

Exploring the Immigration Movement between Australia and United States of America and their Relationship between Economic Factor

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1. Introduction

This narrative visualization aims to explore and communicate the complex relationship between economic factors and immigration patterns between the United States and Australia, and how the Australia-United States Free Trade Agreement (AUSFTA) has impact on it.

The primary findings and messages this visualization conveys include:

1. The impact of AUSFTA on immigration trends between both nations
2. The correlation between various economic indicators (such as GDP, inflation, unemployment) and immigration patterns
3. The relationship between trade volumes and population movements
4. The comparative analysis of economic factors' influences on immigrant populations in both countries

The intended audience encompasses three main groups:

- Policy makers and government officials who need to understand the relationship between economic policies and immigration trends
- Researchers and analysts studying international migration patterns and economic relationships
- Potential migrants and business professionals interested in understanding how economic conditions influence migration opportunities between these countries

The visualization is structured to guide users through progressively complex analyses, starting from basic population trends and moving towards detailed correlation analyses. Through interactive elements such as scatter plots, radar charts, and correlation heatmaps, users can explore the data at their own pace and focus on aspects most relevant to their interests. The narrative approach ensures that even users without extensive statistical knowledge can understand the relationships between economic factors and immigration patterns.

Special attention has been paid to making the visualization accessible and informative through:

- Clear explanations of statistical concepts
- Interactive elements that allow data exploration
- Comprehensive tooltips and guides
- A logical progression from simple to more complex analyses

This visualization serves not only as an analytical tool but also as an educational resource for understanding the intricate relationships between economic factors and international migration patterns in the context of two major developed economies.

2. The Design Process

1. Brain Storming

The brainstorming process began with a structured approach using a 5-page design sheet methodology. On the first sheet, I started by clearly identifying the key components of my visualization project: comparing Australian-born residents in the USA versus American-born residents in Australia. The process was broken down into four main sections. First, I gathered initial ideas by listing out all the essential elements that needed to be considered - the countries involved (AUS vs USA), time factors (ensuring data matching across periods), and various factors like population, AUSFTA impact, trade volumes, and other economic indicators. In the second section, I filtered through possible visualization methods, listing out all potential chart types from basic bar charts to more complex radar diagrams and bubble charts. The third section focused on categorizing these ideas into three main groups: observations over time, geographical representations, and relationship analyses. Finally, I refined these ideas by sketching potential combined visualizations and considering how they might work together to tell a coherent story. This systematic brainstorming approach helped me move from broad concepts to specific, implementable visualization ideas while ensuring all key aspects of the data would be effectively represented.

2. Design Proposal 1

My first design proposal focused on creating an interactive visualization that combines line and bar charts to showcase the relationship between population trends and economic factors for Australia and the United States. The design features a clean layout with three main interactive elements at the top: country selection toggles, an economic factor dropdown menu, and a time period selection range. The main visualization consists of two components: line charts displaying population trends (with red representing Australia and blue for the USA) and bar charts showing the selected economic factor. To enhance user interaction, I incorporated hover functionalities that display exact values and provide visual feedback through enlarged points on the lines and colour changes in the bars. The design allows users to select one or both countries, choose a single economic factor, and adjust the timeframe for analysis. While this approach offers easy comparison capabilities and intuitive interaction, I identified potential limitations including the restriction to displaying only one economic factor at a time and possible visibility issues with the bars when viewing extended time periods.

3. Design Proposal 2

My second design proposal focused on a geographical visualization approach, featuring interactive maps of Australia and the United States combined with multi-factor bar charts. The design allows users to select a specific year and compare multiple economic factors simultaneously across both countries. The visualization uses a color-coded system to represent different economic indicators - including AU Import Growth, AU GDP Growth, and S&P 500 Growth - with bars superimposed on each country's map. Interactive elements were carefully considered, with hover/clicking functionality on both the maps and bars providing detailed population growth rates and specific statistics for the selected year. The maps serve as an intuitive geographical reference, while the color-coded bars enable quick

visual comparison of different economic factors. While this design offers the advantage of displaying multiple economic factors simultaneously and uses colour coding effectively for easy differentiation, I identified a potential limitation where users might misinterpret the bars as representing individual cities rather than national statistics. The design particularly excels in allowing users to select multiple economic factors for comprehensive comparison while maintaining visual clarity through careful colour coding.

4. Design Proposal 3

My third design proposal focused on creating a comprehensive relationship analysis dashboard combining multiple visualization types to explore economic factors' impact on population. The design features an advanced layout where users can select a country and multiple economic factors to analyse their relationships through various complementary visualizations. The interface incorporates scatterplots with interactive hover functionality to show detailed information at specific points, an adaptable radar diagram that maintains a diamond shape for up to four factors but can expand to accommodate more, and interactive bubble charts with customizable parameters. A key innovation in this design is the radar diagram's flexibility, defaulting to a diamond shape but capable of morphing to display additional factors when selected. The proposal also includes box plots and animated bar charts to compare different time periods dynamically. While this design offers rich analytical capabilities and adaptable visualizations that can handle varying amounts of data, I identified potential challenges including implementation complexity due to multiple interactive elements and the risk of overwhelming users with too much simultaneous information. The design prioritizes analytical depth but may require careful user guidance to maintain focus and usability.

