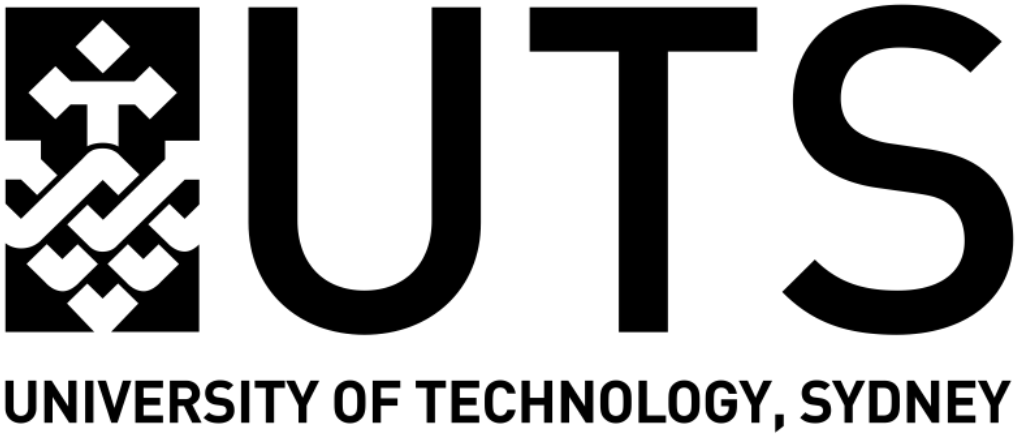

DATA VISUALISATION AND VISUAL ANALYTICS
Assignment 3: Visual Analytics

Table of Contents

1. Introduction

This report is to serve as a visual analytics practice in the context of the Australian International Trade balance in a period of 35 years ranging from 1988 to 2022 with ten main categories including:

- Food and live animals;
- Crude material, inedible, except fuels
- Mineral fuels, lubricant, and related materials
- Animal and vegetable oils, fats and waxes
- Chemicals and related products, nes
- Manufactured goods classified chiefly by material
- Machinery and transport equipment
- Miscellaneous manufactured articles
- Commodities and transactions not classified elsewhere in the SITC

For each main category, there are corresponding sub-categories of which the main category is composed. The Australian Trade is recorded in a dataset having originally two sheets, the export and the import. Each sheet includes main categories and sub-categories attributes with values through years, which are rows. The values are in numerical format with $million unit. Additionally, the column "Total", which is the summation of main categories values, is added at the end of each sheet.

2. Data pre-processing

With this specification for each sheet, it is unlikely to extract patterns, relationships among data, and stories for further purposes. For that reason, additional transformations and calculations are conducted to alleviate the analytics. These handlings are applied for both export and import sheets.

The first calculation is deriving statistical pattern sheets in terms of exports and imports. This calculation shows the proportions of main categories and sub-categories with regard to the total value for each year with the following equation:

$$\text{Proportion}=\frac{\text{Value}_{\text{Category or Sub-category}}}{\text{Total Value}}*100\%$$

Due to the above equation, the values in statistical pattern sheets are in percentage format. With the statistical pattern, the composition changes of export and import total values are scrutinised and plotted thoroughly through the years.

Another additional calculation conducted is generating analytical pattern. Similarly, there are two analytical pattern sheets for the exports and the imports. These patterns represent the degree to which how the main categories and sub-categories have changed through the years by comparing the current year's values to the last year's ones with the following equation:

$$\text{Change}=\frac{\text{Value}_{t}}{\text{Value}_{t-1}}*100\%$$

Where: t is the current year of the value

The values in analytical pattern sheets are formatted in percentage. During generating analytical pattern sheets for the exports and imports, there was an issue that some values equalled 0, meaning it was impracticable for the division. To solve this issue, the results of the divisions with a denominator equal 0 have been set 0%.

Apart from the above calculation, the yearly surplus has also been calculated by subtracting export values by import values to measure how efficient the Australian International Trade for each year.

For the visualisation step, there was an issue arising where export values and import values were located in separate sheets, making trend comparison more challenging. Dealing with this issue was quite feasible, by stacking export values above and import values below in a new sheet, along with adding the column 'Trade' having 'Export' and 'Import' to distinguish values properly. There were 3 sheets for this transformation, 'Raw dollars' with raw values from original sheets, 'Changes' with values from Analytical pattern sheets, and 'Ratio' with values from Statistical pattern sheets.

3. Trend Analysing

Overall, the total values through the years increased, from $42,419 million and $42,365 million in 1988 to $594,498 million and $417,184 million in 2022 in terms of export and import, respectively.

