

Visualising Singapore's Imports and Exports

Prepared by: Vincent KOH How Han, Sheryl YEO Qin Ying, NG Wei En

Abstract — The robust Singapore economy and growth depends heavily on global trade. As a country with virtually no natural resources and comparatively small domestic market, Singapore must be open to external markets in order for the economy to thrive; as two-thirds of Singapore's GDP is generated by external demand. PM Lee mentioned during the recent National Day Rally 2018 about how there might be potential trade impacts and challenges for Singapore; the international system is at a turning point due to the mounting trade tensions between the world's economic giants (U.S. and China / U.S. and Europe). This research paper aims to analyse the available trade (imports and exports) data and identify trade patterns and significant impacts over the years. The visualisation tools — Chord, Sankey, Sunburst, and Time-Series Diagrams developed will aid government bodies like Ministry of Trade and Industry (MITI), Innovation and Enterprise (IE) Singapore and the Straits Times for their analysis and reporting.

1 INTRODUCTION

As the top commodities trading hub in Asia, Singapore has one of the highest trade-to-GDP ratio of 322% in 2017. Trading has become an essential role for Singapore's survivability. In recent years, there has been groundbreaking decisions and measures made by several countries such as United States' departure from the Trans-Pacific Partnership (TPP), China's One Belt, One Road initiative and the Thai Kra Canal which may greatly threaten Singapore's position as a global trading hub.

This research paper documents the exploration and development efforts taken to design and implement a data visualisation web application. The data visualisations uses various relevant datasets provided by the Singapore Government and ASEAN, in hope of uncovering interesting patterns to help Singapore Government anticipate, make better plans for future trading policies and to provide Singapore businesses with the tools to identify trends and patterns in importing and exporting various categories of goods.

2 MOTIVATION AND OBJECTIVES

This research is motivated by the lack of analysis done on Singapore's international trade volume and patterns with its partners. A web-based visualisation application is developed to facilitate data discovery, visualise large datasets and identify interesting patterns to better assist government bodies in gathering of more trading trends, as well as allowing the public to consume detailed data easily with comparisons over the years.

By introducing powerful interactive visualisations like Chord, Sankey and Sunburst diagrams to visualise the trade flow in Singapore, it will illustrate a greater visual emphasis on the major trade flows, activities and the various breakdown of import and export commodities, unlike the common visualisation tools like bar chart and pie chart which is unable to do so.

3 RELATED WORKS

The existing online visualisations have its limitations as it is not dynamic and flexible in terms of showing various key trade factors and do not have the interactivity element that allow users to see everything in a single visualisation.

The following visualisation works are provided by Singstat and ASEANStatsDataPortal, and is limited in scope due to the number of countries being considered for visualising trade performance.

The visualisation from Singstat only reflects:

1. Top 10 Trading Partners by combined import and export figures.
2. Top 10 Trading Partners by largest Product Category

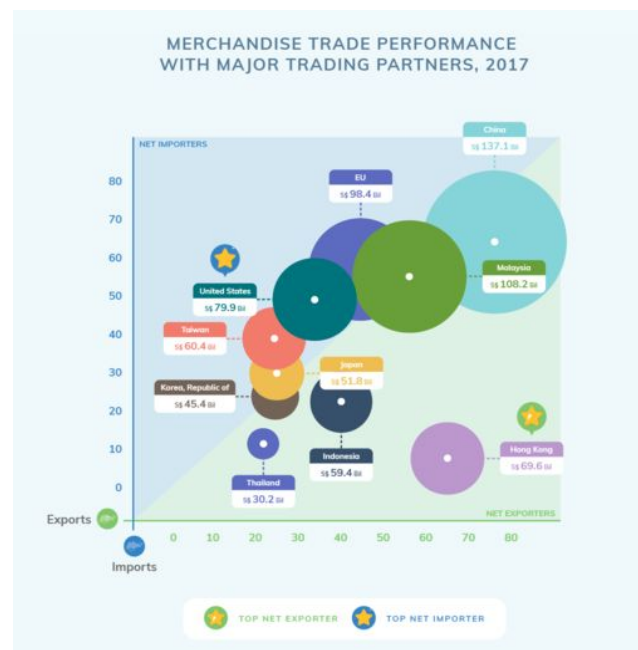


Fig. 1: Interactive chart showing the distribution of Singapore major trading partners in the year of 2017.

