Commerce Among Nations

A Bilateral Trade Data Visualization and Exploration Tool

Process Book

Andrew Lee, Franklin Yuan

https://github.com/candrewlee14/data-viz-project

Table of Content

Project Proposal

Team Information

Project Title: Visualizing Bilateral Trade Between Countries
Project Repository: https://github.com/candrewlee14/data-viz-project
Team Members:

- Andrew Lee, candrewlee14 at gmail.com, u1256173
- Franklin Yuan, franklin.yuan at utah.edu, u1369155

Background and Motivation

When China first joined the World Trade Organization (WTO) in 2002, few people expected how the world's economic dynamics would be so fundamentally impacted by this event. In a span of just two decades, China's exports rose from $333 billion in 2002 to $3,548 billion (or $3.5 trillion) in 2021, a whopping 965% increase. By 2020, China had overtaken the US as the world's biggest trade partner. But as China's trade relations with the world grew, so did tensions between the US and China. In 2018, the Trump administration launched its "trade war" against China by slapping tariffs on two-thirds of Chinese exports to the US. One of the US's main goals was to reduce its deep trade deficit with China which stood at $481 billion before Trump took office.

Franklin is from China and Andrew is from the US. We both are very interested in the trade relations between the US and China. We are particularly interested in gaining more insight into the countries' bilateral export and import data both in gross volume and by product category over the years. This project is our attempt to create a visualization that makes the analysis on any two countries' bilateral trade data more accessible to the general public.

Project Objectives

The visualization allows a user to select two countries in the world to study their bilateral trade relations. Through exploring the visualization, a user will be able to answer:

- How much did country A import from and export to country B over the years?
- What products are country A's top exports and imports with country B?
- How much of a specific product did country A export to country B in a given year?
- How much is the trade balance between country A and country B in a given year?
- How has the bilateral trade balance changed over the years?

The goal is to help the user develop a deeper understanding and intuition of the trade relations between two specific countries.

Data

The dataset we are using will likely come from the World Trade Organization (https://stats.wto.org/). Countries periodically report their trade information with other countries. These trades are broken down into product/sector categories (Animal, Dairy, Chemical, Manufacturing, etc).

The bilateral import data they publicly offer includes the following information and more:

- Importing country
- Exporting country
- Product category
- Volume in US dollars
- Year

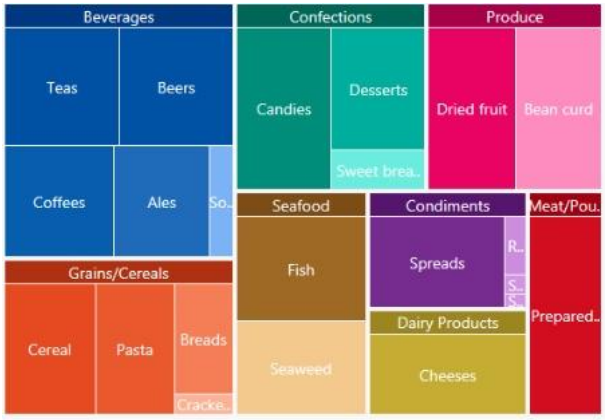
There shouldn't be a lot of data processing and wrangling involved in this project. The data from the World Trade Organization is highly structured, tabular data in CSV files with clearly defined types, so it should be relatively straightforward to use that data when making our visualizations. Most of the difficulty of this project will be on the frontend design and visualizations.

Visualization Design

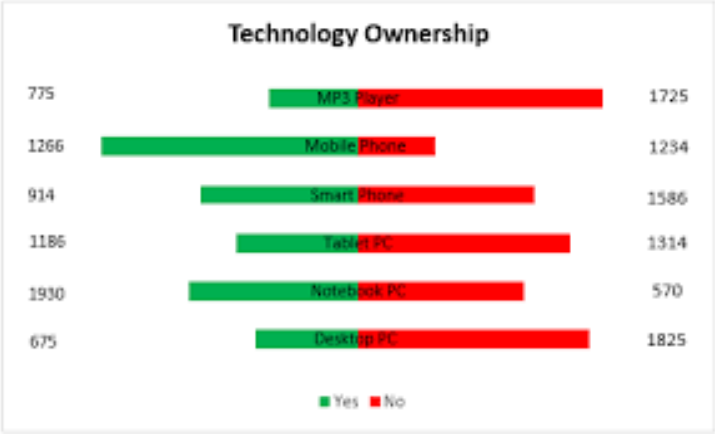
Brainstorming

We first come up with many different types of visualization we can create to present the data.

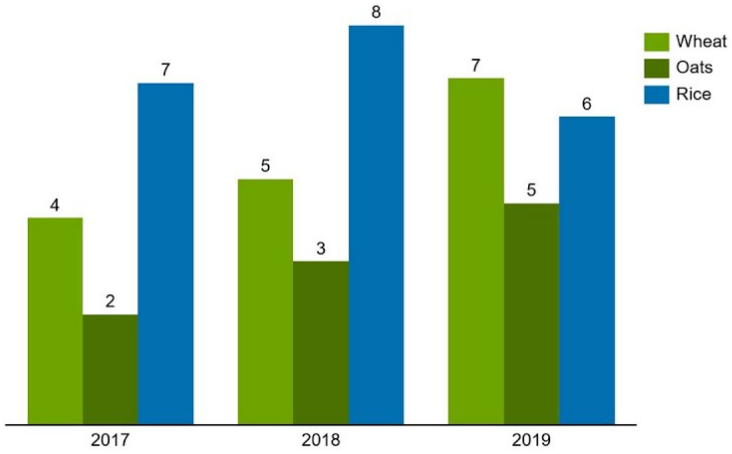
- A tree map can be used to show a given country's exports based on the volumes of product/sector categories.



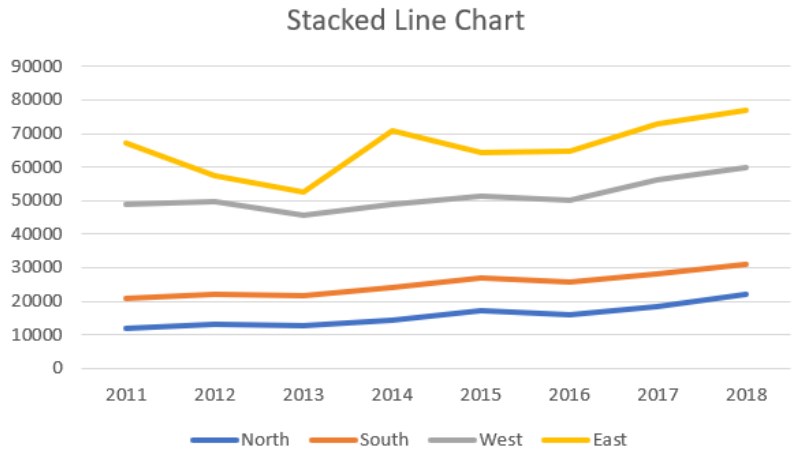
- The trade balance of different product categories between two countries can be represented by a diverging bar chart. We can rank these bars based on various criteria such as the trade surplus towards either country.



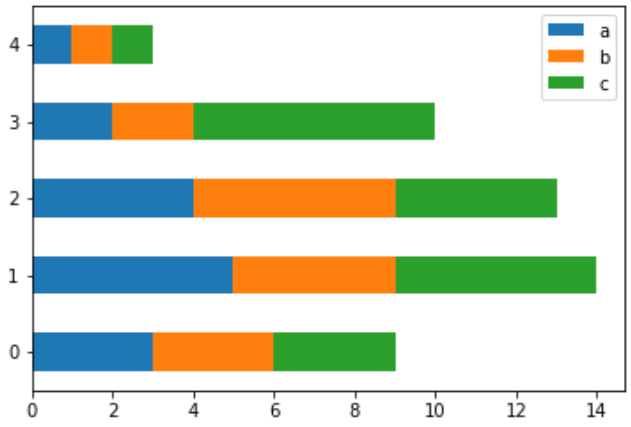
- Clustered bar charts can also be used to show the change in export volumes across different product categories over the years.



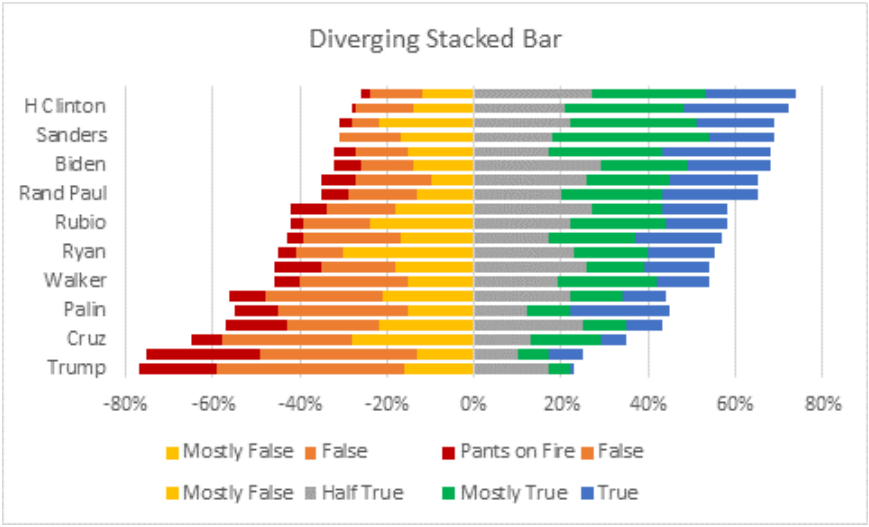
- We can also use a line chart to show how a country's exports/imports change over the years.