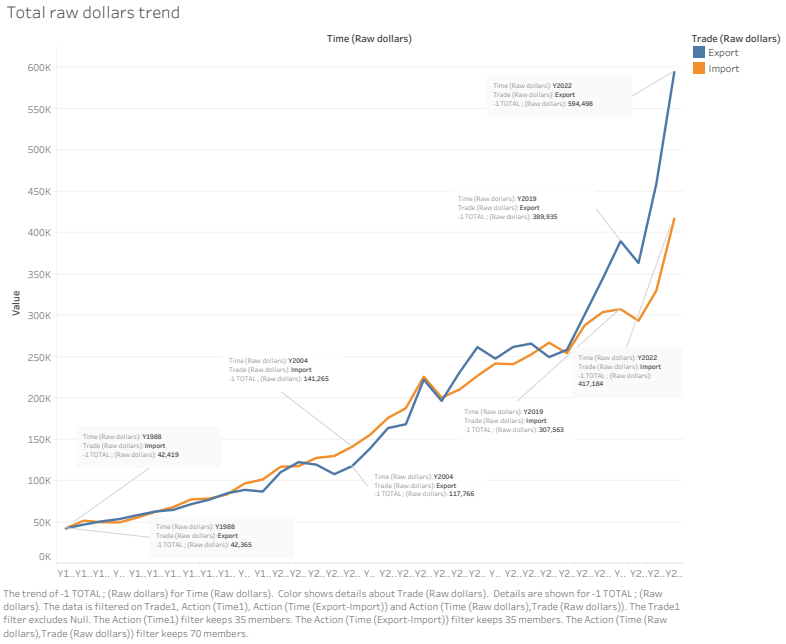

Fig.1: The total raw dollars trend through the years

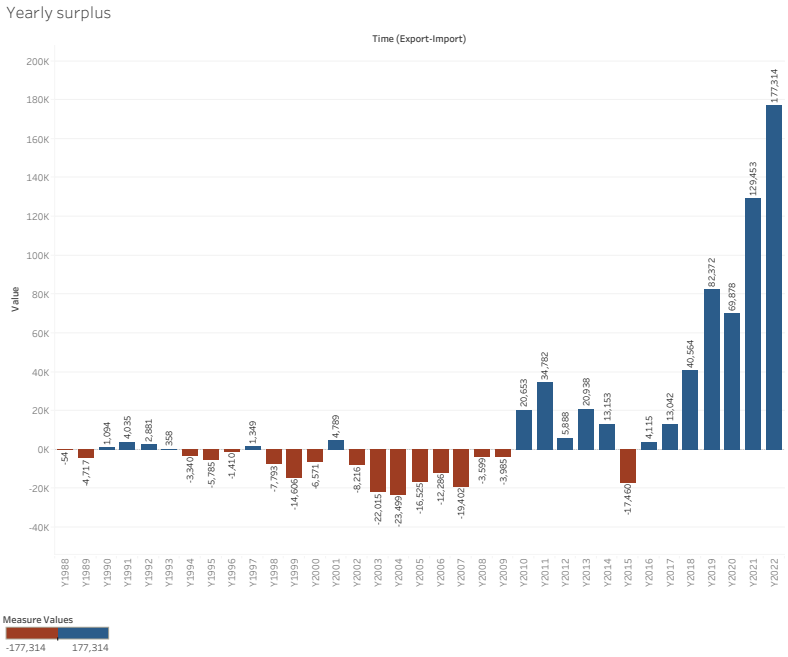

Fig.2: The yearly surplus of Australian International Trade

One metric that is used in trade balance to evaluate economy growth is the yearly surplus. In general, for the first two-thirds of the 35-year period, Australian trade mainly had a deficit, meaning the imports overwhelms the exports and landed at the bottom in 2004 with a $-24,399 million deficit. After that, the export total values were constantly resilient and overpassed the import value in 2009. Except for the year 2015, when the deficit happened again, the export total values maintained the growth pace till 2022, reaching the surplus peak of $177,314 million.

From the Fig. 1, it is obvious that the increase in the export and total export values is pretty steady, meaning the total values of the current year were higher than that of the previous year in both exporting and importing. Having said that, both exports and imports still had witnessed declines in several years. While the import change's declines happened in the years 1990, 1991, 2009, 2013, 2016, and 2020, it was the years 1999, 2002, 2003, 2009, 2012, 2015, and 2022 for the change's downturn of the export.

The justification for these change's decreases in imports was the recession in 1990-1991, when the interest rate was raised highly in order to prevent inflation, leading to the unemployment rate peaking at 11% and constraining domestic consumption; the Global Financial Depression in 2009, which is the consequence of extreme stress and volatility of international financial markets and banking systems, triggered sheer losses in financial activities and increase in unemployment; and the Covid-19 in 2020, with methods and efforts including immediate suspension of economic activities to curb the widespread of the pandemic, and creating economic stagnation and fell, and unemployment rise as side effects (Reserve Bank of Australia, n.d). The 2009 global financial crisis and the Covid-19 in 2020 were also responsible for the decrease of change in terms of exports in 2009 and 2020. Additionally, there was another year, 2003 that shared the same perspective. Interestingly, the Australian economy has grown strongly in 2003-2004, along with partner countries' resurgences. The reason for this decline was the exceptional exchange rate of the Australian Dollar with respect to other currencies. Furthermore, the constraint in the domestic supply has also contributed to this trend, leaving Australia with change of 90,38% for the export value in 2003 (Australian Government, 2004)