The significant limitation in Fig. 1 is the lack of interactivity as only the Top 10 trading partners are displayed and all other trading partners are simply omitted for simplicity. There are no filter options available to vary the years and to show more trading partners, limiting the visualisation in terms of its versatility.



Fig. 2: Horizontal bar chart showing the imports and exports by various countries in the Year 2012 and 2016

Fig. 2 from Singstat has the following limitations:

1. Time frame is limited to only 2016 and 2017. It would be better if data visualisation is interactive and allow the user to adjust the time frame.
2. Countries are sorted by combined imports and exports figures. Ranking by imports or exports is not possible.



Fig. 3: Power BI Dashboard illustrating the trade relationship between countries and the various type of products traded

The Power BI dashboard by the ASEANStatsDataPortal allows for a comprehensive overview and slicing of trade information by imports, exports and its categories with interactivity for data exploration.

However, the following limitations were discovered:

1. Fig. 3 visualisation is confusing as the selected filters at the top row are applicable to selected charts only. (e.g. Year filter only applies to graphs on second row only)

4 DATA COLLECTION, EXPLORATION & PREPARATION

The team gathered all the required data from two different data sources, Department of Singapore Statistics (SingStat) and ASEANStatsDataPortal after evaluating the relevance to the main objectives and motivation of this research. We conducted an initial exploratory data analysis and the findings are as shown below:

1. ASEAN data contains different scale of value for region (in million dollars) and country (in thousand dollars)
2. Singstat data are recorded monthly
3. The spaces were used as indentation for country name in ASEAN data
4. ASEAN data contains the total which could be a double-edged sword depending on which visualization the data is used at.

The team took some effort to tidy the data with Python and Pandas library, ensuring consistency in scale and unit across all the datasets.

Iteration 1: Prototype Visualization

The team does not have any experience in creating a static webpage, and thus we decided to try loading data using JavaScript in HTML. During the prototype stage, we realised that as the loading time increase, JavaScript will not be able to load data completely, resulting in partial data loaded. To overcome this issue, the team brainstormed and came up with two methods to counter this issue:

1. Store raw string when page loaded. Only proceed when function is called.
2. Split dataset into smaller versions, for example splitting it by years et cetera. Then, load the correct dataset when function is called.

With the two new methods in mind, the team performed numerous tests to ensure that the method will not fail in any circumstances.

Iteration 2: Type of Dataset v.s. Type of Visualization

Before proceeding to create any visualization, we realised that there are several variations to the dataset. Mainly, by the country, type of trades and time.

The team researched on various visualisation ideas, technologies and designs that can effectively represent the trade data. While researching, the form of clarity, aesthetics and technological implementation were taken into consideration.

To ensure that the visualizations will be able to present the data accurately, we planned out each and every dataset and their visualization by whiteboarding. Not only it helped the team to visualize the end product, but also ensured that the team is on the right track.

The team decided on Sankey, Sunburst and Association Grid Heatmap diagram and looked into sources like d3js.org, bl.ocks.org and observablehq.com. The team took some time to go through and understand how the visualization is built and how the parameter inputs are accepted by these charts.

During the process, we realise that Association Grid Heatmap diagram is not possible for this project due to the limitation of the dataset our team choose. As the diagram is use to visualize countries to countries, the dataset selected by our team is use for visualizing trades between Singapore and other countries, which limit us from creating the Association Grid Heatmap diagram.

As the team lack of relationship type visualization, we look into Chord Diagram. Chord Diagram is a powerful visualization that help visualize relationship in an overview manner.

In addition, our team decided to adopt line chart to help visualize trade trends between Singapore and other countries. This will allow us to see the changes in trades over the years and also to help us identify any significant changes when external trade policy was introduced.