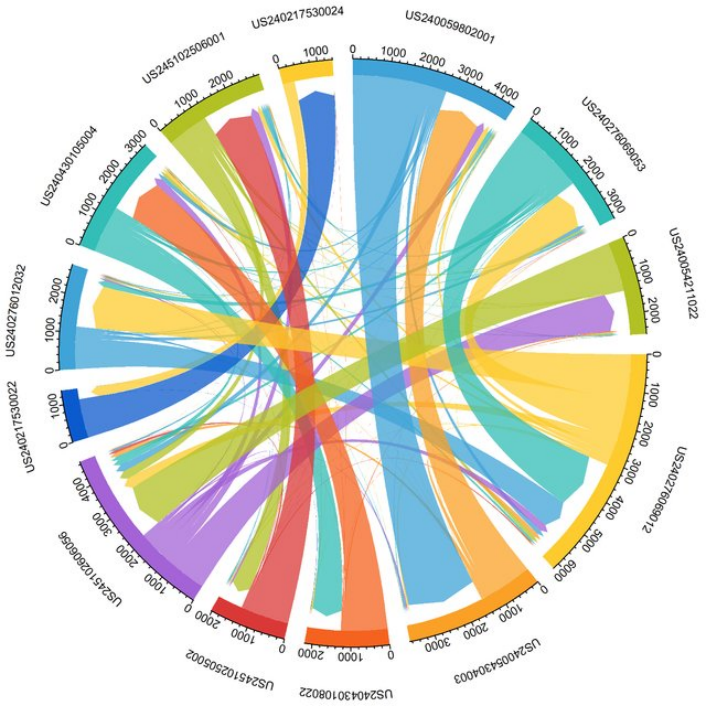
- A stacked bar chart can be used to compare two countries' exports/imports broken down by product category.



- A diverging stacked bar chart can be used to view multiple product's sub-categories.



- A country-to-country export/import chord graph (arrow indicates trade direction) if we want to see the trade relations between more than two countries. This can get a bit overwhelming with too many categories or countries.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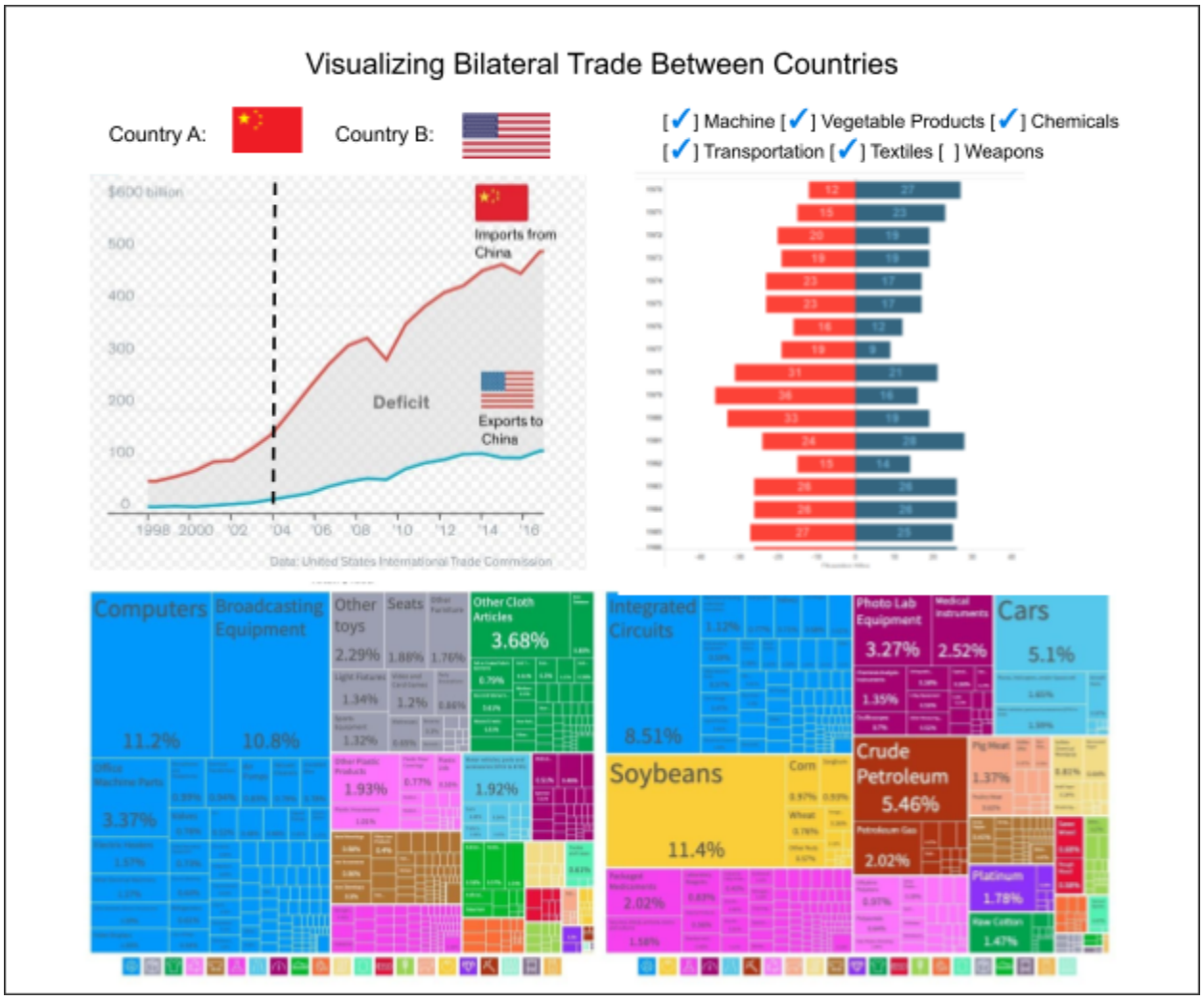
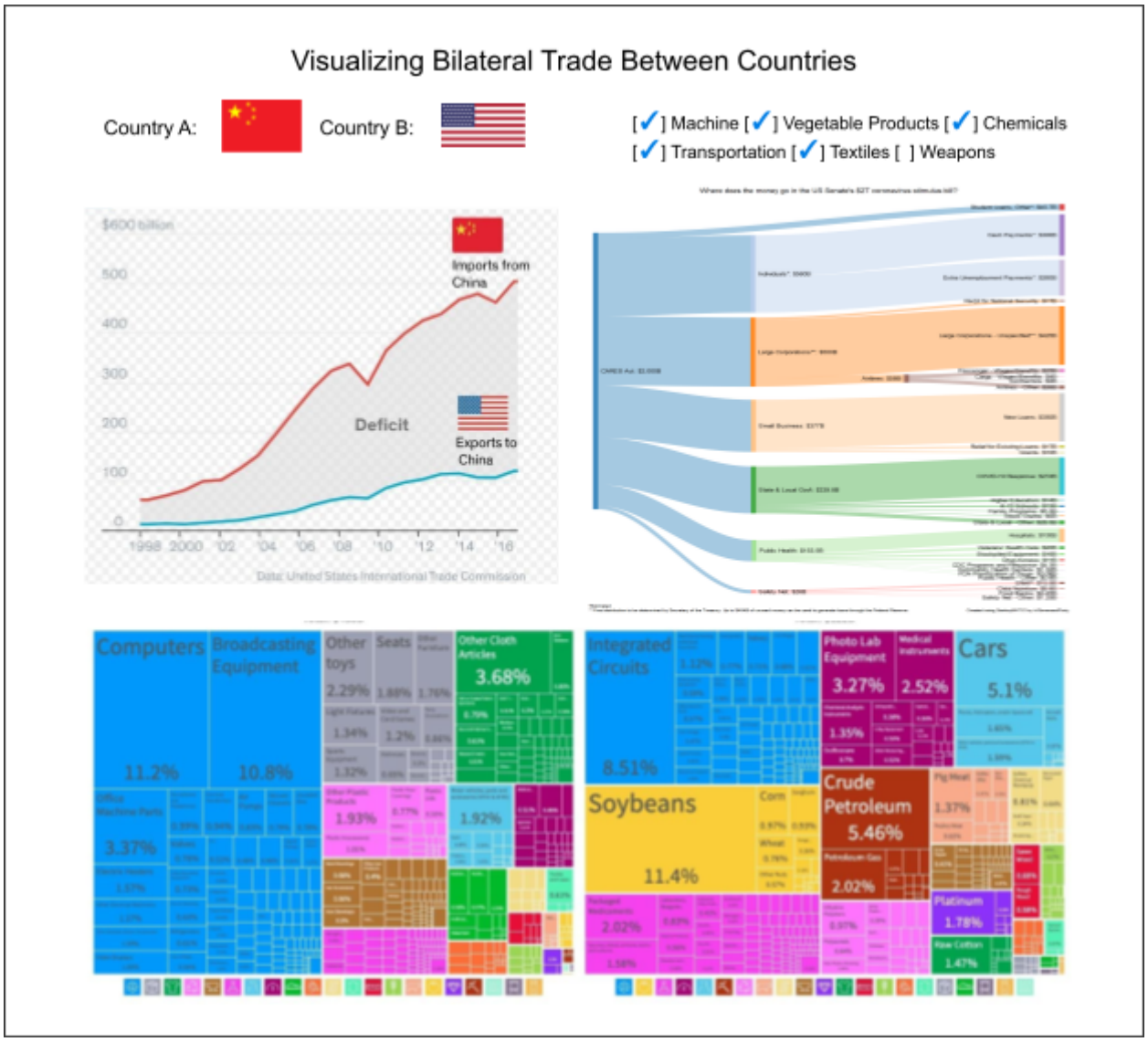
Prototype 1: Line chart, Centered Stacked Bar Chart, Tree Map



