensity scaling to reflect deviation magnitude.

This approach provided optimal balance between visual clarity and analytical depth while respecting our dataset's unique characteristics.

- **Comparison Option:**

We simplified the user interface by removing the **checkbox** that enabled multi-state comparisons in a separate tab. Instead, we integrated this functionality directly into the design as a dedicated tab, allowing users to freely select any state for comparison without requiring an additional toggle.

5.2.2 Comparison Page

- **Crime Visualization:**

We selected **line graphs** over **horizon graphs** for crime trend visualization due to their superior clarity in displaying state-by-state comparisons. A configurable limit on simultaneously displayed crimes prevents visual overcrowding while maintaining analytical value.

- **Economic Visualization:**

In alignment with our economic visualization methodology (**Section 7.1.2**), we implemented **heatmaps** as the standard for displaying value variations, enabling more effective state-to-state comparisons.

6 Final Product Overview

6.1 Main Page

6.1.1 Main Dashboard

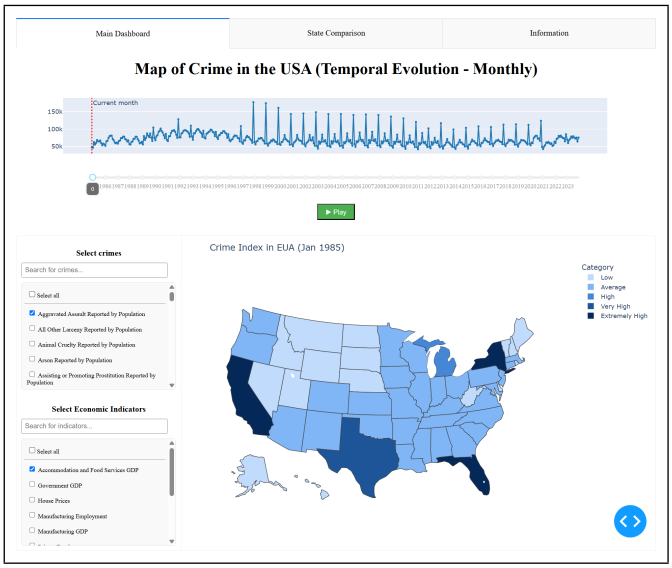

Figure 3: Screenshot of the Main Dashboard Implemented

The main dashboard serves as the entry point for exploring crime and economic data across U.S. states. Key features include:

- **Interactive Map**:
  - Choropleth visualization of crime rates by state
  - Color-coded using IQR classification (7 categories from "Extremely Low" to "Extremely High")
  - Dynamic updating based on selected crimes and time period
- **Temporal Controls**:
  - Slider for precise month/year selection (January 2019 - December 2023)
  - Play/pause animation to observe temporal trends
  - Horizon graph showing aggregated crime trends
- **Data Selection**:
  - Multi-select crime checklist with search functionality
  - Economic indicator selection panel
  - "Select all" toggle for both crime types and economic metrics
- **Visual Encoding**:
  - Geographic encoding for spatial patterns
  - Sequential color scheme (blues) for crime intensity
  - Diverging color scheme (red-blue) for economic deviations

6.1.2 Pop-Up Page

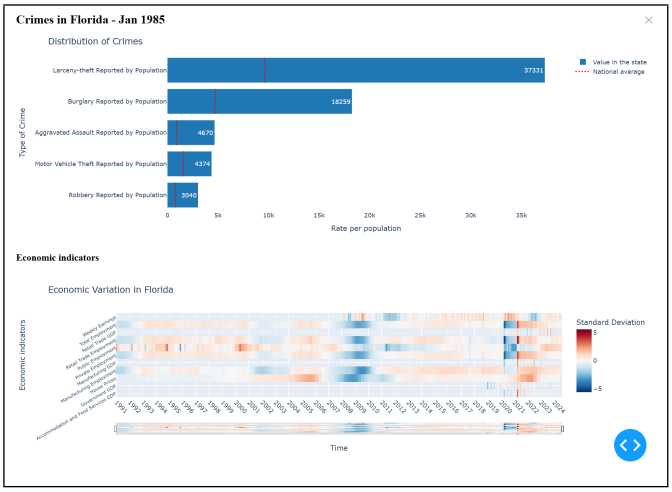

Figure 4: Screenshot of the Pop-Up Implemented

When users click on any state, a detailed modal appears with:

- **Crime Distribution**:
  - Horizontal bar chart showing top 5 crimes (or selected crimes)
  - Red reference line indicating national average
  - Value labels for precise comparison
- **Economic Heatmap**:
  - Time-series heatmap of selected economic indicators

- Z-score normalization for cross-metric comparison
- Interactive rangeslider for temporal zooming
- Current period highlighted with red marker