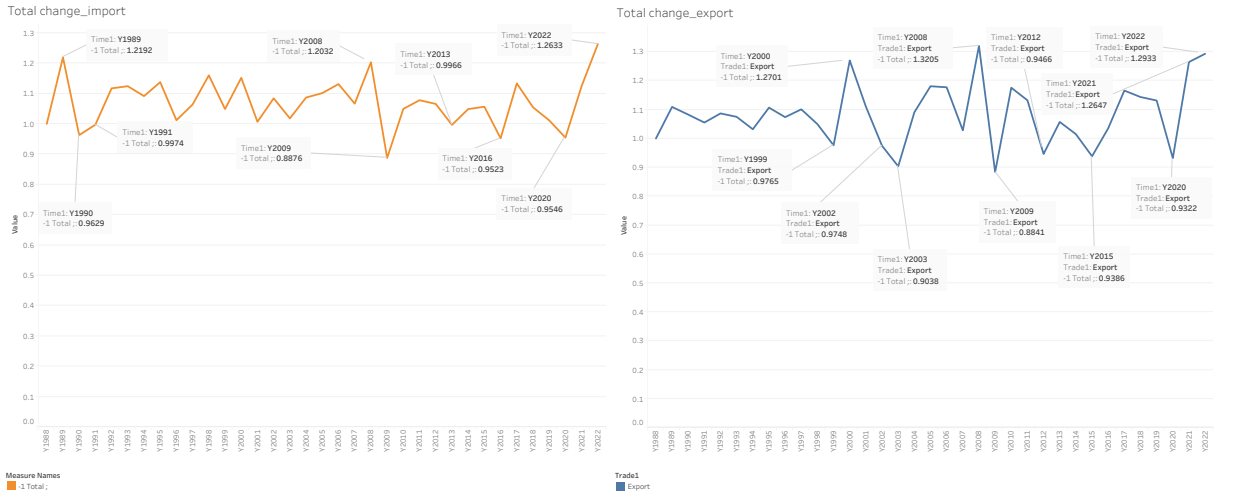

Fig.3: Import (left) and Export (right) changes through the years from 1988-2022

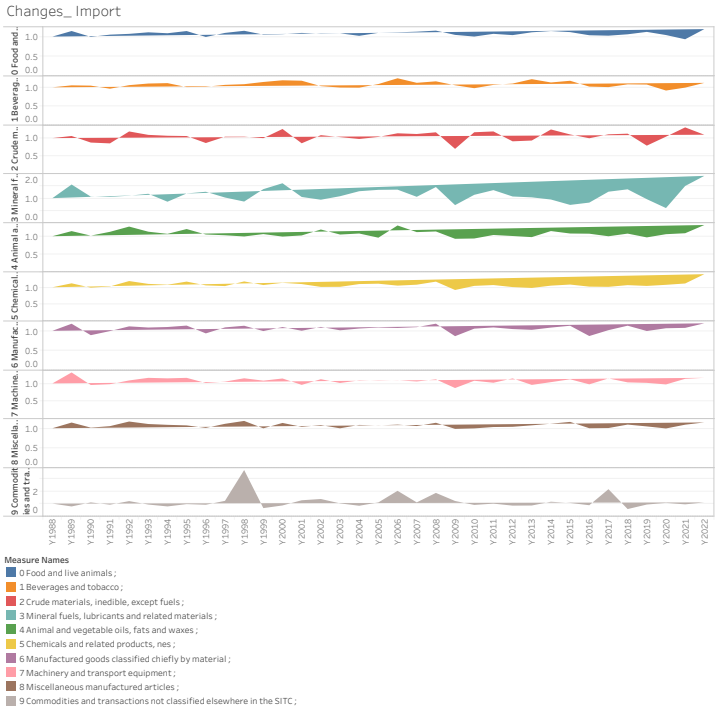

Fig.4: Import changes of main categories through the years from 1988-2022

Another year witnessed a remarkable decline in import change is 2016, from 106.58% in 2015 down to 95.23% in 2016. This change's reduction was interpreted owing to the China-Australia Free Trade Agreement (ChAFTA) was in force, letting importing machinery, transportation equipment, and manufactured goods from China, which is the biggest exporter of these products (World Integrated Trade Solution, n.d), more approachable for consumers as well as small and medium businesses (Australian Government, n.d). Looking at the below graphs of the Australian International Import Composition, it is more sensible to explain why this ChAFTA considerably affected the change of total imports in 2016, where the main category, 'Machine and transport equipment' prevailed with 40.63% of the composition.

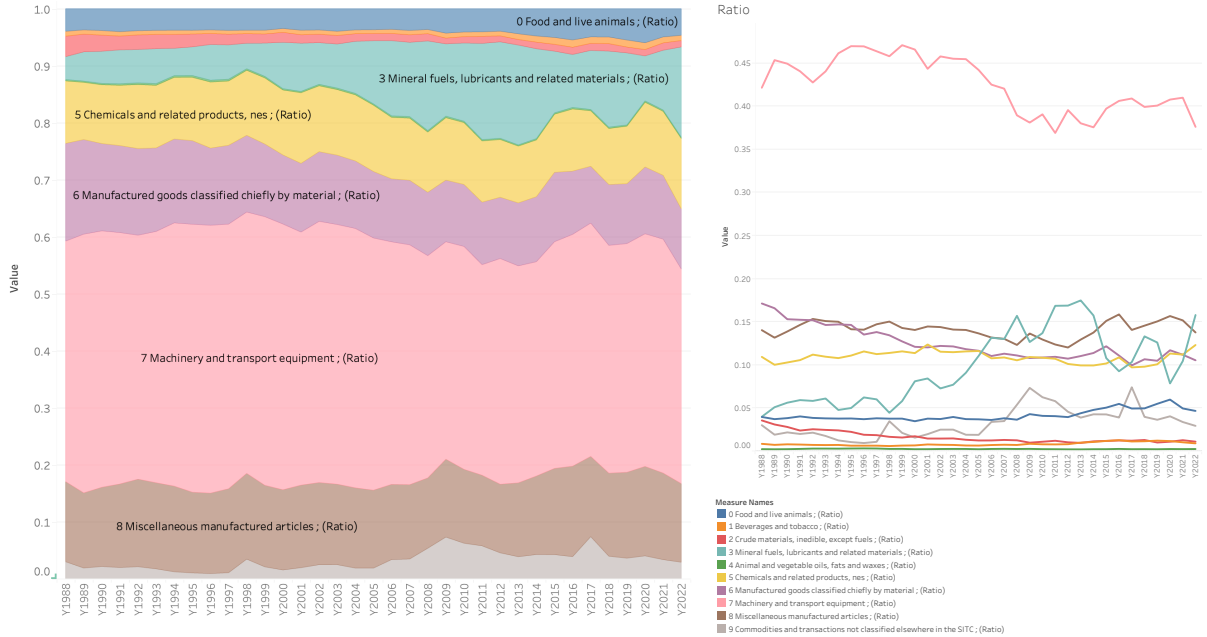

Fig. 5: Australian International Import Trade Composition in area graph(left) and in line graph(right)

On the opposite side of the decrease, both export and import analytical pattern graphs have notable spikes in increase. The import change soared in 1989 to 121.92%, in 2008 to 120.32%, and in 2022 to 126.335%. Regarding export change, they are the years 2000, 2008, 2021 and 2022 with 127.01%, 132.05%, 126. 47%, and 129.33%, respectively. While the tax and tariff reductions included in the Australian economic reform starting from the middle of 1980s played as the main drivers for the flush of the import change increase from 1983 to 1989, peaking at 121.92% in 1989 (Anderson, 2014), the astonishing import change of 120.32% in 2008 was the consequence of an aggregation of many free trade agreements between Australia and Singapore (2003), the USA (2005), and Thailand (2005) that has boosted up the domestic consumption, especially automotive demand. For the year 2022, it is understandable to have a surge after the Covid-19 with exceptional import change increasing up to 126.33%, mostly with the main category 'Mineral fuels, lubricants, and related materials', 190,8%, in order to re-throttle up the economy machine idling during the pandemic. On the export side, the change increases are recorded in the year 2000 with the depreciation of the Australian Dollars and the 2000 Sydney Olympic Games fuelling up the soaring of the export change (Anderson, 2014). The first half of the 2000s witnessed the commodity demand boom due to the urbanisation and industrialisation in emerging marketing like China and South East Asia, making the prices of iron ore and coal, the main ingredients for steel fabrication, rocket from $10 per tonne in 2003 to $170 per tonne in 2008 for iron ore, and from $40 per tonne to around $120 in early 2008. This pricing movement has contributed significantly to the export of Australia in 2008. Additionally, this movement has been observed in 'Crude materials, inedible, except fuels' and 'Food and live animals', and 'Animal and vegetable oils, fats, and waxes' in 2008, which is the consequence of the high demands for crop productions and fast livestock growing. As the import change, the export changes increased in 2022 due to the recovery after the Covid-19 demanding crude fuels highly.