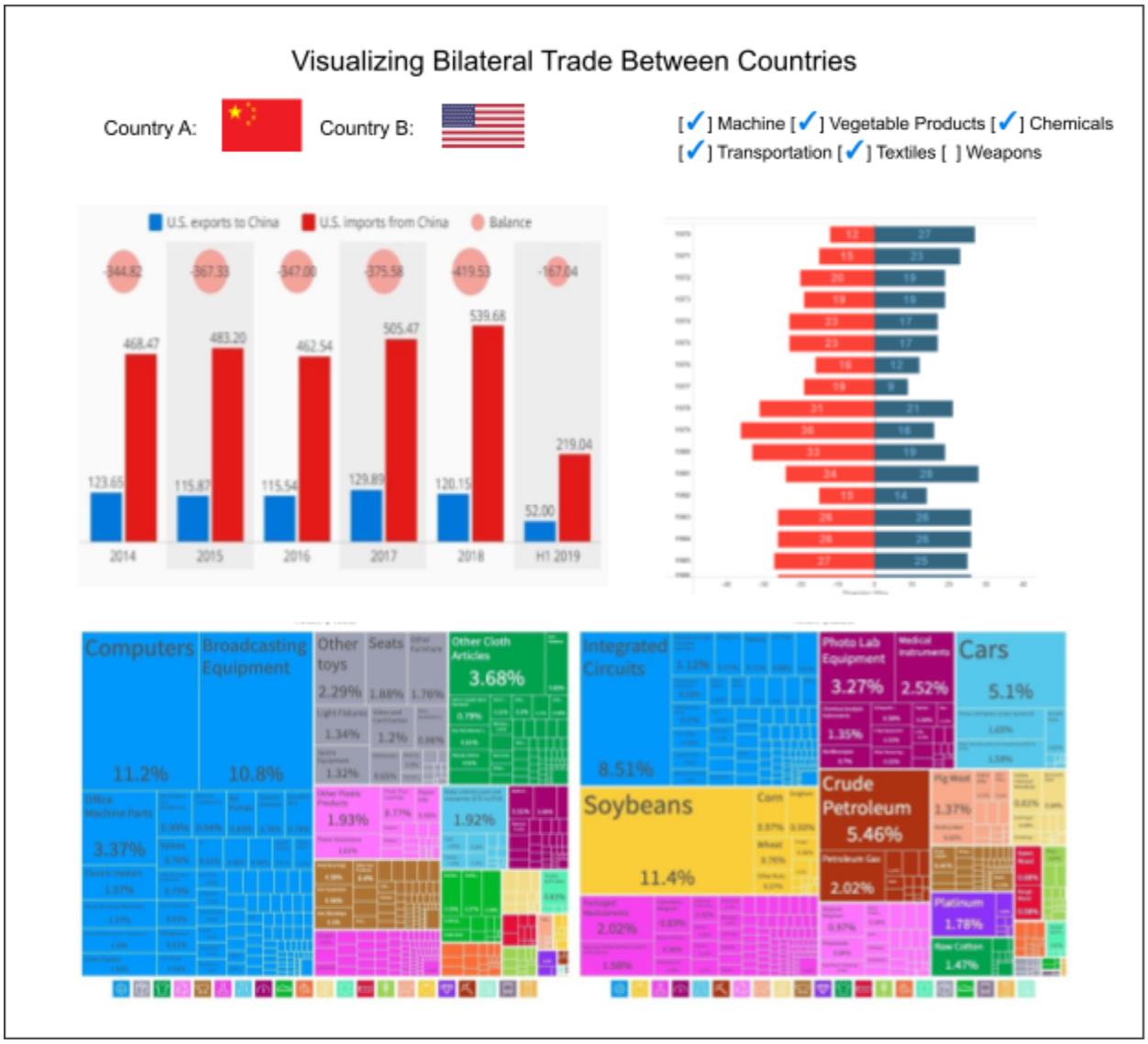
- A user can change country A and country B
- In this version, the main visualization will be the line chart where both countries' exports over the years are compared. If a user can select a specific year on the line chart which will automatically update the other views.
- Centered stacked bar chart: a user can select any number of product categories to show the trade balance. The bars can be reordered based on various criteria.
- Tree maps: one for country A on the left and one for country B on the right, showing each country's major export to the other country grouped by product categories. When the mouse hovers over a rectangle, more details will appear.

Prototype 2: Line Chart, Sankey Diagram, Tree Map



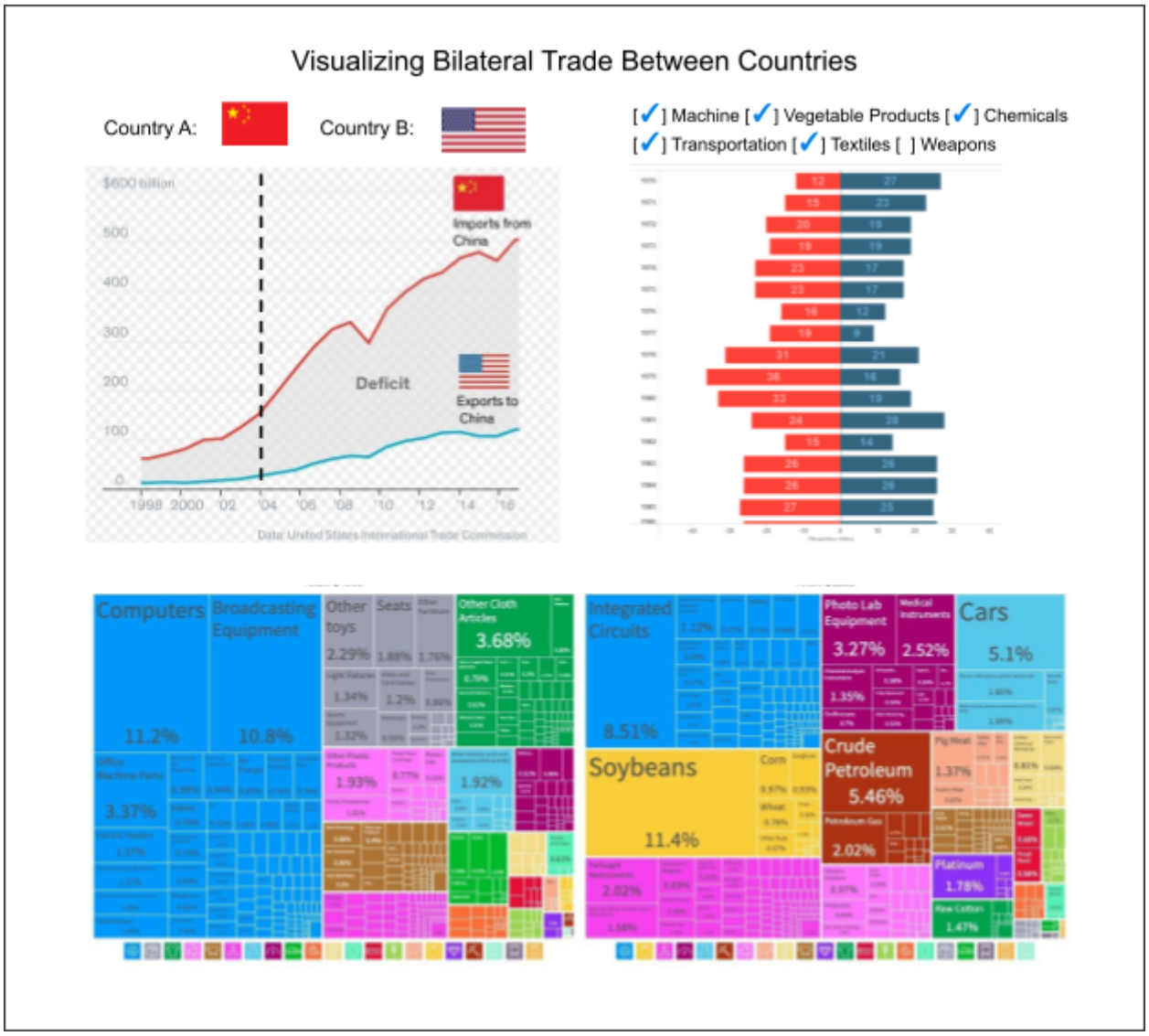
- The main difference between Prototype 1 and Prototype 2 is the visualization on the top right. Instead of a bar chart, Prototype 2 has a Sankey diagram that shows the export flows between the two countries grouped by product categories. A user can select and unselect product categories to show on the diagram.

Prototype 3: Clustered Bar Chart, Centered Stacked Bar Chart, Tree Map



- The main difference between Prototype 1 and Prototype 3 is the visualization on the top left. Instead of a line chart, Prototype 3 has a clustered bar chart that shows the export changes across different product categories over the years. Like the line chart, a user can use the mouse to select which year to reflect in the other views.

Final Design



- A time slider will be added to allow users to change the year of the data which will automatically update the Bar Chart and the Tree Maps.

Must-Have Features

- Dropdown menu for choosing country A and country B
- A line chart
  - X-axis: year
  - Y-axis: trade volume
  - When hovered over, the other views will update automatically based on selected year in the line chart
- A centered stacked bar chart
  - Diverging color

    - Filtering based on product categories
    - Option to reorder the bars based on certain criteria
- Two tree maps
    - Color encoding for different product categories
    - Hover to show details
- A time slider to adjust the year

Optional Features

- Playable animations that show the change in bilateral trading over time. The boxes in the treemap could change shape, and the bars in the centered bar chart may shift sizes and rankings.

Project Schedule

Week 0 (October 16–October 22)
- Explore different datasets
- Prepare Project Proposal
- **October 21, 2022:** Project Proposal Due

Week 1 (October 23–October 29)
- Data acquisition and wrangling
- Plan overall technical architecture and the website's framework
- **October 25, 2022:** Mandatory class meeting to discuss our project

Week 2 (October 30–November 5)
- Implementation part 1

Week 3 (November 6–November 12)
- Implementation part 2
- **November 11, 2022:** Project Milestone Due (a functional project prototype)
    - Code in its current state
    - Process book in its current state
    - Working visualization prototype

Week 4 (November 13–November 19)
- Implementation part 3
- Mandatory project review with TA Mentor

Week 5 (November 20–November 26)
- Debugging
- Refine website design
- Any other catch up

Week 6 (December 27–December 3)
- Finish process book write-up
- Record screen-cast
- **December 2, 2022:** Final Project Due
- Finish peer evaluation

Peer Feedback

Peers: Kaden Hendrickson, Ethan Ramos

Objectives:
Both Kaden and Ethan were really intrigued by our project, especially by our motivation in doing it. They considered the project's scope appropriate; however, they did raise their concern in us putting too much data on the website. Our split between must-have and optional features seemed reasonable to them. As we showed them the dataset we found and the web framework we were planning to use (Svelte), they thought our week-by-week project schedule was well-thought-out.