5. Final Design Justification: Population and Economic Factors Dashboard

The visualization dashboard design is based on design proposal 3 because it offers comprehensive relationship analysis through multiple complementary visualizations, and is grounded in Munzner's nested model for visualization design and validation (Munzner, 2009). This model emphasizes the importance of addressing both domain situation and abstract task requirements before moving to visual encoding and interaction techniques. Design proposal 3's combination of scatterplots, radar diagrams, and bubble charts directly addresses these requirements by providing different analytical perspectives and levels of complexity. This approach was particularly crucial given our diverse audience of policymakers, companies, and potential migrants, each bringing different levels of data literacy and analytical needs, who can choose visualization types that best match their analytical capabilities and requirements.

Visual System Considerations

The design leverages key principles of human visual perception, particularly:

1. **Pre-attentive Processing:** The use of distinct visual channels such as spatial position, colour, and form allows users to quickly identify patterns and relationships without cognitive overload (Ware 2004, as cited in Dhiti-ai, 2021). This is exemplified in:
 - The scatterplot's position encoding for relationship analysis.

- The radar diagram's shape form variations for multi-factor comparison.
 - The bubble chart's size and colour encoding for quantitative variables.
2. **Visual Working Memory:** Considering the limitation of human working memory to 3-4 items of visual information (Luck & Vogel 1997, as cited in Chen & Du 2017), the design:
- Defaults to one plot if multiple forms of the plot can be selected.
 - Each page has at most three different plots.
 - Implements progressive disclosure through interactive elements.
 - Uses consistent visual encodings across different visualization types

Colour Design Rationale

The colour scheme employs blue and red strategically for both country identification and relationship visualization:

1. **Relationship Encoding:**
 - Blue represents positive correlations/relationships
 - Red indicates negative correlations/relationships
 - This follows conventional data visualization practices where blue typically represents favourable or positive trends, while red signals caution or negative patterns
2. **Perceptual Effectiveness:**
 - Strong visual contrast between blue and red aids quick pattern recognition
 - Intuitive colour mapping (blue=positive, red=negative) reduces cognitive load
 - Helps policymakers and analysts quickly identify important relationship patterns
3. **Dual Purpose:**
 - Colours serve both country identification and relationship indicators
 - Consistent application across different visualization types maintains clarity
 - Supports both expert and general audience understanding

Layout and Interaction Design

The dashboard's layout structure implements Shneiderman's Visual Information-Seeking Mantra: "Overview first, zoom and filter, then details-on-demand" (Shneiderman, 1996):

1. **Overview Layer:**
 - Welcome page with content overview

- Summary panel for quick insights
- Multi-view coordination for context maintenance

2. Interactive Elements:

- Time period selection controls
- Economic factor filtering
- Drill-down capabilities through hover and click interactions

Narrative Structure and Flow

The visualization employs a "Martini Glass" structure that balances author-driven and reader-driven approaches (Segel & Heer, 2010):

1. Author-Driven Opening:

- Starts with a welcome page and guided tutorial
- Sequential progression from population to economic data
- Clearly structured introduction to build understanding

2. Reader-Driven Exploration:

- Opens up to interactive exploration allowing users to:
- Select economic factors and countries
- Interact with multiple visualization types
- Explore data through hover and click interactions

3. Progressive Disclosure:

- Interactive elements introduced gradually
- Focused panels for specific data aspects
- Adaptable visualizations based on user selections
- Summary view for quick insights

This structure serves our diverse audience (policymakers, companies, migrants) by providing both guided insights and freedom for personal exploration, ensuring users understand key concepts before diving into detailed analysis.

Audience-Specific Considerations

The design caters to different audience needs through:

1. Policymakers:

- Comprehensive overview of trends

- Detailed statistical comparisons
- Export capabilities for report generation

2. Companies:

- Focus on economic indicators
- Interactive filtering for specific time periods
- Comparative analysis tools

3. Potential Migrants:

- Intuitive interface design
- Clear visual hierarchy
- Guided exploration of key metrics

Implementation Choices

The technical implementation leverages D3.js for several reasons:

1. **Flexibility:** Custom visualizations can be created to match specific requirements
2. **Performance:** Efficient handling of interactive elements and data updates
3. **Accessibility:** Built-in support for ARIA labels and keyboard navigation
4. **Scalability:** Component-based architecture for future extensions

Conclusion

The design choices reflect a careful balance between analytical depth and usability, grounded in established visualization theory and best practices. The multi-layered approach ensures that different user groups can effectively access and analyse the data according to their specific needs and expertise levels.

3. Implementation

3.1. Technical Implementation

The visualization dashboard was implemented using R and Shiny, deviating slightly from the original D3.js plan in Design Proposal 3 due to several practical considerations:

- **Implementation Efficiency:**
 - R's statistical packages provided robust data analysis capabilities
 - Shiny's reactive programming model streamlined interactive visualizations
 - Integration with ggplot2 and plotly enabled rapid development of complex visualizations
- **Technical Challenges:**

- Managing multiple coordinated views while maintaining performance
 - Implementing complex interactive features like the morphing radar diagram
 - Ensuring smooth transitions between different visualization types
 - Handling real-time updates across multiple linked components
 - Coordinating data flow between interconnected visualizations
- **Modifications from Original Design:**
 - Simplified the radar diagram to a fixed shape (circle) but still allowed selecting different economic factors hence the morphing style still preserved.
 - Added a table below each page to help user switch pages
 - Enhanced interactivity through plotly integration
 - Added navigation controls for better user orientation

3.2. Interactive Narrative Visualisation Implementation

Overview

The implemented visualization creates a guided narrative experience exploring the relationship between economic factors and immigration patterns between Australia and the United States. The dashboard is structured into seven key sections, each building upon previous insights while maintaining a cohesive narrative flow.