The next part is an analysis in export trade composition and analytical patterns to find outliers, and change points throughout the period.

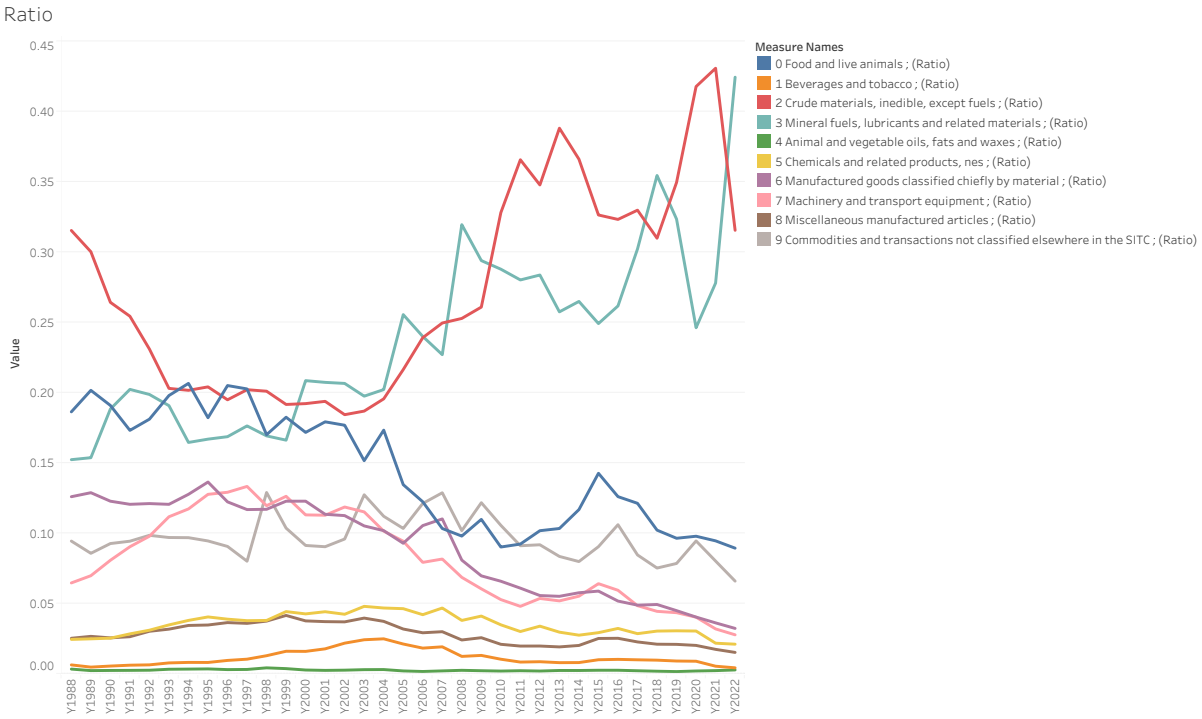

Fig.6: The export trade composition of Australia from 1988-2022

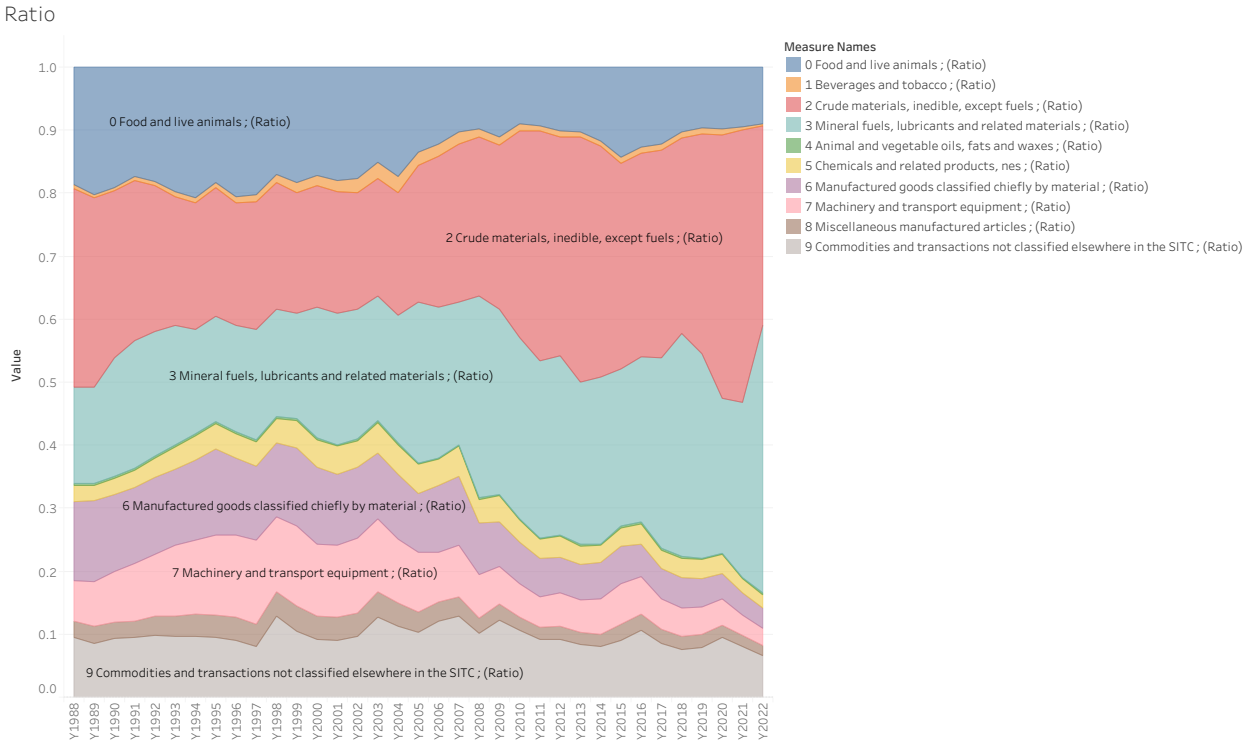

Fig.7: The export trade composition of Australia from 1988-2022 in are graph

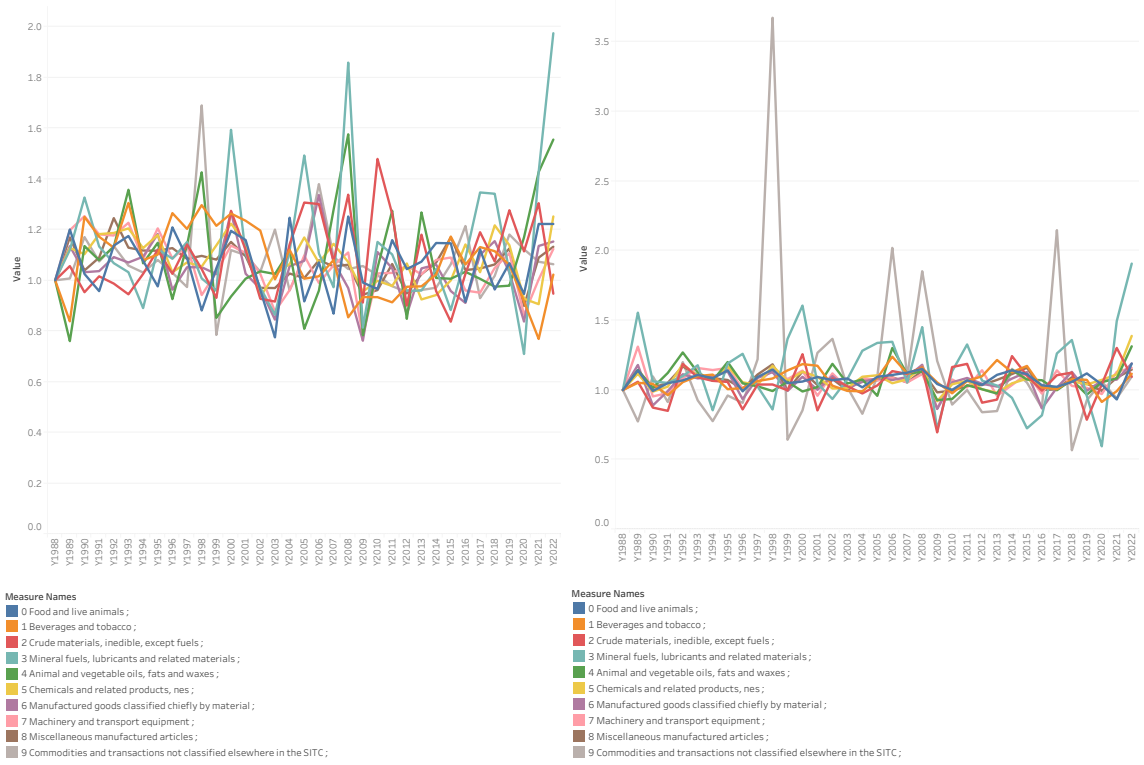

Fig.8: Export (left) and Import (right) trade change graphs of Australia from 1988-2022

While the main category ‘Machinery and transport equipment’ has dominated the import section with roughly 42%, there was a shift in the weights of the main categories in the export section. For the first half of the period, three main categories, ‘Food and live animal’, ‘Crude materials, inedible, except fuels’, and ‘Mineral fuels, lubricants and related materials’ shared a similar weight, around 20%, and led the main portions of export trade. But after 2005, the commodities price boom shifted the Australian economy to focus on mining and resources exporting, elevating the proportions of ‘Crude materials, inedible,

except fuels' and 'Mineral fuels, lubricants and related materials' rapidly from 21.66% and 25.58% in 2006 to 31.58% and 42.48% in 2022, respectively. These figures explicate the Australian economy, which heavily relies on natural resources mining and raw material exporting, leaving other main categories decreased through time. Another exciting thing easily to be detected is the abnormal export and import change of main category 'Commodities and transactions not classified elsewhere in the SITC' in 1998, which were 367.4% for the import and 169% for the import. This could be explained by relying on the financial crisis in Asia with a series of currency devaluations, turning gold as safe-haven asset during the downturn. For that reason, a large amount of gold headed to Australia for processing due to Australian expertise in metal mining and refining, and then these gold amounts were re-exported to investors across the world (Australian Bureau of Statistics, 2021).

4. Dashboard

For data analysis, it is necessary to have interconnections between fragmented data in order to have a deeper understanding. A dashboard is a powerful tool to link data trends and patterns that happened simultaneously at specific points. In this report, the main category 'Mineral fuels, lubricants, and related materials' is attached to the dashboard for sub-categories examination. Looking at the dashboard, main category 'Mineral fuels, lubricants, and related materials' contains 3 sub-categories:

- Coal, coke, and briquettes
- Petroleum, petroleum products, and related materials
- Gas, natural and manufactured