Visualization:
They really liked how we planned to use three different kinds of charts to visualize the data. Our main visual encodings include lengths and areas which represent the trading volumes and colors which match the major product categories. One suggestion they gave us was to only have one treemap and give the users more ways to interact with it and explore. Having two treemaps side-by-side might be too much.

Features:
The main features we presented to them include a country selector, tooltips, a time slider that may play animations that show the change over time, and a product category filter. They considered our designed interaction meaningful and asked us whether all of the views are coordinated which we confirmed.

Our response:
We appreciate the feedback Kaden and Ethan gave us and definitely want to make sure that we present the right amount of data to the users. We will consider trimming the number of treemaps from two to one as we implement our design.

TA Proposal Feedback (Pranav Rajan)

This is a very cool project and I'm excited to see what insights you find in your final project. Your background and motivation is solid and I think you have enough metrics and variety of metrics to create different kinds of visualizations and a dashboard. I really liked your visualization designs and the final visualization layout and the timeline of completion is well documented. As you build your project you might want to think about what kind of interactions and widgets you want your audience to use for updating and interaction with your visualizations to gain insight about the data you have gathered. Some questions that might help are: who is the audience you are designing for (policy and economic experts, people curious about China-US trade relations etc) and what kinds of widgets you want people to use to interact with your visualization tool to find interesting insights. I think you guys are well on your way and I'm excited to see your progress at the next milestone. Good job and good luck with implementation!

Implementation

Data Update

We initially planned to use data from the World Trade Organization, but found a cleaner data set from Harvard University's Dataverse (https://dataverse.harvard.edu/dataverse/atlas). The trade data has already been cleaned by Harvard researchers; any inconsistent reporting has been resolved which is why we decided to go with this one. It uses a trade classification system called Harmonized Systems (HS) which groups all products into 10 major categories. These main categories also break down to a more detailed level which will give the users more insight into the bilateral trade.

The original data set is stored in several dta files and contains data fields, such as ISO country code and Product Complexity Index, that we don't need. After downloading the dta files, we wrote a Python script to convert the dta files into csv format and dropped all needless columns in order to reduce the data size. Though the trade data is available from 1995 to 2020, to keep it to a reasonable size and limit the website's startup time, we decided to only use trade data between 2010 and 2020.

Design Evolution

Framework and Language

We chose to use the Svelte framework because it speeds up development of good component-driven UIs (compared to vanilla HTML & Javascript) without adding too much bloat (compared to React/Angular). Reactive variables and blocks make it easy to re-run code whenever data changes, which allows components that share data to refresh dynamically on filters, sorts, brushes, etc.

We also chose to use Typescript within Svelte. Typescript allows us to confidently write code that modifies and maps data, knowing the output types are what we would expect when passed into other functions and components as properties. This makes it easier to do the complex data manipulation necessary in a visualization project.

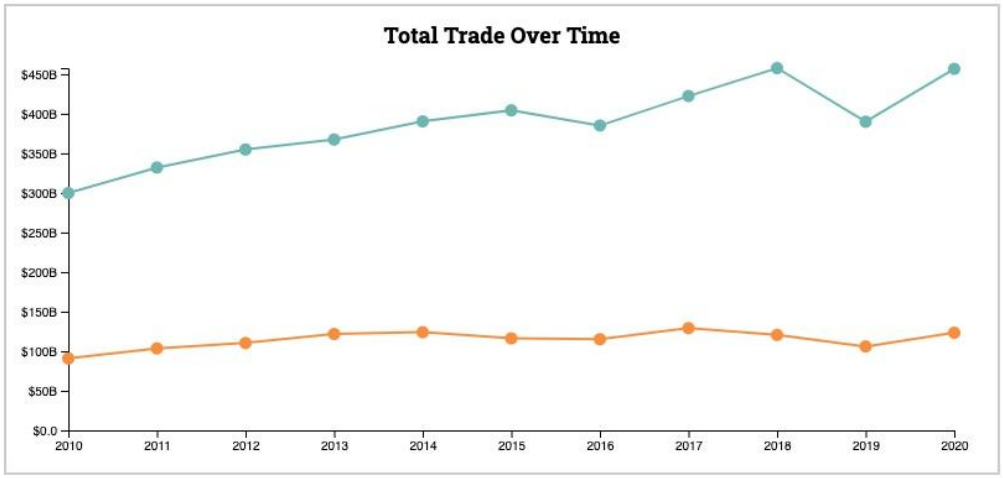
1st Iteration

Country Selector:

- We wanted an easy way to select two different countries, and settled on a searchable dropdown list. We were able to use a packaged Svelte component for this and style it to our liking.

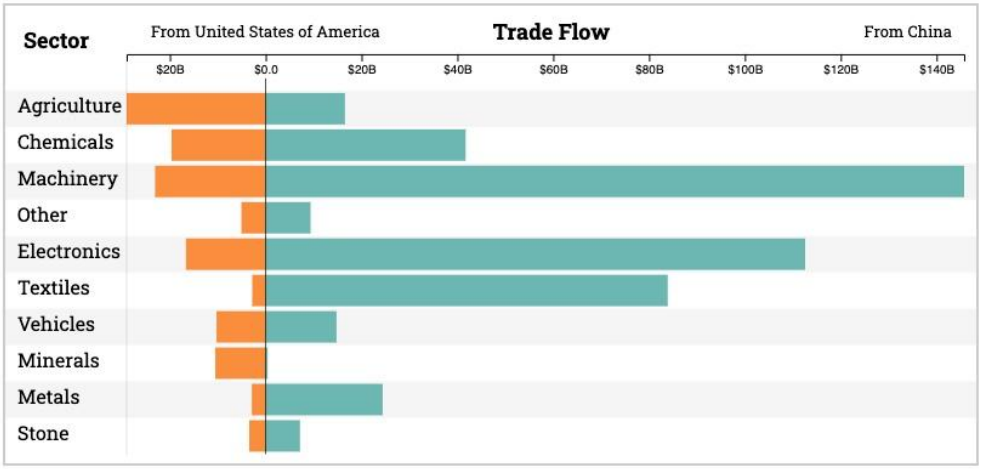
Line Chart:

- We created a line chart to give the user a chronological view of the trade between the two selected countries. The line color matches the color we assigned to the country in the selector.
- The x-axis ranges from the year 2010 to 2020; the y-axis represents the trade volume and updates when we select different countries.



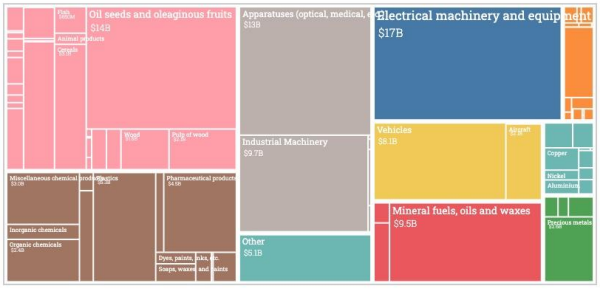
Diverging Bar Chart:

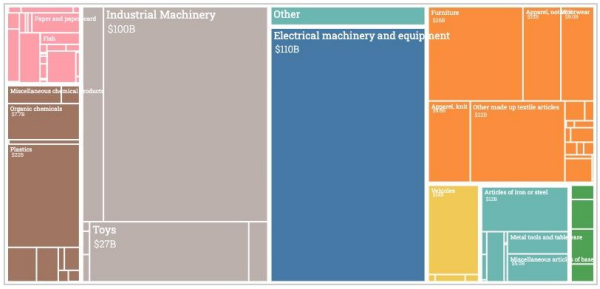
- We created a stacked diverging bar chart to help users compare the bi-directional trade volume across all major product categories.
- For now, we were only using the trade data from 2020.
- The dividing line moves as data changes to allow the best use of space.



Treemaps:

- The side by side comparison allows the users to see the composition of a country's exports to and imports from another country.
- It took us a while to get the treemaps right as we are using a more drilled down version of the trade categories.
- We hadn't gotten the size of the texts quite right yet.

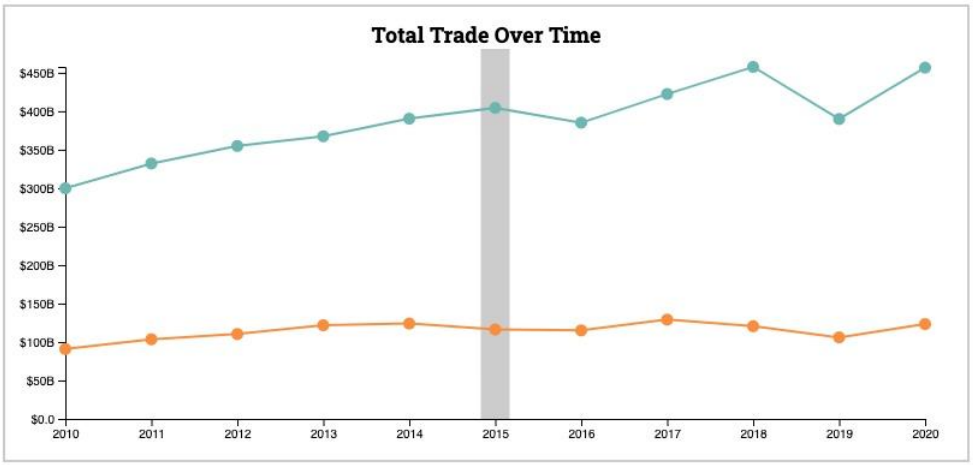




2nd Iteration (Project Milestone)