1. Welcome Page



Introduction

Table of Contents

1. Welcome



The welcome page serves as an entry point, introducing:

- Project scope and objectives
- Research questions
- Target audiences (policymakers, companies, potential migrants)
- Navigation guidance
- Interactive tutorial system

This section establishes context and prepares users for the analytical journey ahead.

2. Population Changes Analysis

This section examines immigration patterns before and after the Australia-United States Free Trade Agreement (AUSFTA):

Interactive Elements:

- Radio buttons for time period selection (Pre-AUSFTA, Post-AUSFTA, Comparison)
- Animated bar race showing population changes over time
- Boxplots displaying statistical distributions

Key Features:

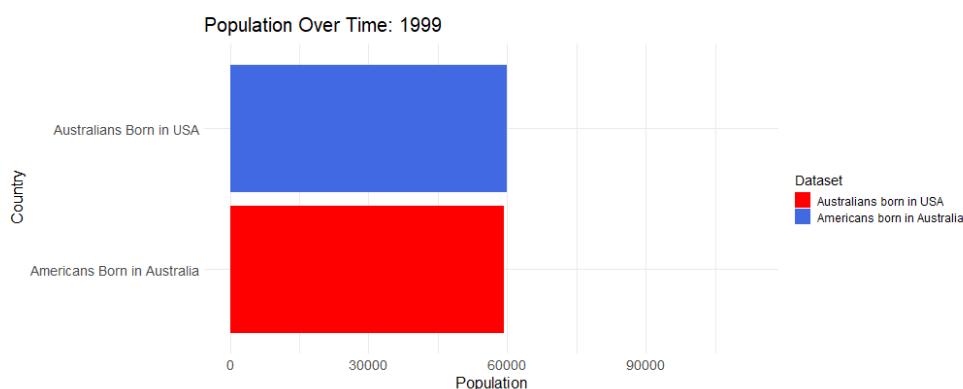
- Clear visual distinction between periods
- Dynamic updates reflecting user selections
- Statistical summaries for each period
- Trend analysis through animation

This visualization effectively shows how AUSFTA influenced migration patterns between the two countries.

Immigration Trends by AUSFTA Period

Select the plot to display:

- Pre-AUSFTA
- Post-AUSFTA
- Comparison

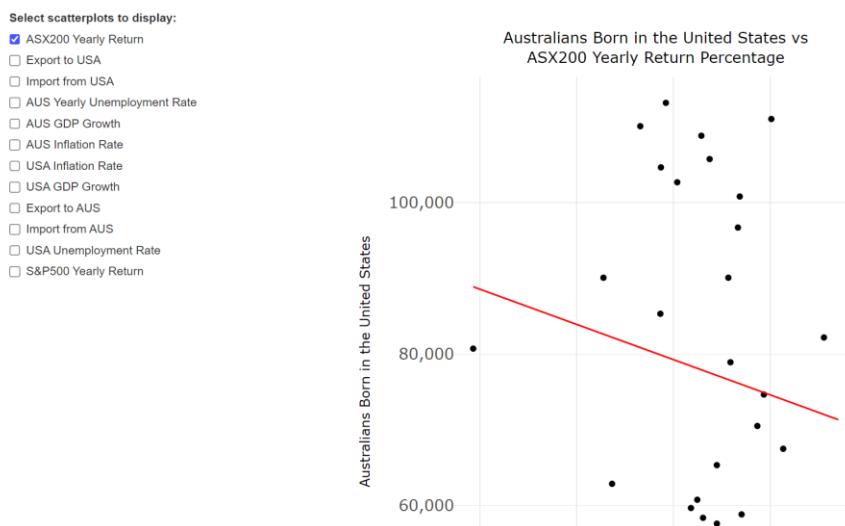


3. Australians Born in United States Analysis

This section explores economic factors affecting Australians born in the US through three complementary visualizations:

a) Interactive Scatterplots

- Multiple economic indicators selectable simultaneously
- Trend lines showing relationships
- Hover functionality for detailed data points
- Color-coded correlation indicators