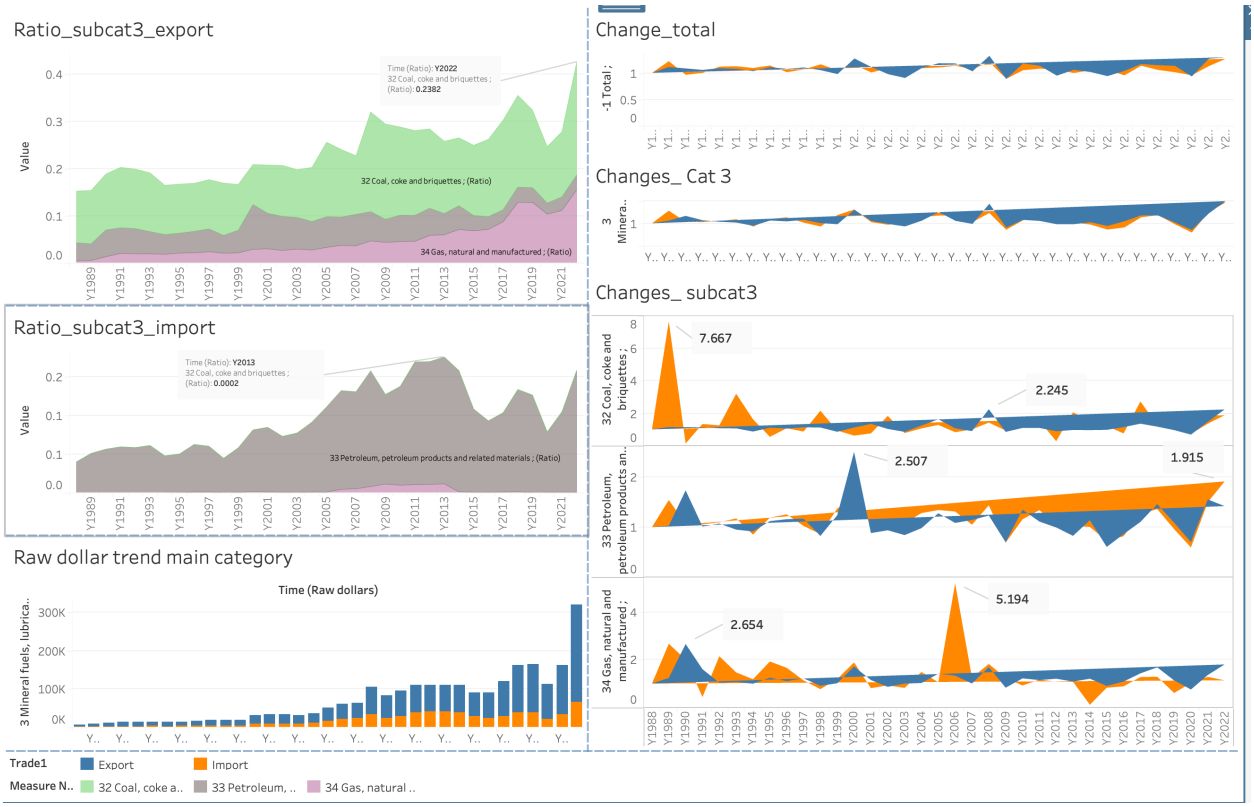

Fig.9: Dashboard view of main category 'Mineral fuels, lubricants, and related materials'

The dashboard is comprised of 6 sheets, with 'Import Ratio', 'Export ratio' and 'Raw dollar trend' on the left side in ascending order, and 'Total change', 'Main category change', and 'Sub- categories change' on the right side in ascending order. According to the ratio sheets, the sub-category 'Coal, coke, and briquettes' weighs most heavily of all time in the export sector, with the proportion expanding consistently from 10.94% in 1988

to 23.82% in 2022. For the import, the sub-category ‘Petroleum, petroleum products, and related materials’ was dominating of all time, with 0.01% in 1988 to 0.02% in 2013. For the raw dollar trend, the export values overwhelmed the import ones in all years, creating continuous positive surplus values. For the right side sheets, while the import and export analytical patterns of total values are identical to the ones of the main category, especially in the years 2000, 2006, 2009, and 2020 with regard to the aforementioned events, the sub-categories' analytical patterns operated quite differently, except for the export change value of ‘Coal, coke, and briquettes’ in 2008; the export change values of ‘Petroleum, petroleum products, and related materials’ and ‘Gas, natural and manufactured’ in 2000; and all the change values in the years 2009 and 2020. The export change value of ‘Coal, coke, and briquettes’ peaked at 766.7% in 1989. For the ‘Petroleum, petroleum products, and related materials’, it was 191.5% in 2022, and 519.4% in 2006 for ‘Gas, natural or manufactured’. Correspondingly, for the export values, they were 224.5% in 2008, 250.7% in 1999, and 265.4% in 1990 for ‘Coal, coke, briquettes’, ‘Petroleum, petroleum products, and related materials’, and ‘Gas, natural and manufactured’, respectively.

The second dashboard was an interactive one where the year could be selected so that export and import values are shown in two discrete treemap graphs properly.