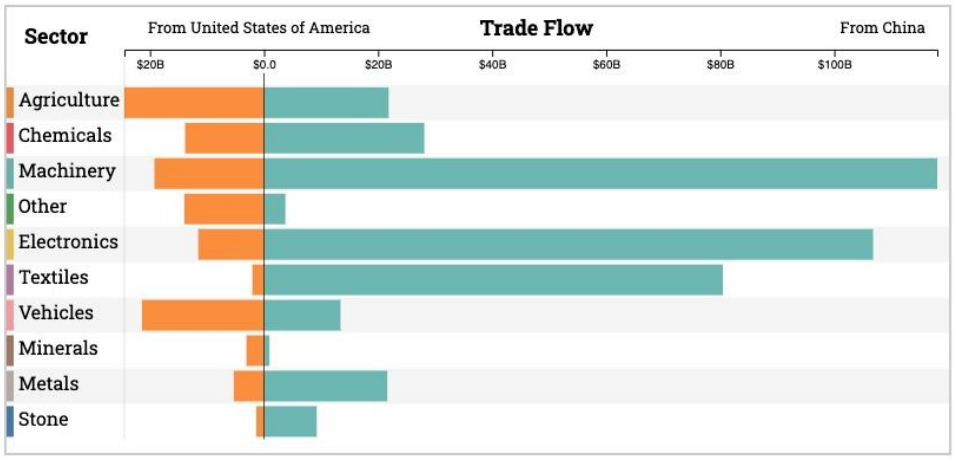
Line Chart:

- We added an interactive feature to the line chart. A click on the data points moves the gray bar to a specific year. This updates the other views (diverging bar chart and tree maps) to the data of that specific year.



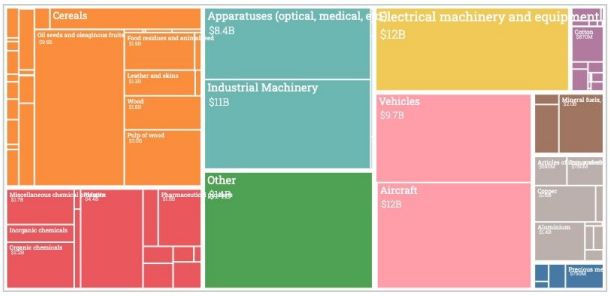
Diverging Bar Chart:

- We color coded the product categories and rendered the legend on the left side of the chart.



Tree Maps:

- The color encoding from the diverging bar chart is also reflected by the rectangles in the tree maps.



Updates to Must-Have Features:

- For the line chart, we replaced this following feature with a different one:
    - ~~When hovered over, the other views will update automatically based on selected year in the line chart~~
    - A click on the data points moves the time bar to a specific year which also updates the other views to the data of that specific year.

Next Steps:

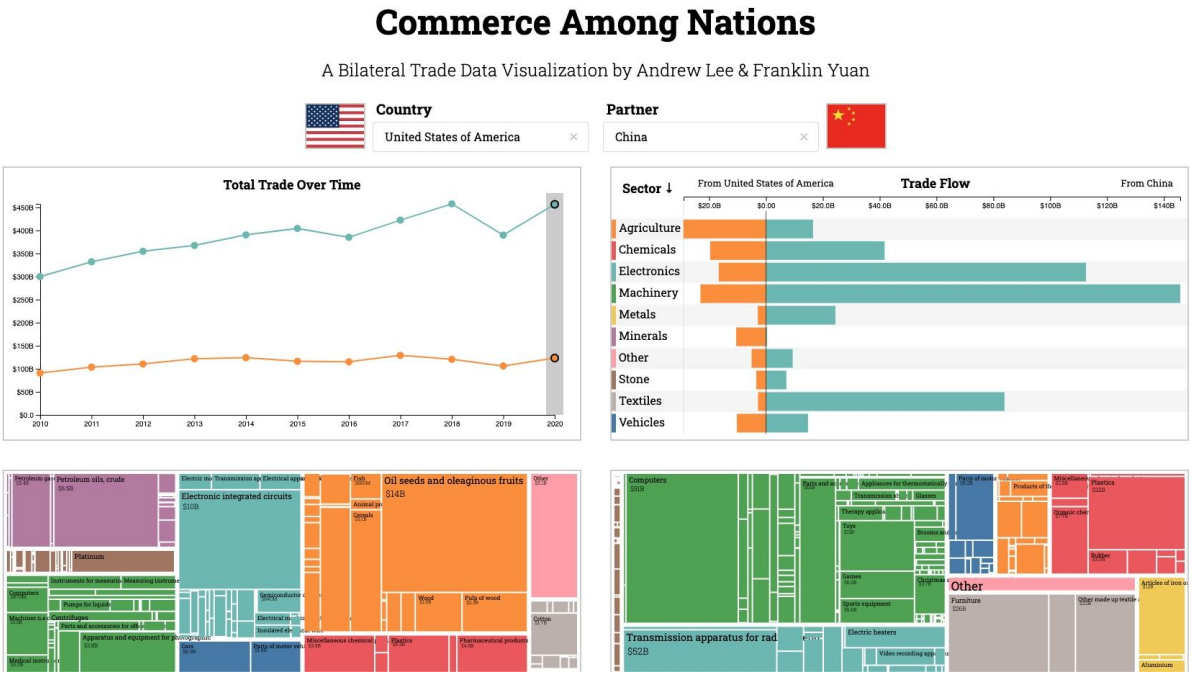
- **Data Splitting**: for performance improvements, we should split data into each country by year
- **Tooltip**: add a tooltip and hovering feature to all charts to show details
    - Stretch goal: pie-chart-type viz for categories in year of line chart
- **Time Brushing:** create a one-dimensional brush on the line chart to enable users to select multiple years of trade data for viewing. The bar chart and tree map will also be updated automatically to show the aggregated data.
- **Sector Multi-Select**: when selecting a sector on the right, the line chart updates with the sum of the exports for those sectors together and filters the tree maps to only show products in those sectors.

- **Diverging Bar Chart Ordering**: add ordering that enables the users to order the product categories alphabetically (asc-dsc), by net trade value (asc-dsc), by gross export value (asc-dsc), and by gross import value (asc-dsc).
- **Country Flags:** add country flags SVGs (useful link) and choose two colors to use, no matter the country
- **Tree Map**: change to use only one that fills the width of the screen, and let the user toggle to see imports vs exports. Add filter to allow the users to exclude and only show certain product categories on the tree maps
- **Axis Labels & Legends:** add axis labels & legends
- *Originally planned but now dropped tasks*:
    - Diverging Bar Chart: make the bars collapsable. when user clicks on a specific bar, its subcategories will appear on the bar chart
    - Line Chart: add an option for users to choose a layer either in total $ value or share of the overall export/import volume

3rd Iteration

Overall Design Updates:

- In this iteration, we maintained the same visualization layout as the last iteration but added more functionality and interactions. We changed our project title from “Bilateral Trade Data” to “Commerce Among Nations” to enhance our storytelling.
- *Color scheme*: we unified the color scheme and assigned each trade sector a specific color.

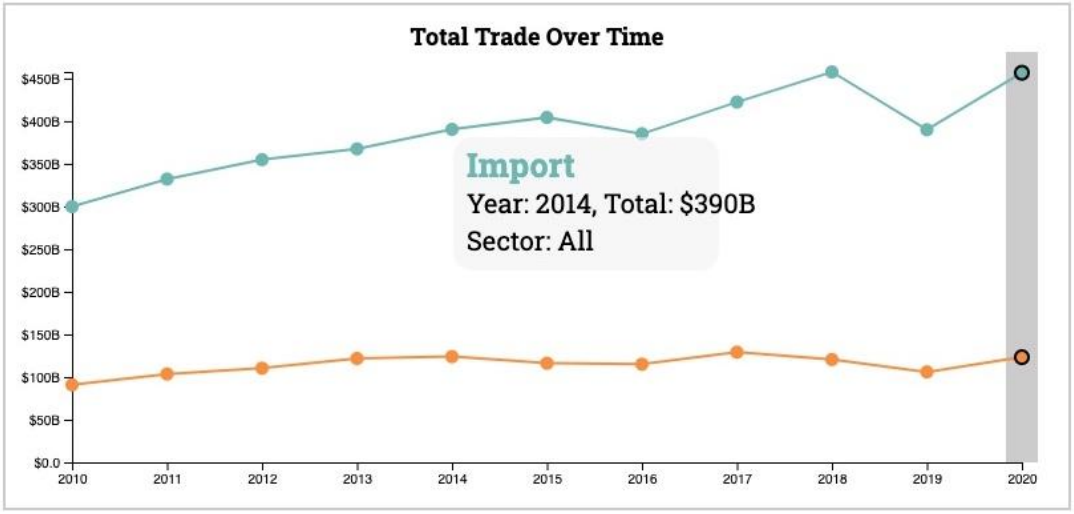


Data Splitting:

- Our last iteration has a considerate rendering delay when we switch between years. We think the delay has a negative impact on user experience and would like to improve on that.
- We identified the delay came from loading CSV files in real time. To improve the performance, instead of splitting the trade data into CSV files by year (from 2010 to 2020) we decided to split the data into CSV files by country. This way, all of each country's trade data wll pre-loaded as we pick its trading partner and switching to other years renders almost immediately.