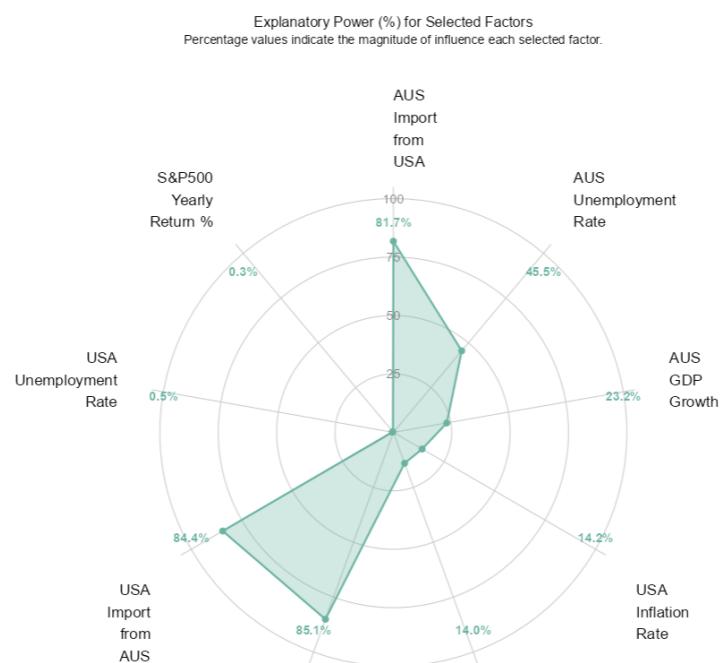


b) Radar Chart

- Visual comparison of factor influence
- Adaptable display based on selected variables
- Clear percentage indicators
- Interactive selection mechanism

Select variables for radar chart:

- ASX Yearly Return %
- AUS Export to USA
- AUS Import from USA
- AUS Unemployment Rate
- AUS GDP Growth
- AUS Inflation Rate
- USA Inflation Rate
- USA GDP Growth
- USA Export to AUS
- USA Import from AUS
- USA Unemployment Rate
- S&P500 Yearly Return %



c) Bubble Chart

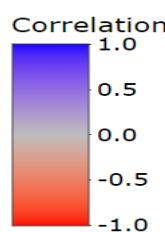
- Size encoding for explanatory power
- Colour encoding for correlation direction
- Position encoding for relationship strength
- Interactive filtering and selection

Select bubbles to display:

- ASX Yearly Return %
- AUS Export to USA
- AUS Import from USA
- AUS Unemployment Rate
- AUS GDP Growth
- AUS Inflation Rate
- USA Inflation Rate
- USA GDP Growth
- USA Export to AUS
- USA Import from AUS
- USA Unemployment Rate
- S&P500 Yearly Return %

Explanatory Power Legend

Weak Moderate Strong



This multi-view approach allows users to explore relationships from different perspectives while maintaining analytical context.

4. Americans Born in Australia Analysis

Mirrors the previous section's structure but focuses on Americans born in Australia:

Visualization Components:

- Synchronized scatterplots
- Adaptive radar diagram
- Interactive bubble chart
- Coordinated views

The parallel structure helps users compare patterns between both populations while maintaining consistent interaction patterns.

5. Economic Indicators Correlation Analysis

Features a comprehensive heatmap showing relationships between all economic factors:

Key Elements:

- Color-coded correlation strengths
- Interactive tooltips with exact values
- Hierarchical organization of indicators
- Clear visual patterns through colour gradients

This visualization serves as a synthesis tool, helping users understand broader economic relationships.

6. Summary and Insights

Provides a structured overview of key findings:

Components:

- Population trend summaries
- Economic factor analysis
- Cross-market correlations
- Key insights for different audience groups

Features:

- Clear section organization
- Highlighted key findings

- Audience-specific takeaways
- Links to detailed sections

7. Appendix

Contains:

- Data sources
- Additional resources

Navigation and User Guidance

The implementation includes several features to maintain narrative flow:

1. Consistent Layout:

- Fixed navigation bar
- Persistent section access
- Clear section indicators

2. User Assistance:

- Interactive tutorials
- Help buttons
- Context-sensitive guidance
- Clear instructions

3. Narrative Flow:

- Progressive disclosure of information
- Logical sequence of analyses
- Clear connections between sections
- Guided exploration paths

Technical Features

The implementation leverages several technical capabilities to enhance the narrative:

1. Interactivity:

- Real-time updates
- Synchronized views
- Smooth transitions
- Responsive design

2. Data Handling:

- Efficient data processing
- Dynamic filtering
- Coordinated updates
- Cached calculations

3. Visual Consistency:

- Unified colour scheme
- Consistent interaction patterns
- Standardized layouts
- Clear visual hierarchy

Target Audience Considerations

1. Policymakers:

- Comprehensive statistical analysis
- Clear trend identification
- Policy impact visualization
- Long-term pattern analysis

2. Companies:

- Economic indicator focus
- Market relationship analysis
- Trade pattern visualization
- Investment trend analysis

3. Potential Migrants:

- Population trend analysis
- Economic condition comparison
- Clear pattern identification
- Accessible data presentation

Implementation Challenges and Solutions

1. Data Complexity:

- Challenge: Managing multiple interrelated datasets.

- Solution: Efficient data structure and reactive programming.

2. User Guidance:

- Challenge: Balancing depth with accessibility
- Solution: Progressive disclosure and interactive tutorials

3. Performance:

- Challenge: Maintaining responsiveness with multiple views
- Solution: Optimized data handling and cached calculations

The implementation successfully combines narrative structure with interactive exploration, allowing users to both follow a guided story and explore data independently based on their interests and needs.

3.3. Using the Implementation

The interactive visualization dashboard can be accessed through the following steps:

1. System Requirements:

- R version 4.2.0 or higher
- RStudio (recommended for best experience)
- Required packages: shiny, ggplot2, plotly, dplyr, scales, ganimate, readr, jsonlite, reshape2, rintrojs, shinyjs
- Minimum 8GB RAM recommended for smooth performance

2. Getting Started:

- Download the complete project folder containing:
 - All R scripts
 - Data files (.csv and .json)
 - Required resources
- Open the R script file in RStudio
- Run the application using the 'Run App' button

3. Hidden Features:

- Every page has a tutorial popped up when first visiting, welcome page has a tutorial button, other pages can trigger tutorial by switching out and switching back.
- Bottom navigation panel on every page allows quick jumps between sections.