6.2 Comparison Page

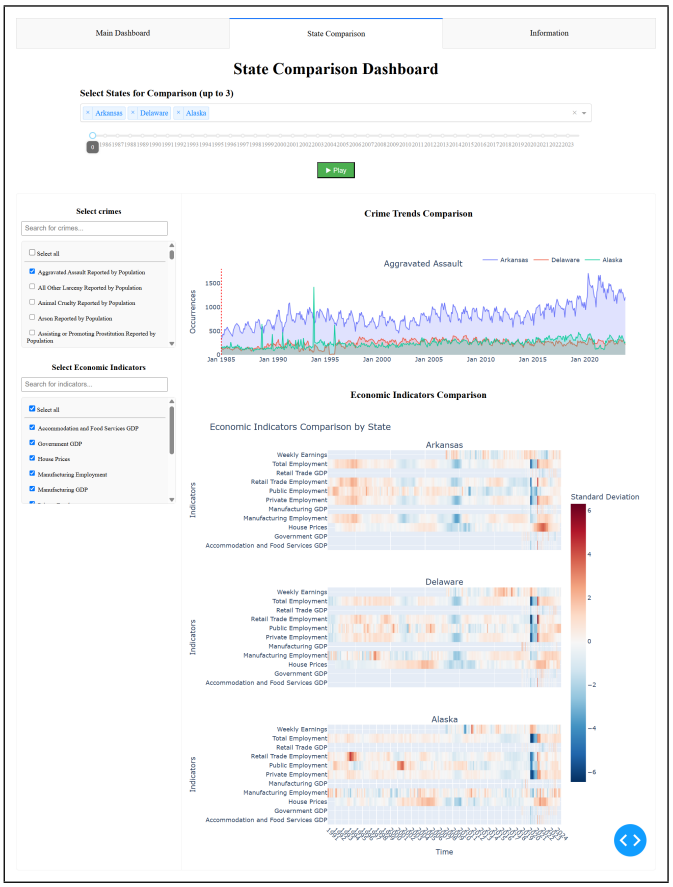

Figure 5: Screenshot of the Comparison Page Implemented

This dedicated interface enables side-by-side analysis of up to 3 states with:

- **State Selection**:
  - Dropdown menu with all 50 states + DC
  - Dynamic filtering of invalid combinations
- **Crime Trend Visualization**:
  - Small multiples layout (one row per crime type)
  - Horizon-style graphs with area encoding
  - Shared timeline with synchronized current period marker
  - Color-coded by state for easy comparison
- **Economic Comparison**:
  - Matrix-style heatmap showing all selected metrics
  - Row grouping by state-metric pairs
  - Standardized scores for relative performance analysis
  - Annotated current period reference
- **Interactive Features**:
  - Linked highlighting across visualizations
  - Consistent play/pause controls for temporal analysis
  - Responsive design adapting to number of selections

6.3 Information Page

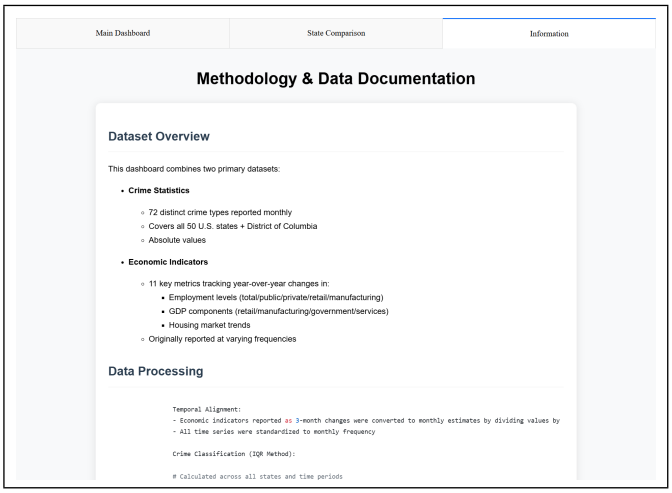

Figure 6: Screenshot of the Information Page Implemented

The methodology section provides transparent documentation of:

- **Data Processing**:
  - Temporal alignment procedures
  - IQR-based crime classification
  - Z-score normalization for economic indicators
- **Visual Design Choices**:
  - Color encoding rationale
  - Small multiples strategy
  - Horizon graph implementation
- **Technical Implementation**:

  - Dashboard architecture
  - Performance optimization
  - Responsive design considerations

- **Data Sources**:
  - FBI Crime Data provenance
  - Urban Institute economic metrics
  - Update frequency and coverage details

This multi-tab interface provides a comprehensive analytical tool that combines:

- Macro-level spatial patterns
- Micro-level state-specific insights
- Temporal trend analysis
- Cross-state comparative capabilities

All visualizations implement principles from the Advanced Data Visualization course, including:

- Effective use of color and layout
- Appropriate abstraction levels
- Thoughtful interaction design
- Perception-based encoding choices

The system successfully addresses all initial research questions while maintaining usability across different analytical scenarios.

7 Conclusion

This project developed an interactive visualization system to explore relationships between economic factors and crime patterns across U.S. states. Our work demonstrates how thoughtful visualization design can make socioeconomic research accessible while maintaining analytical rigor, serving as an effective communication tool between data scientists, policymakers and the general public. The system successfully bridges the gap between complex statistical data and meaningful interpretation, providing valuable insights into the crime-economy relationship.

7.1 Evaluation

The dashboard's usability was evaluated through formal user testing with students from various academic backgrounds. Participants were asked to complete specific analytical tasks while providing feedback on:

- Visualization clarity and interpretability
- Interface usability
- Effectiveness in answering research questions

Key findings from the evaluation:

- Participants consistently reported that the visualizations helped them understand complex datasets
- Technical users valued the system's analytical capabilities and interactive features
- General audiences appreciated the intuitive design that made advanced data analysis accessible
- The comparison functionality (limited to 3 states) proved particularly valuable for identifying regional patterns

7.2 Critical Reflection

While the project achieved its objectives, several limitations merit discussion:

Timeline Implementation:

- The final slider-based timeline represents a simplification of our initial interactive concept
- Technical constraints prevented implementation of hover-based tooltips and multi-level navigation

Comparison Limitations:

- The 3-state limit was necessary to prevent visual clutter with complex datasets
- Testing revealed cognitive overload when comparing more than three jurisdictions simultaneously

Design Tradeoffs:

- The heatmap visualization, while effective for correlations, required careful color scaling

- Some temporal granularity was sacrificed for monthly alignment of economic indicators

These constraints highlight the ongoing challenge of balancing analytical depth with usability. Future work could explore:

- Adaptive interfaces that adjust complexity based on user expertise
- Enhanced temporal navigation tools
- Dynamic comparison limits based on data density and display size

References

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