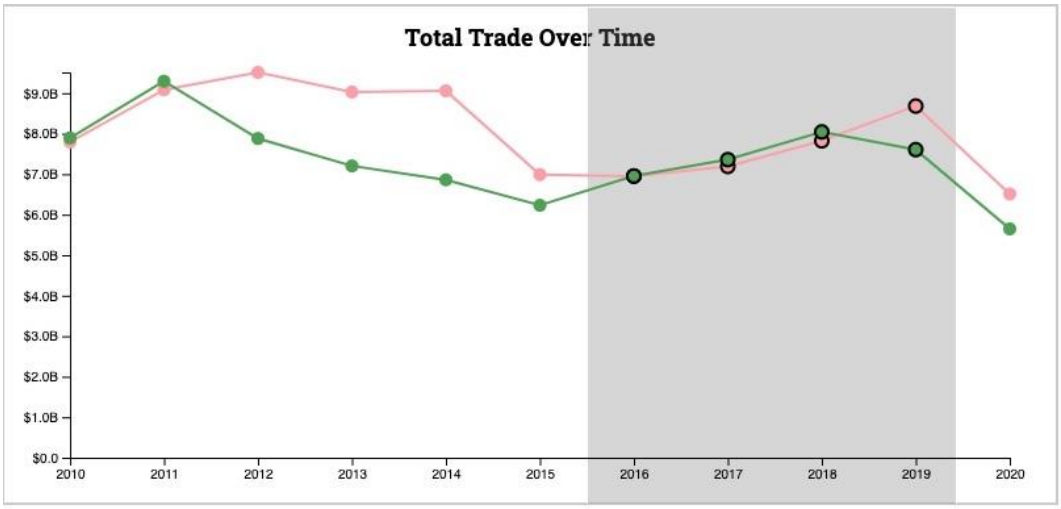
Tooltip:

- Having a functional and informative tooltip is very important to our visualization's success. It puts a given data point's relevant information all in one place and only appears as users interact with and explore the visualization.
- To start, we implemented tooltips on both the line chart and diverging bar chart. As shown in the screenshots below, when a circle (in the line chart) or a bar (in the diverging bar chart) is hovered over, sector name(s), year and trading volumes are shown in a translucent box.



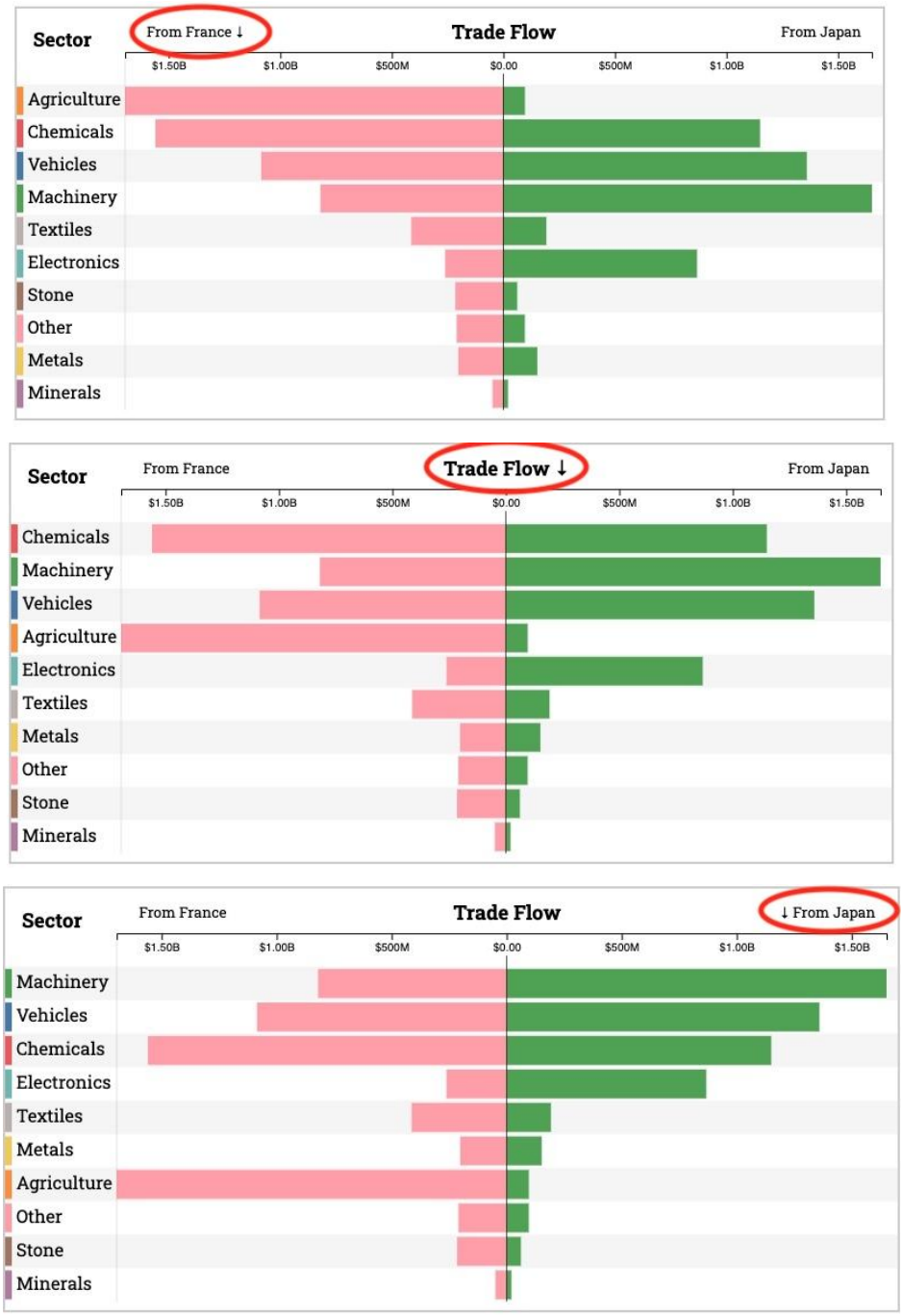
Time Brushing:

- Users may also be interested in understanding bilateral trade over multiple years rather than just in one specific calendar year. This can be done through brushing which allows users to select only a subset of data in a visualization.
- We created a brush over the Total Trade Over Time line chart which enables users to select a range of years. The selection of time range simultaneously updates the diverging bar chart and tree map.



Diverging Bar Chart Sorting:

- Previously, the sectors within the diverging bar chart were ordered arbitrarily. One of our project objectives is to enable users to know what products are country A's top exports and imports with country B. Naturally adding a sorting capability to the diverging bar chart is an indispensable part of this project.
- We implemented different sorts based on the four table columns (by sector names alphabetically, by export volume, by total trade volume and by import volume). Each sort can be done in either ascending or descending order, as shown in the following three screenshots.



Sector Multi-Select:

- Since our visualization uses a trade classification system called Harmonized Systems (HS) which groups all products into 10 major sectors, users may also be interested in learning about one or more specific product sectors.
- We implemented a sector multi-select feature that enables users to customize the visualization based on their interested product sectors. They can select and unselect a product sector by simply clicking on either the labels on the left side of the table or the

diverging bars. As users make their sector selection, the line chart and tree map both update to focus solely on the selected product sectors.

Country Flags:

- A country's flag is one of its most universally recognizable symbols. Since our visualization is about bilateral trade relations between countries, adding the country flags to the country selector is a must.
- Fortunately, we found a curated collection of all country flags in SVG format online and were able to simply call different URLs to embed the SVG into our web page.

Updates to Must-Have Features:

- We replaced the following must-have feature and added a similar one under line chart:
  - ~~A time slider to adjust the year~~
  - Time brush to select a range of years of data to show

Next Steps:

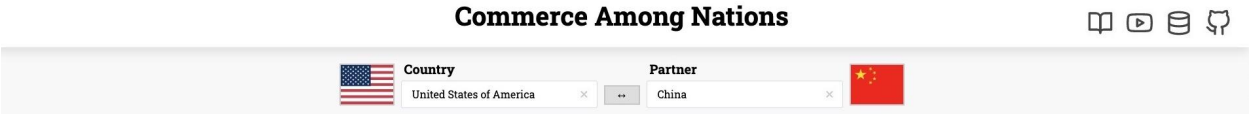
- **Page design & layout:**
  - Change background color
  - Embed process book (PDF format), data source, screencast and Github repo
- **Treemap:**
  - Change to have only one treemap instead of two

    - Add an export/import switch button
- **Bar-line chart & diverging bar chart:**
    - Add surplus/deficit visualization
    - Add chart legends
    - Set two main colors to represent the countries
    - Add a button to clear sector selection
- **Tooltip redesign**:
    - Add tooltip to treemap and improve its overall design
    - Add more information (such as percentage share) to the tooltip info box
- *Originally planned but now dropped tasks*:
    - Create a dark mode
    - Move the country selector to top right corner of the web page

4th Iteration

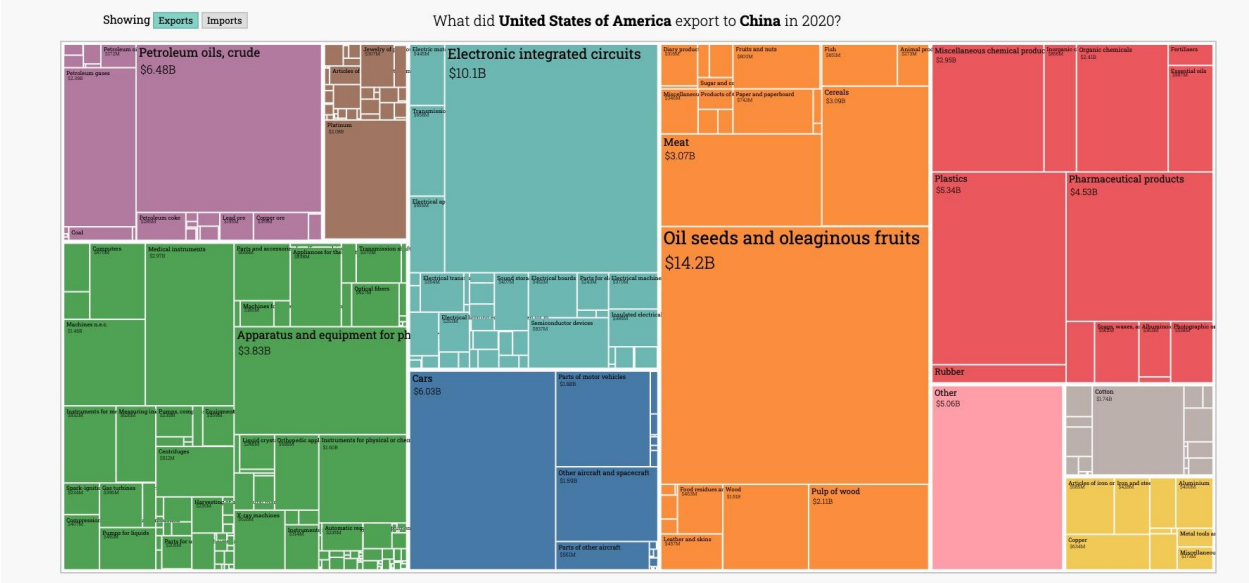
Page Design & Layout Updates:

- We made some stylistic changes to our overall page layout, including adding extra icons that link to our process book, screencast, data source, and Github repo.
- We also changed the webpage's background color from pure white to light gray.
- We also added a swap button between the two dropdowns to make swapping the two trade partners a more intuitive process.