- Hovering over scatter plots, bubbles, and heatmap box reveals exact data points.
- Multiple selections possible in radar charts for complex comparisons.

4. Key Interactions:

- Radar charts require selecting at least 3 variables.
- Visualizations other than boxplot, animation and radar chart support zoom and pan functions.

5. Navigation Tips:

- Use the "Where would you like to go next?" panel at the bottom
- Follow the suggested narrative flow for first-time users
- Return to Welcome page for overall context
- Check Summary section for key insights

6. Troubleshooting:

- If visualizations don't load, wait for a few seconds, this is because animation is rendering.
- Ensure all data files are in the correct directory.
- Check R console for any error messages.

4. Conclusion

This project successfully developed an interactive narrative visualization exploring relationships between economic factors and immigration patterns between Australia and the United States. Through multiple coordinated views and guided exploration, the implementation effectively serves our diverse audience of policymakers, companies, and potential migrants.

The key achievement was creating a cohesive narrative structure that guides users through complex data relationships while maintaining analytical depth. The project demonstrated how interactive visualizations can make complex economic relationships accessible without sacrificing analytical rigor.

While the minimalistic design approach supports clarity and reduces cognitive load, there's room for discussion about the colour palette. The current predominantly blue and white scheme could potentially be enhanced with strategic use of additional colours to highlight key information, without compromising the clean aesthetic.