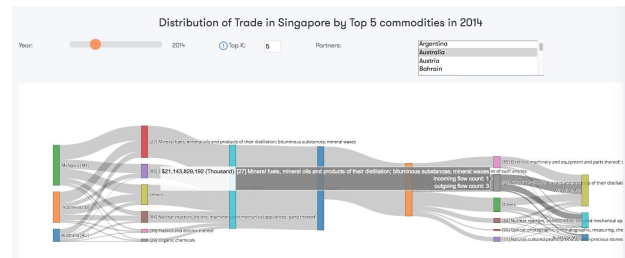
Iteration 3: Chart Filtering and User Interactivity

After the first version of the visualisation has been completed, the team looked into how we can further improve the visualisations. One of the methods that we looked into was to add filters to further enhance the visualisations, which was also one of the limitations the existing visualisations had. Filtering helps users to focus on specific information from a large data set to aid better information gathering and to enable easier identification of anomalies behaviour or patterns.

As most of our datasets are in years, the team decided to standardize all the datasets to use years as the standard scale. Due to the nature of trading, we also included filtering by imports and exports to see the balance of trade for each country.

Next, our team took time to look through the documentation provided by d3js and plot.ly to see how we can further improve the interactivity of the web page.

5 TRADE VISUALIZATIONS



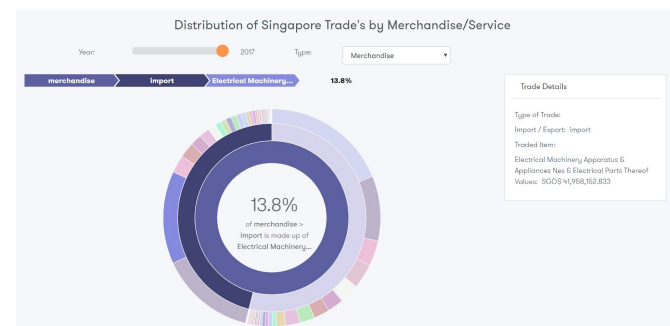
5.1 SANKEY DIAGRAM

The motivation behind this visualisation is the lack of existing works available with functionalities to illustrate the drill-down of the following in a single diagram:

1. Trade figures between Singapore and multiple countries and regions
2. Imports and Exports
3. Commodities and services

The team wanted users to be able to have the flexibility of being able to zoom into Singapore’s imports and exports figures with respect to their selected countries to see the various categories of commodity associated with it. This can be done by holding on the Ctrl button on Windows and Command button on Mac and selecting multiple values in the Partners’ filter.

On top of that, the Top K filter also gives the user the flexibility to limit the commodities into k categories with the last category grouping all other categories into a single “Others” category. This level of flexibility is useful in removing noisy data whereby many categories of commodities contribute to insignificant trade figures should be removed from the visualisation as they do not add any value or meaning.



5.2 SUNBURST DIAGRAM

The beauty of using a Sunburst diagram instead of a usual pie chart to display Singapore’s import and export figures for merchandise and service is that it provides a very visual approach towards studying hierarchical data. Specifically,

how imports and exports are subdivided into various categories and the proportion of each category relative to other categories can be easily understood. The interactive nature of the diagram allows user to individually explore and hover over specific categories to find out the proportion of import or export it contributes towards.

Users can toggle between displaying either Merchandise or Service dataset and view the breakdown of details on the right side that include the total trade figures as well.

The breadcrumbs proved to be a useful supplementary navigation tool to assist the user in exploring the depths of the hierarchy of trade figures. It also encourages the exploration of categories of trade as well as providing at-a-glance legend showing where the user is currently navigating to.



5.3 TIME-SERIES DIAGRAM

Time-series diagram is important to identify trends over the years. Definitely is not something that is lacking out there in the community, but our team is thinking of further pushing the ability of a time-series. Instead of having Singapore to another country comparison or Singapore to all country comparison, we decided to allow the user to choose which country they would like to choose for comparison.