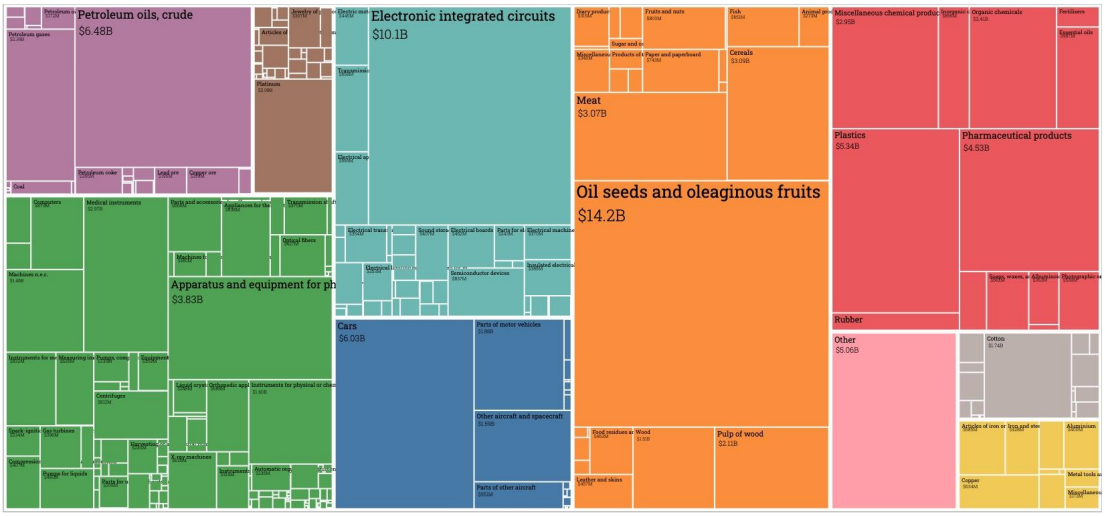


Tree Map Enhancement:

- In our previous iterations, having both the exports and imports treemaps side by side has always seemed too crowded. After our last iteration, we decided to have only one treemap shown at a time and create an export/import toggle button to allow users to switch between the two views. We also added an auto-updated title to the treemap to enhance storytelling.

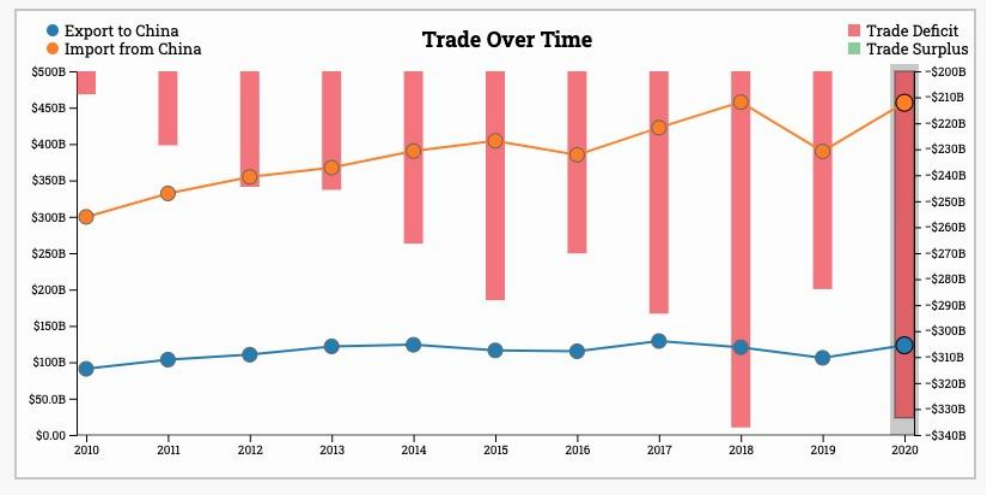


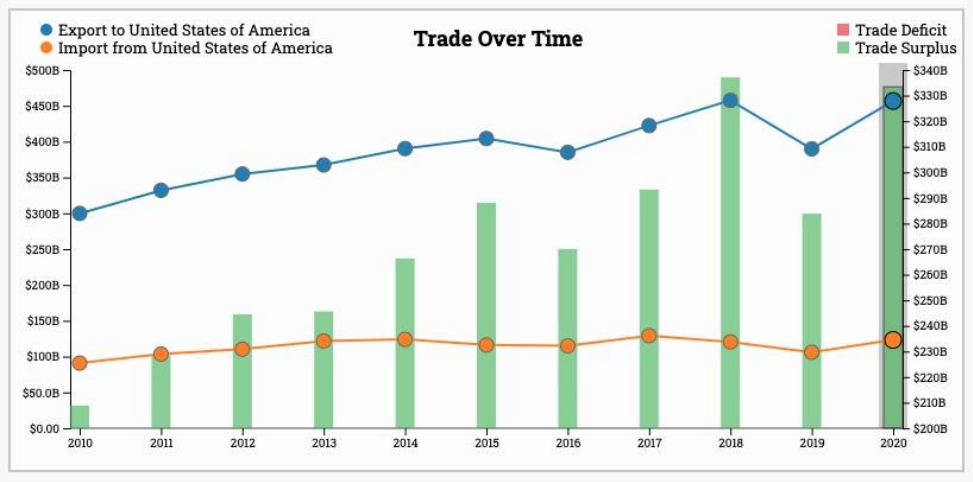
- Due to the sheer size of the data shown in the treemap, we also created a zoom in/out feature that allows users to zoom in on a specific product sector on the treemap by simply clicking on the sector. Zooming back to the full view only takes another mouse click anywhere on the treemap.



Bar-Line Chart Enhancement:

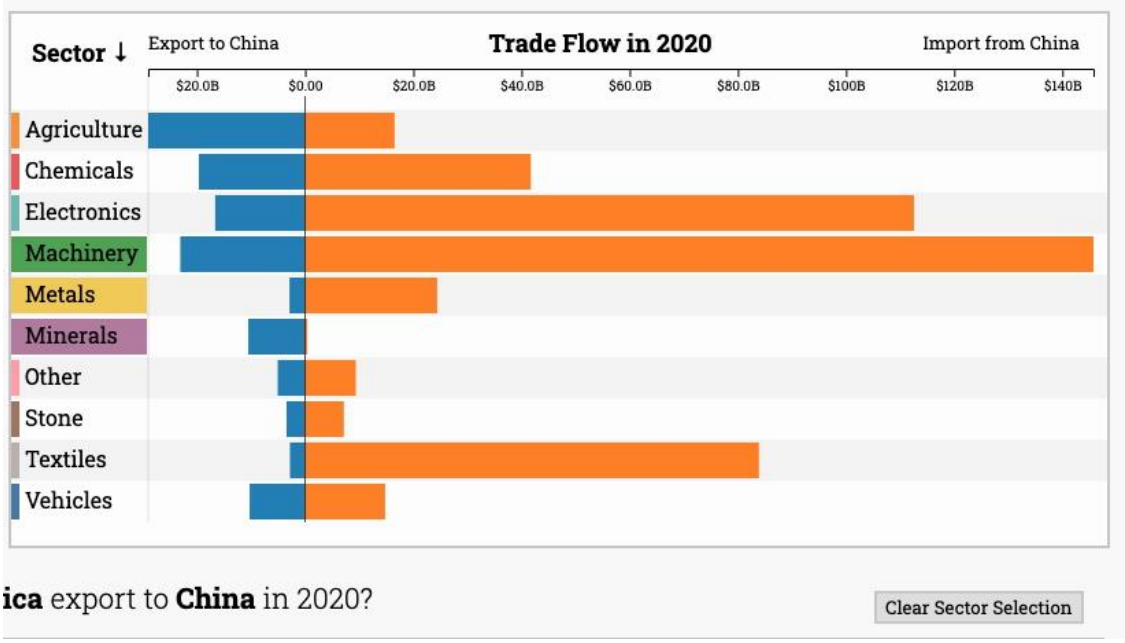
- One thing we noticed that was lacking from our last iteration is a straightforward visualization of how the bilateral trade balance changed over the years.
- That's why we changed the Trade Over Time line chart to a bar-line chart. An extra y-axis is added on the right side for the newly added vertical bars which represent the trade surplus and deficit between the country and its trade partner in a given year. We chose to use the color red for deficit and the color green for surplus for obvious reasons. We also added legends to help users interpret the slightly more complicated bar-line chart.