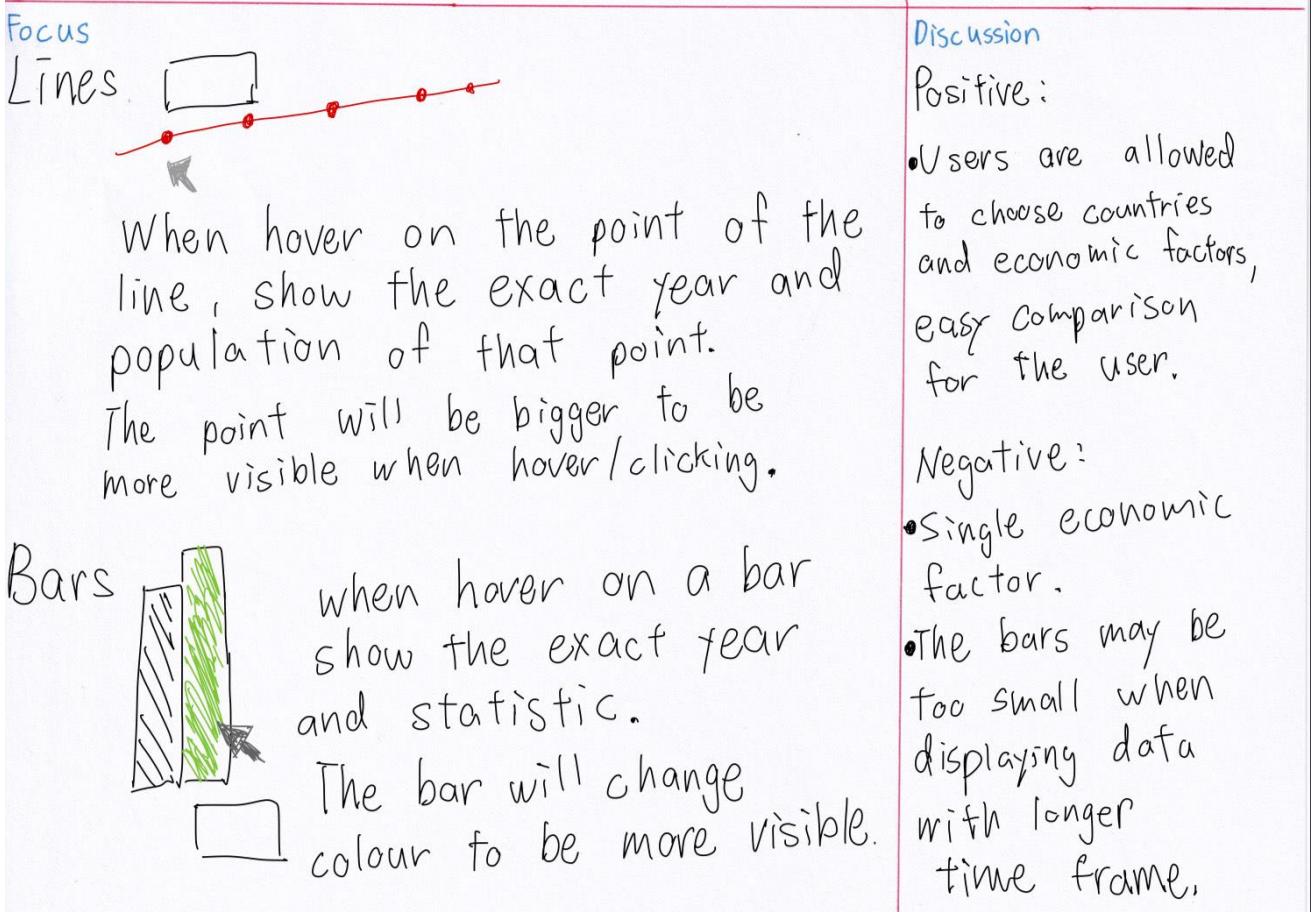
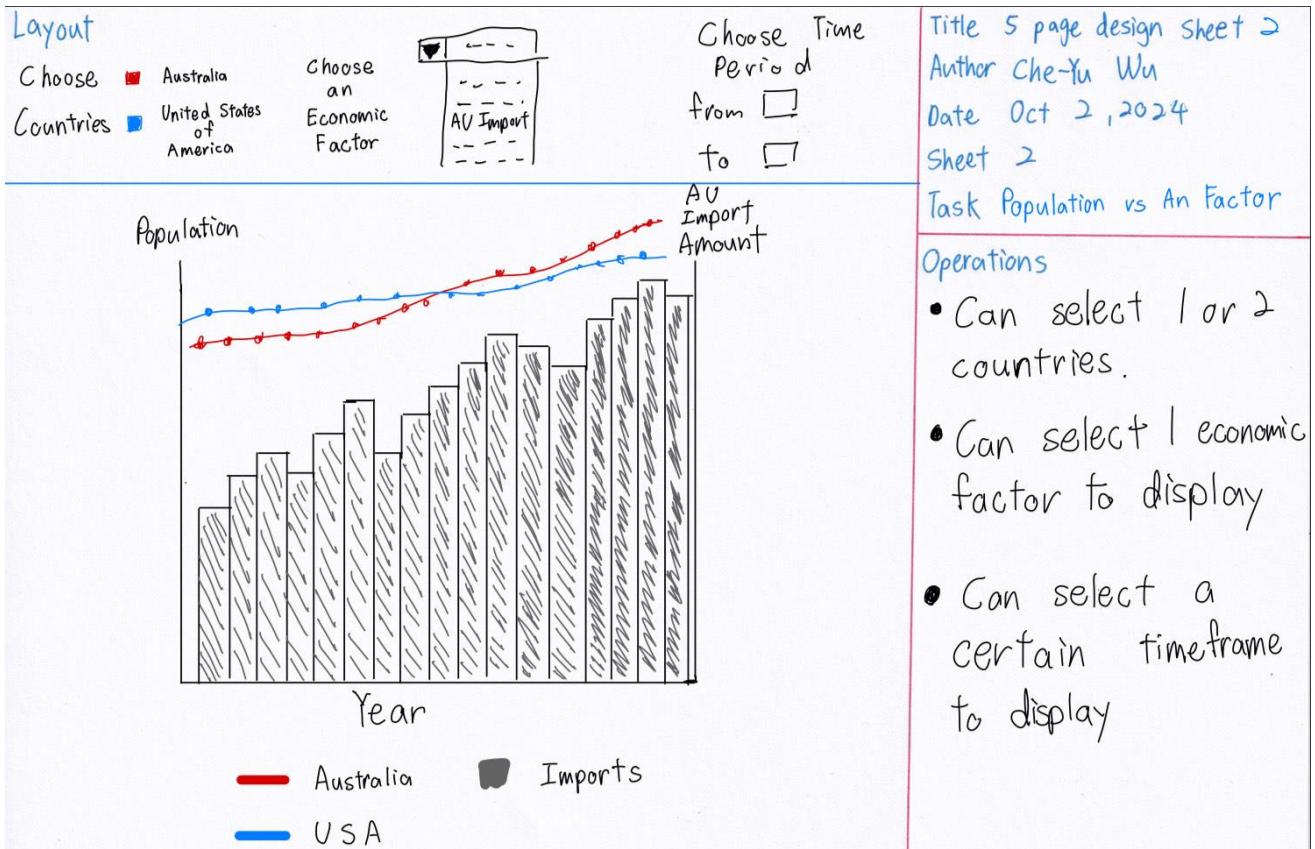
Future work could incorporate real-time economic data feeds, predictive analytics capabilities, and mobile optimization. The project provided valuable insights into balancing user accessibility with analytical depth, and the importance of narrative structure in data visualization.

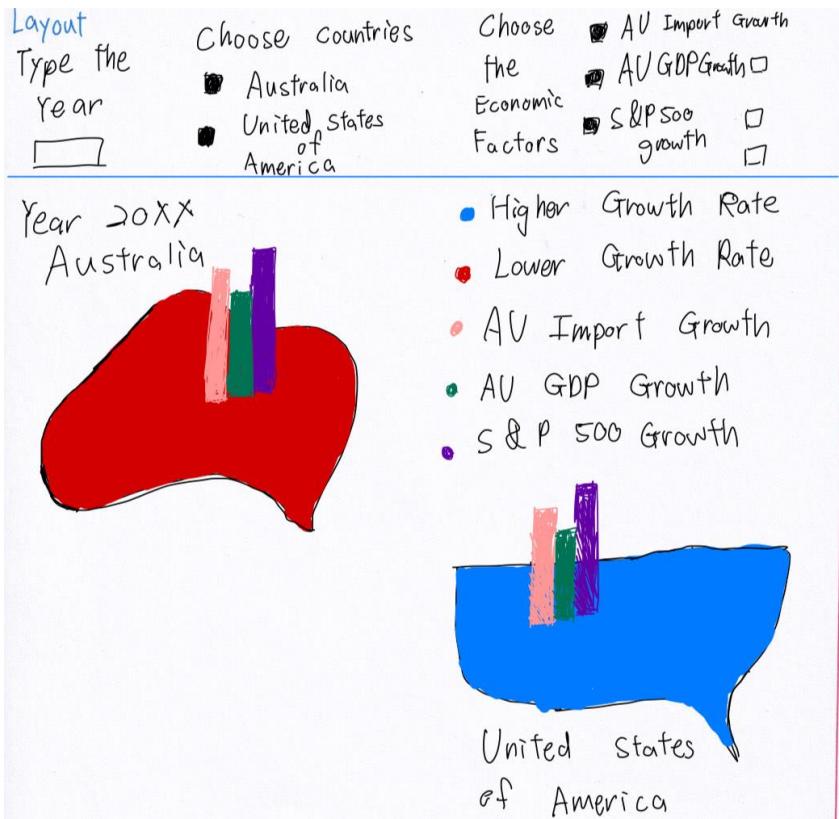
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<https://doi.org/10.1109/VL.1996.545307>