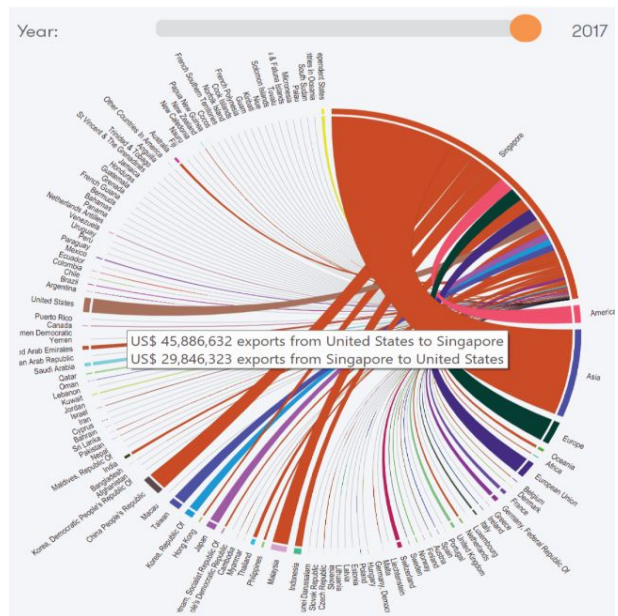
In addition, we also added a filter to allow user to choose if they would like to see the trend by import or export or both.

5.4 CHORD DIAGRAM

The Chord Diagram displays the proportion of trade volume between Singapore and its trading partners. The data is arranged radially around a circle with its import and export trade figures denoted by the arcs connecting the data points in a circular fashion.

A slider filter on the top of the visualisation is used to select the year in which the trade figures are analysed.

Hovering over the nodes of the Chord Diagram will display a tooltip reflecting the outgoing exports from that country/region while hovering over the arc will reveal both exports and imports between Singapore and that country/region.



6 KEY FINDINGS AND INSIGHTS

United States' departure from Trans-Pacific Partnership

Despite United States leaving TPP officially on January 23, 2017, trading activities between Singapore and United States was not affected with export from Singapore around US\$ 29 million in 2016 and US\$32 million in 2017, representing an increase of approximately US\$ 3 million. However, this observation may be inconclusive as it might just signify the start of a butterfly effect whereby the effects on trade activities might be trickled down from trade between U.S and other countries slowly down to Asia and then to Singapore.

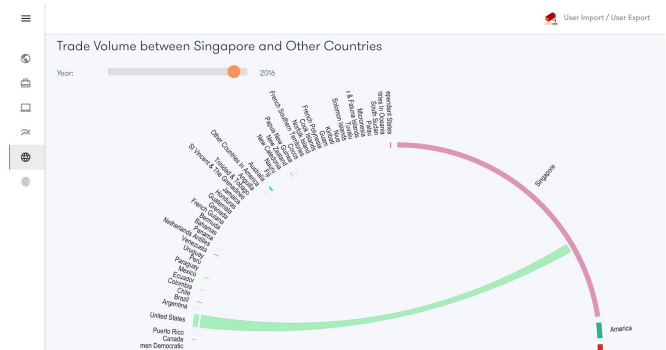


Fig. 4.1: US Trade Volume with Singapore in 2016

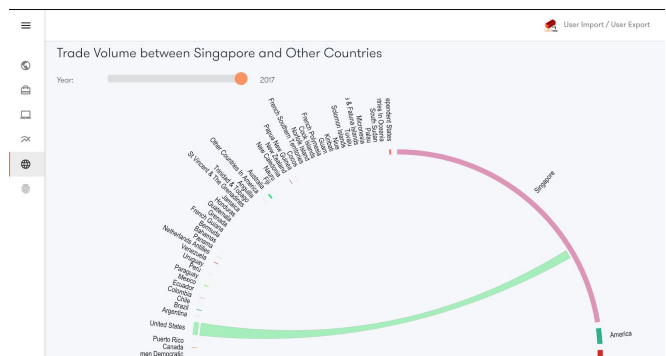


Fig. 4.2: US Trade Volume with Singapore in 2017

The trade war may significantly affect Singapore's export-dependent economy in the time to come, possibly triggering a full-blown recession. Singapore's manufacturing sectors and services such as transport and storage will be negatively affected. In view of this, Singapore can only start to anticipate possible repercussions, be flexible and be proactive in forming a strategic group of partners (e.g. ASEAN) to serve and engage trade activities with. Hopefully by building a strong base in the ASEAN region, Singapore can minimise any potential negative impacts of the full-blown trade war if it were to happen.