Diverging Bar Chart Enhancement:

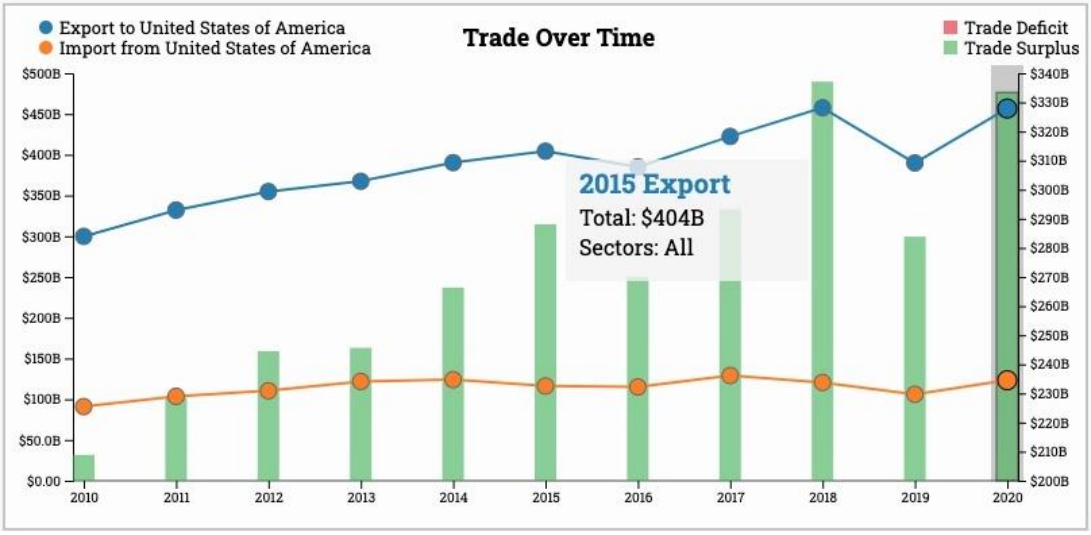
- In our previous iterations, a country's theme color is determined by an ordinal scale. This brings inconsistent styling as we change to different country pairs. We decided to fix the two theme colors for the main country and its trade partner and settled on the blue-orange combination.
- We also added a Clear Sector Selection button under the diverging bar chart to make clearing sector selection less cumbersome to the users.

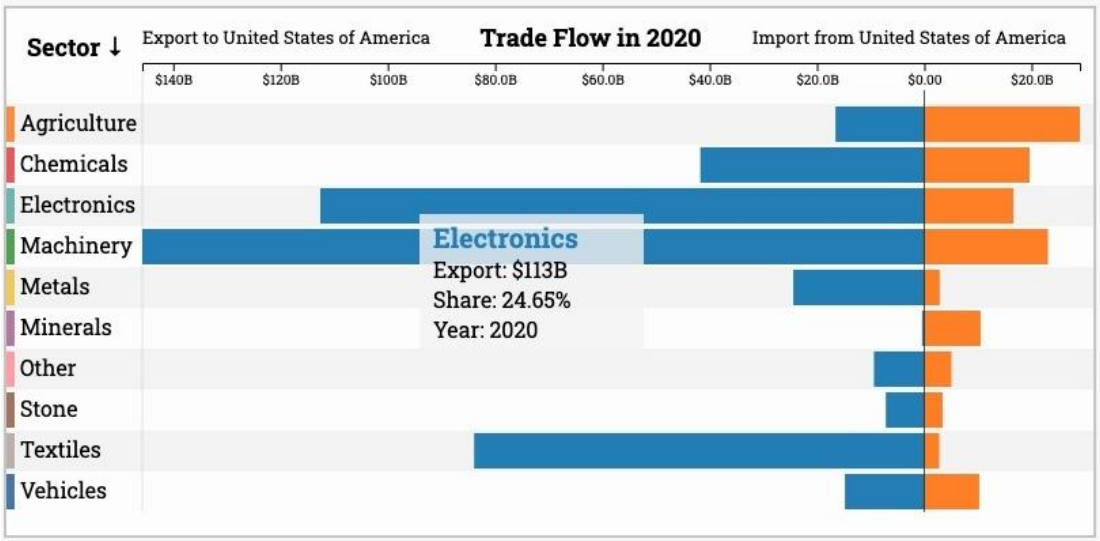


Tooltip Redesign:

- We found our tooltip design from our last iteration a bit lacking and decided to redesign it by adopting more intuitive styling and adding more informative information to the info box.

- The end results are shown below in the screenshots. We have enabled tooltips in all three charts and added both color and information to enhance users' experience as they interact with the visualizations. In particular, we made sure that tooltips in each chart only show the most relevant information in the chart's context.





Updates to Must-Have Features:

- We changed the must-have feature of showing “two tree maps” to only “one treemap” due to limited screen space.
- We also updated the “line chart” requirement to a “bar-line chart” to reflect our design change.

Next Steps:

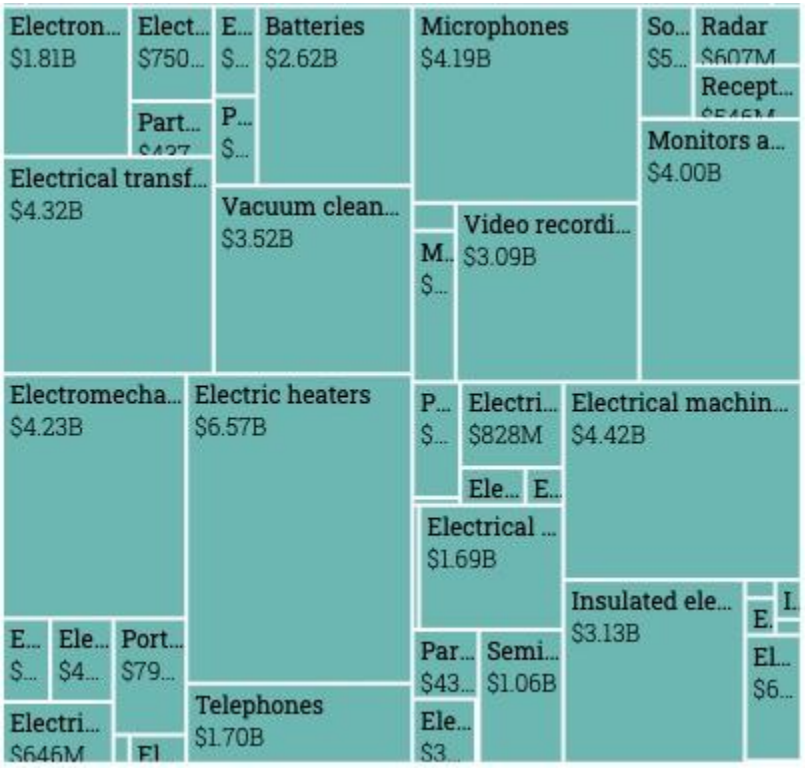
- Final stylistic touch-ups
- Record screencast
- Finish process book
- Edit Github README to give an overview what we are handing in

5th Iteration

After receiving feedback from our TA Pranav, we made a few stylistic and formatting changes to improve the visualization’s overall clarity. The changes include:

- Add axis labels to bar-line chart

- Allow ellipsis for long product names that get cut off in the treemap



Final Design

Must-Have Features

- Dropdown menu for choosing country A and country B

- A bar-line chart
    - X-axis: year
    - Y-axis: trade volume
    - A click on the data points moves the time bar to a specific year which also updates the other views to the data of that specific year.
    - Time brush to select a series of years of data to show
- A diverging stacked bar chart
    - Diverging color
    - Filtering based on product categories
    - Option to reorder the bars based on certain criteria
- One tree map
    - Color encoding for different product categories
    - Hover to show details

Final Visualization

For a full interactive experience, please visit our project website https://candrewlee14.github.io/data-viz-project. **Note: please view the website in Chrome browser for the best experience.**

Screencast Script

Have you ever wondered what products are traded between the U.S. and China? Have you wanted to know how that's changed over time? How about Iran's top export to the U.S.? The answers might surprise you!

Welcome to Commerce Among Nations, a bilateral trade exploration tool. To start, select any country in the world and its trade partner to explore their bilateral trade over the past decade. On the line chart on the left, you can view imports, exports, and trade differences over time. On the right, a stacked bar chart breaks down the traded goods into 10 major sectors and compares the trade flow in each sector within a selected time range. Further down, a more granular display of all exports or imports are shown in a treemap colored by product sector.

You can select a specific year by clicking on the circles or bars on the line chart or select a range of years by using the 1-dimensional brush. On the diverging bar chart on the right, You can sort the product sectors by name, export volume, import volume, or total trade volume. You can even multi-select to isolate a group of sectors by clicking on their labels or bars to toggle that sector. When selections change, the trade over time plot on the left and the treemap below are updated. You can clear your selections by clicking the Clear Selection button.

To switch between showing the exports and imports on the treemap, simply click on the toggle buttons on the left or the diverging bars on the stacked bar chart. You can click on any product sector on the treemap to get a better view of the breakdown within that sector. You can return to the original view by clicking it again. The tooltip feature lets you see the trade amount and the product's share of the total exports or imports.

Now it's your turn to explore! Switch to any other countries you'd like and learn more about their trade! Thanks for watching.

Video link: https://www.youtube.com/watch?v=OXdyF8Prxyw

Evaluation

In Econ 101, we learned that countries are always better off when they buy and sell from one according to the notion of comparative advantage. But how exactly do two countries in the world trade with each other? What kind of products do they trade? And how has the trade between the two countries evolved over the years? These were some of the questions we set out to answer when we first started on this visualization project.

With our final visualizations, we think we can answer all of the questions very well. On the line-bar chart, we displayed how much country A exported to or imported from country B over time. On the diverging bar chart, we broke down products by sectors and allowed users to sort by top exports, imports or total trade volumes. On the treemap, we showed how much of each product the countries exported and imported with the help of the tooltip. We think the bars in the bar-line chart illustrated the trade balance in a given year (and a range of years) very well. The lines in the bar-line chart shows how the country's total exports and imports changed over the years. And in addition to the individual charts, the interaction allows all three charts to work together nicely. For example, as you select a range of years on the line chart and then a couple product sectors in the diverging bar chart, you'll be able see the breakdowns of *those* sectors

during *those* years in the treemap. We think each graphic provides different insights while also staying related and explorable together. The final product ended up looking and functioning better than the prototype we designed; we're quite happy with what we've accomplished.

Related Work

1. Harvard University's Atlas of Economic Complexity website (https://atlas.cid.harvard.edu/explore)
2. OEC World (https://oec.world/)