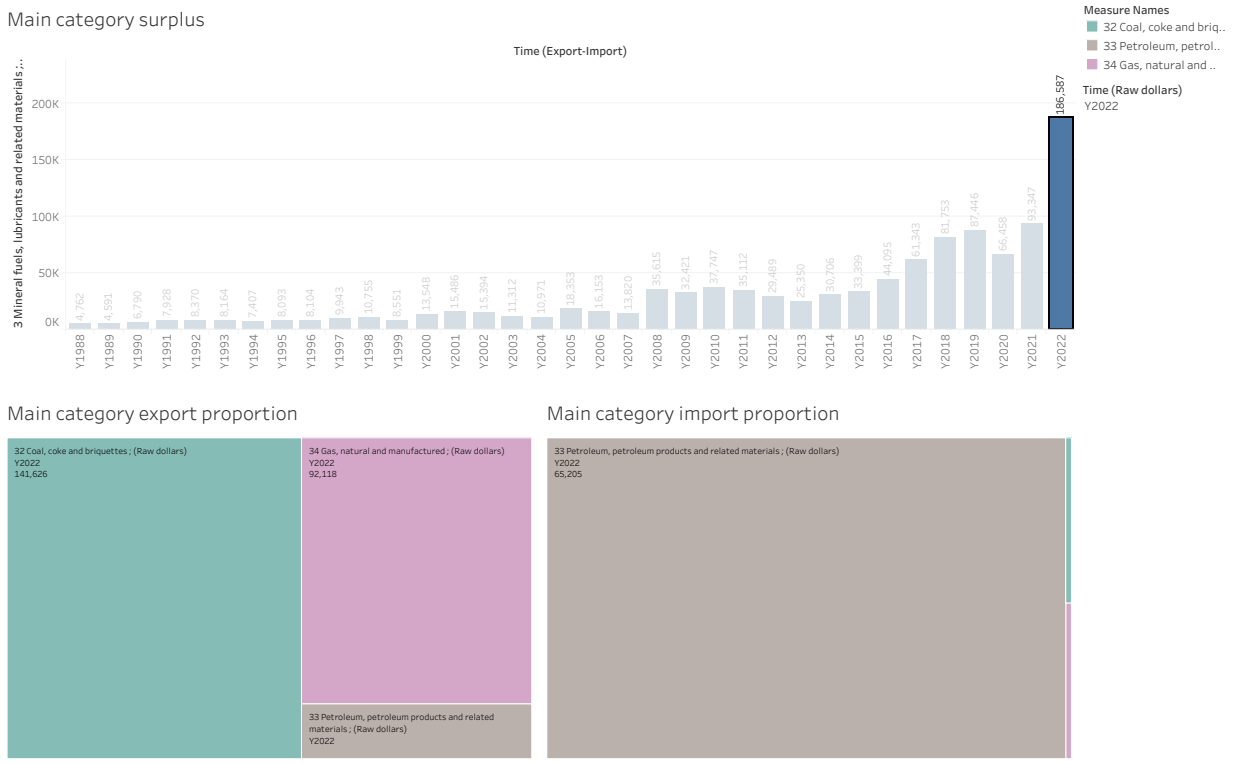

Fig.10: Interactive dashboard with selecting year for export and import sub-category value and surplus in 2022

In the year 2022, the yearly surplus has doubled, from $93,346 million in 2021 to $186,587 million. Looking down the treemap graphs, it can be seen that the surplus mostly come from ‘Coal, coke, and briquettes’ with $141,626 million for export value, followed by ‘Gas, natural and manufactured’ with $92,110 million export value. Meanwhile, in the import sector, the ‘Petroleum, petroleum products and related materials’ keep dominating with $65,205 million import value. The other import values of ‘Coal, coke, and briquettes’ and ‘Gas, natural and manufactured’ were merely inconsiderable, $375 million and $352 million respectively, representing two sticks in the import treemap graph when standing aside the ’Petroleum, petroleum products, and related materials’. This could be empirical evidence to state that the Australian economy

is mainly based on mineral mining, an industry harnessing heavy equipment to collect ores, and these pieces of equipment require petroleum, a fuel type that is not much in Australia. Consequently, significant import of Petroleum and related materials is sensible to maintain the critical industry of Australia.

5. Storyboard

In practice, a report is created to transfer content to the reader. Despite the sheets and dashboards being enriched with colours, labelling, and shapes, they still need a narrative to guide readers or spectators through the presentation/report in an identified order. The story is reserved to handle this task, with the architecture of story points containing a dashboard that is arranged in a specific order to elevate the storytelling experience.