Singapore - China Trade Relationship

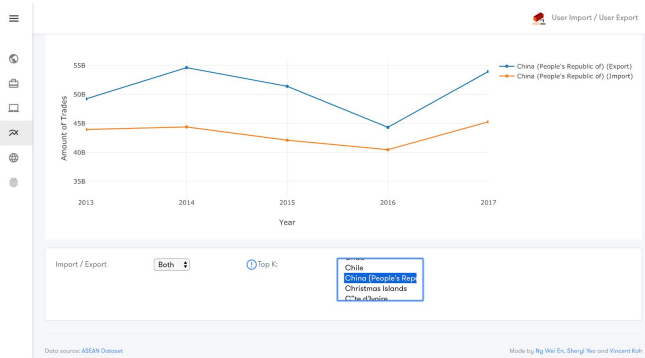


Fig. 5: Singapore-China Trade Trends from 2013 to 2017

As one of Singapore's major trading partner, China is considered one of the largest importer. According to Today Online, China and Singapore pledged to increase its cooperation on both its trade and regional infrastructure projects, including those under Beijing's Belt and Road Initiative (BRI), where both sides will collaborate to improve connectivity and financial support as well as enhancing training and technology transfer.

With the help of the BRI, it will help improve the connectivity between Singapore and other BRI countries, which will indefinitely improve the trade of Singapore. In addition, there are many Chinese companies using Singapore as their base to oversee operations in the region. Being part of China's BRI will also encourage more Chinese companies moving their base of operations to Singapore which will also help to improve Singapore economics.

This can be seen in Fig. 5 where there is a significant increase in both exports and imports from 2016.

On the other hand, the weakening of China's yuan caused the China economy to weaken and it has affected export-oriented countries like Singapore as shown in the downward spike in China's exports during the time period 2015 to 2016 in Fig. 5. This means that the exports were deemed more expensive to the Chinese buyers, reflecting a price disadvantage. Singapore's economy was negatively affected by the slowdown of China economy which potentially impacted the

value of the Singapore dollar. As the Singapore dollar weakens, imports became more expensive, which similarly resulted to a decrease in imports as reflected in Fig. 5. This shows that if any of our major trading partners were to be affected by any crisis, Singapore's economy and trade will be dragged down as it is largely dependent on trade to its Gross Domestic Product (GDP) amongst all countries in the world.

Declining Oil Trade in 2015

In 2015, oil exports plunged 32.2 per cent amid lower shipments to Malaysia, Indonesia and Australia. Oil re-exports fell as well, contracting 41.3 per cent in 2015. The decline was mainly due to falling shipments to Indonesia, Malaysia and Australia as well. In volume terms, oil-re-exports expanded 1.8 per cent in 2015.

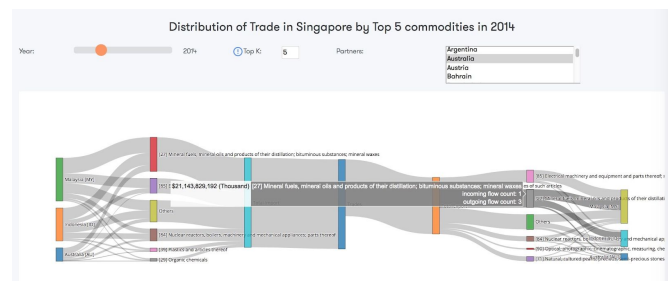
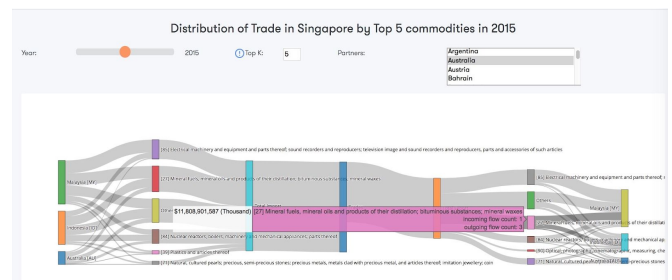


Figure 5.2: Sankey Diagram showing Exports of [27] Mineral Fuels, mineral oils & product of distillation to Malaysia, Indonesia and Australia, 2014.