6. Appendix

<p>Title: 5 page design sheet 1 Author: Che-Yu Wu Sheet: 1 Date: Oct 2, 2024 Task: Brainstorming</p>	<p>Australian born in USA vs American born in Australia</p>	<p>2. Filter Here we can use</p> <ul style="list-style-type: none"> • Bar Chart on a map • Line chart • Bar Chart • Bar Chart (animated) • Line chart with Bar Chart • scatterplot • radar diagram • Bubble Chart • Box plot
<p>1. Ideas</p> <p>Countries: AUS vs USA</p> <p>Time: need to match for each data</p> <p>Factors: population vs AUSFTA, trade volume, other economic factors.</p> <p>A specific time vs showing different factors on the map</p> <p>Map: Cartogram, Choropleth proportion map, bar chart on map</p> <p>AUS vs USA</p> <p>Relationships:</p> <ul style="list-style-type: none"> Scatterplot (correlation) Heatmap Radar Diagram (R-squared, explanatory power of factors vs population) Sankey diagram Bubble Chart AUS or USA population vs Export 	<p>Timeframe</p> <p>Time series:</p> <ul style="list-style-type: none"> Line chart Barchart (animated) Line chart + Barchart <p>Area Chart</p> <p>longer R² the large of side</p>	<p>1. Observations over a time period</p> <ul style="list-style-type: none"> - Line Chart - Bar Chart - Line chart combined with bar chart <p>2. Map</p> <ul style="list-style-type: none"> - Bar chart on a map where we can use colour for different map states and bars <p>3. Relationship</p> <ul style="list-style-type: none"> - Scatter plot - Radar diagram - Bubble Chart
<p>4. Combine and Refine</p> <p>Sheet 1 Population AUS, USA vs an Factor over a time period</p> <p>Population</p> <p>Year</p> <p>AUS • USA</p> <p>Choose a factor</p> <p>A D B D C D D D</p>	<p>Sheet 2</p> <p>AUS</p> <p>Population of the year and the factors</p> <p>USA</p>	<p>Sheet 3</p> <p>More people</p> <p>Less people</p> <p>Year: ==</p> <p>Factors: ✓ V</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>Relationship between USA or AUS and other factors</p> <p>AUS population</p> <p>factor 1 → 3</p> <p>radar diagram</p> <p>Bubble Chart</p> <p>Box plot</p>



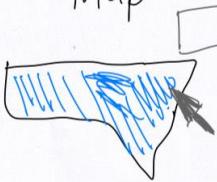


Title 5 page design sheet 3
Author Che-Yu Wu
Date Oct 2, 2024
Sheet 3
Task Year Growth Rate and factors observation

Operations

- Choose a specific year.
- Allowed to choose only 1 country to display but usually choose 2 for comparison.
- Can choose multiple economic factors to display and compare how they are related to population.

Focus Map



When hovering/clicking on the map, show the population growth rate and population of that year.

Discussion

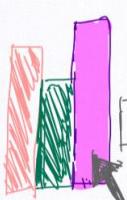
Positive:

- Can select multiple economic factors.
- The use of colour coding allows people to distinguish each category easily.

Negative:

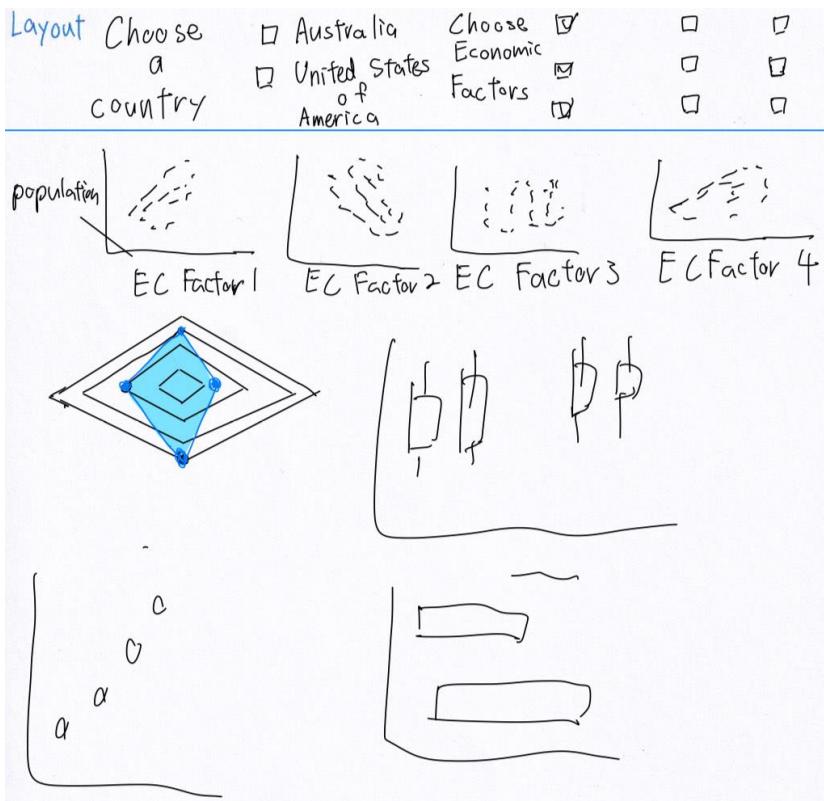
- People may think the bars represent the bars represent one of a city in the country.

Bars



When hovering / clicking the bar, the bar changes colour (becomes lighter/darker/contrast, yet to decide)

It will also show the actual statistics.



Title 5 page design sheet 4

Author Che-Yu Wu

Date Oct 2, 2024

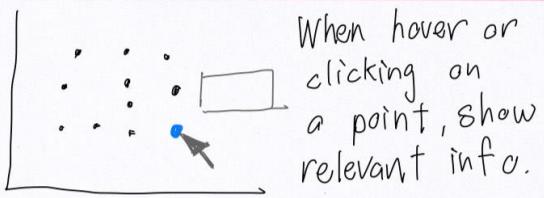
Sheet 4

Task Relationship Analysis

Operations

- Choose one country
- Choose Economic Factor to see the relationships
- Observe the relations and explanatory powers

Focus
Scatterplot



Discussion

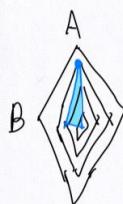
Positive:

- Multiple chart types are displayed.
- Charts and diagrams are adaptable to amounts of factors selected.

Negative:

- Maybe too complex to implement due to all the interactions.
- Might display too much info and user cannot focus.

Radar Diagram



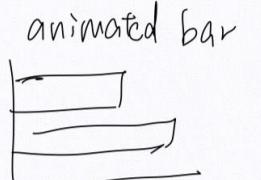
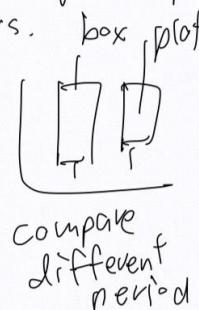
Default is a diamond shape. If select less than 4 factors, will still show a diamond. If select more than 4 will change shape to cover more factors.

Bubble Chart



can hover on bubble

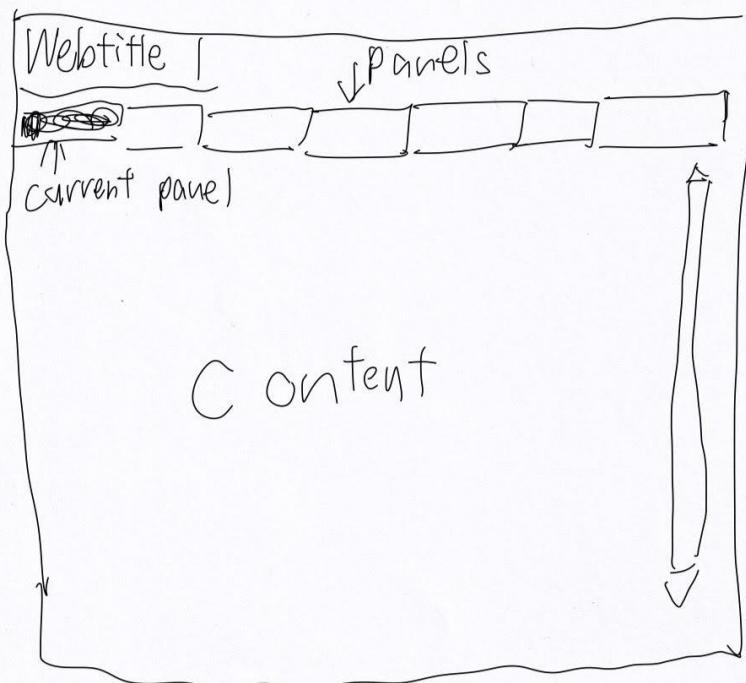
can choose number of bubble



use animation to show change

Layout

Use Web sheet 4 Dashboard Style



Focus: Minimalistic Style

2. Story telling

- Starting From a welcome page
- then present the plots sequentially in different pages.
- Tutorial Guidance for each page
- A summary page for the users want to quickly grasp the information

3. Population

↓
population vs Economic

↓
Economic vs Economic

Title 5 page design sheet 5

Author Che-Yu Wu

Date Oct 2, 2024

Sheet 5

Task Dashboard design

Operations

- Users can switch between panels.
- Each panel has its focus.

Details

- Need to take 2 weeks to finish.
- Some of the colours and implementations might still change
- Will be created by R or D3, D3 preferred.
- Data set will be cleaned by R.