From the above Sankey diagram, we can see that in 2014, the commodity type [27] which represents oil exports was the 2nd largest commodity type to be exported to Malaysia, Indonesia and Australia.

Figure 5.2: Sankey Diagram showing Exports of [27]



Mineral Fuels, mineral oils & product of distillation to Malaysia, Indonesia and Australia, 2015.

Fast forward to 2015, the combined total export of this commodity type dropped from 2nd to 3rd place, showing a drastic drop from US\$ 21M in 2014 to US\$11.8M in 2015.

This downtrend in oil exports was largely due to depressed commodity prices, in particular oil prices. The continued decline in oil prices in 2015 is expected to significantly affected overall trade in Singapore. This is largely due to the

fact that Singapore's GDP largely depends on the oil industry. According to the Economic Development Board(EDB), Singapore is dubbed "the undisputed oil hub in Asia" as we are one of the world's top three export refining centres. To provide some perspective, Singapore's oil industry accounts for 5% of the country's gross domestic product(GDP).

As Asia's leading oil trading hub, any impact on oil prices will likely cause significant impact on our major oil trading partners, as seen in the visualisations above.

7 LIMITATIONS

The visualisations as chosen above were steps in the right direction to provide users with a clearer overview of how trade figures is distributed across the many categories and over 100 countries. Classification of commodities in the Sankey Diagram was done by retrieving data from ASEANStats DataPortal, which could be narrowed down to 6 digit for maximum specificity but in our case, only the 2 digit categorisation were used. In our current data visualisation, data analysis is performed using a one-to-many relationship between Singapore and other countries/regions as trading partners. To achieve a more comprehensive and extensive analytical model, we could potentially explore a many-to-many approach and display data containing trade of each and every country/region relative to all other countries/regions.

8 CONCLUSION

Analysing Singapore's trade figures proved to be an arduous task and requires a good level of understanding of the interdependencies of trade numbers between imports/exports at in order to see the bigger picture. One such diagram that made this possible is the Sankey Diagram. With all the trade visualisations generated, users which include government bodies like Ministry of Trade and Industry (MIT), Innovation and Enterprise (IE) Singapore and the Straits Times can now perform a better analysis and breakdown of trade figures by having the ability to dissect trade figures down to the commodity type level and comparing it across multiple countries/regions over a time period. This would aid analysts in forecasting and estimation of trade figures for future years to come as well as for policy makers to better assess the details of trade agreements that Singapore should partake in so as to remain competitive in the ever changing trading landscape.

Some of the biggest takeaways from the visualisations are as followed:

The effects of Trans-Pacific Partnership is not so apparent in visualisations because its impact is likely to be in the form a trickle-down effect and not directly affecting trade between U.S and Singapore.

Singapore's dependence on China, especially with the Beijing's Belt and Road Initiative (BRI), is more apparent than ever. As Singapore's major trading partner, China's willingness to trade with Singapore will have a significant impact on our overall GDP.

The oil industry accounts for approximately 5% of GDP each year and as Asia's leading oil trading hub, Singapore is always closely observing its oil exports to ensure it holds on to its lead. Our dependence on oil trade proved to be crucial when oil prices fell in 2015, causing our oil export figures to drop by almost 50%.

All in all, U.S's departure from TPP may eventually cause a negative impact on Singapore's trade but remains to be seen, China's influence on Singapore's trade has been more important now than ever before and Singapore's dominance in the oil trading industry will be closely dependent on oil prices and outlook of the oil industry.

ACKNOWLEDGMENTS

We would like to thank Professor Kam Tin Seong for taking time out for our consultation session with him and his valuable input about how the actual trade figures between countries may not necessarily be well represented from available dataset has given us a different perspective to approach this project.

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