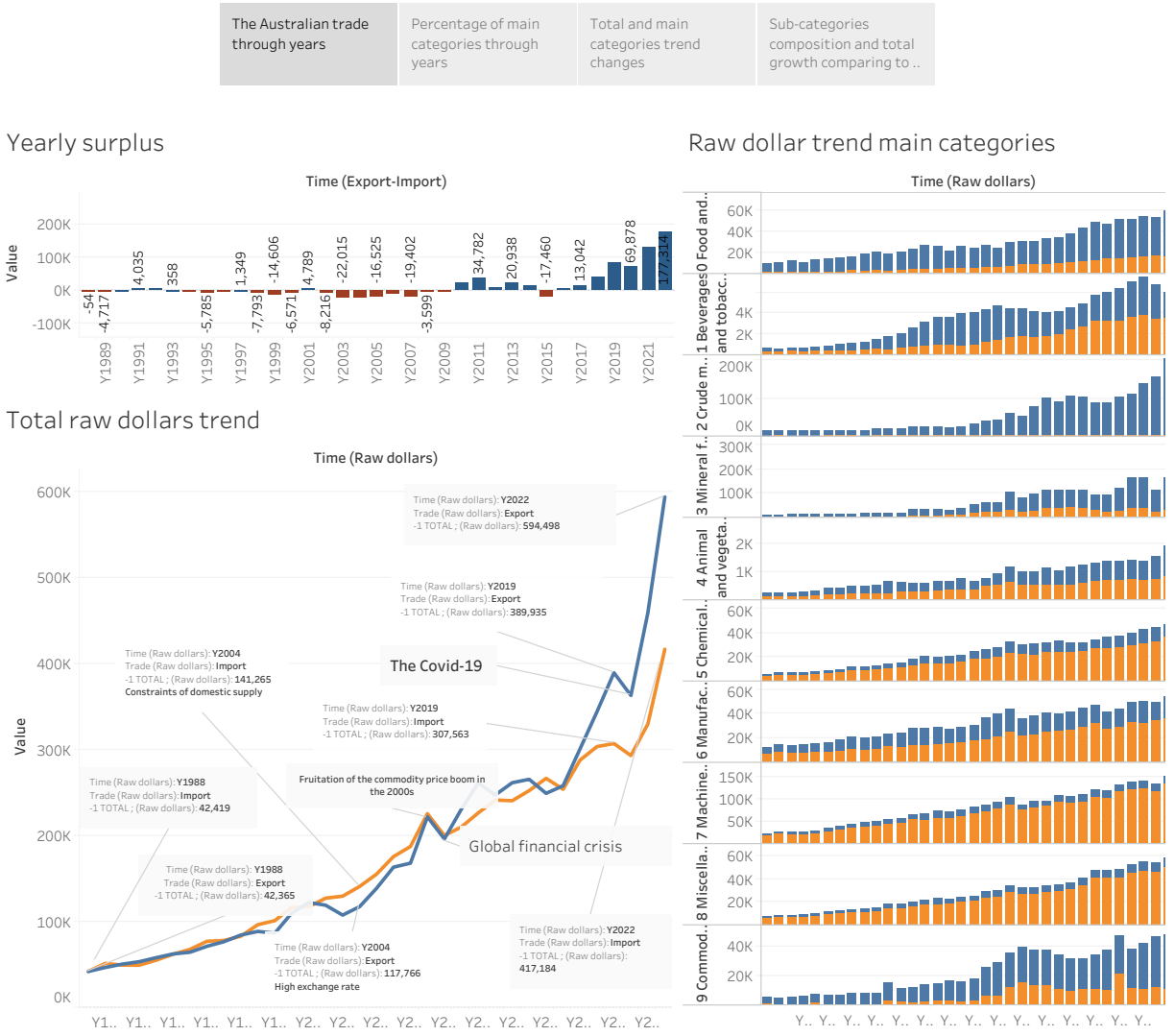

Fig.11: The first story point presenting overall view of the Australian Trade

This story point provides a comprehensive view of the Australian trade through 35 years, with detail on yearly surplus, and import and export values of each main category with babel and figures in change points to plot out the trend. With this story points, it is obvious to recognise that the Australian trade so far has risen steadily, especially, in the period 2004-2009, the growth seems more soaring with the commodities price boom in emerging markets in Asia. There are some years that witness a growth downturn, such

as 2009 with the global financial crisis and 2020 with the covid-19. But after those years, impressive recoveries happened and ended up with roughly $595,000 million for export value and $417,184 million for import value. While main categories 'Animal and vegetable oils, fats and waxes', 'Chemicals and related products, nes', 'Manufactured goods classified chiefly by material', 'Machinery and transport equipment', and 'Miscellaneous manufactured articles' are mainly responsible for the import, the other main categories including 'Food and live animals', 'Crude material, inedible, except fuels', 'Mineral fuels, lubricant, and related materials', 'Animal and vegetable oils, fats and waxes', and 'Commodities and transactions not classified elsewhere in the SITC' contributed most to the export values. The yearly surplus, for the first half of the period', mainly had negative values. For the rest half, the situation improved considerably with yearly surplus in 2022 reached $177,314 million.

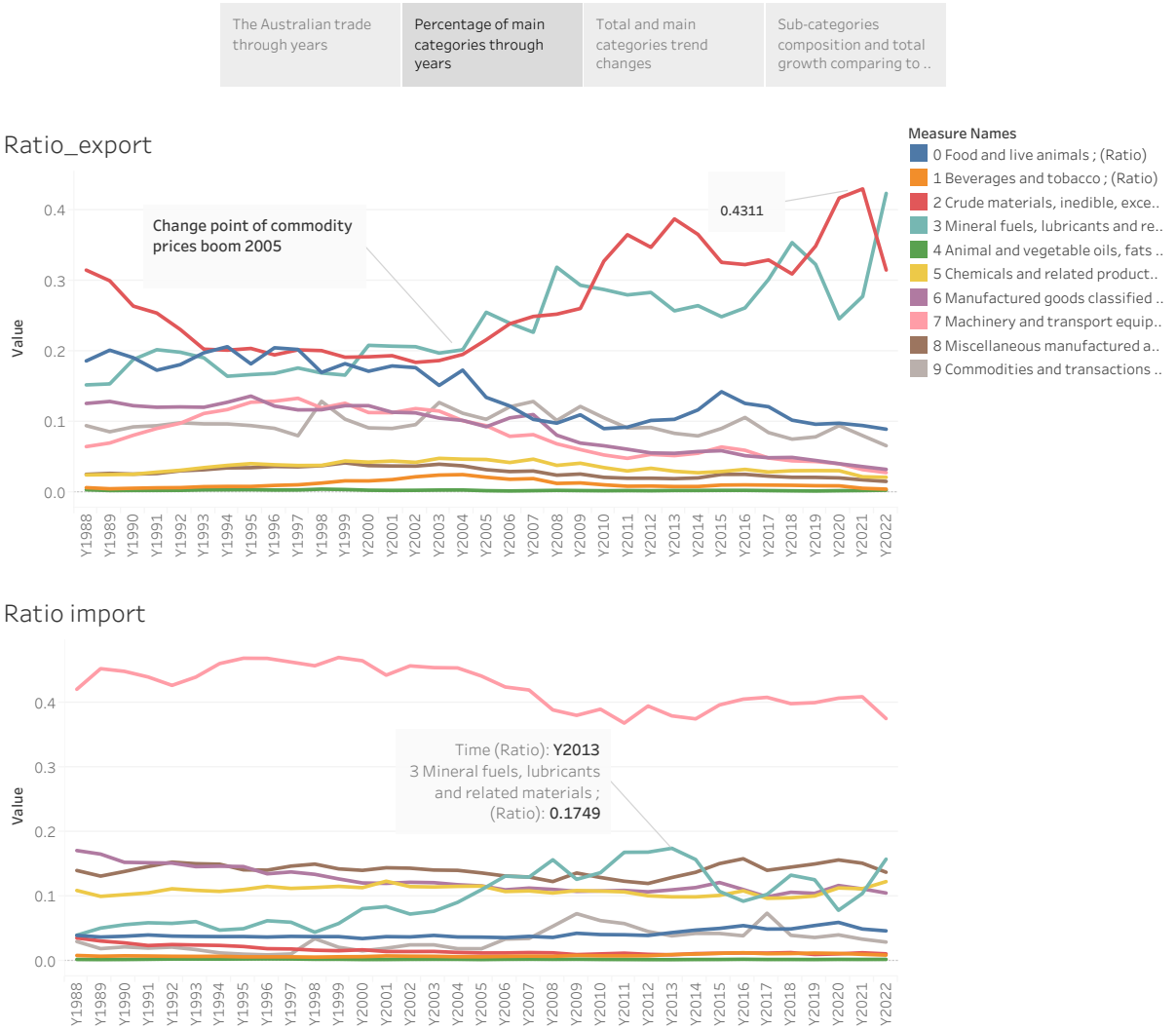

Fig.12: The main categories percentage with regard to export and import

In the import sector, while the main category 'Machinery and transport equipment' has been prevailing with roughly 40% for all time, the other main categories maintain a levelling-off tendency, except for the 'Mineral fuels, lubricants and related materials' slightly increasing and peaking at 17.49% in 2013. Then this main category slightly decreased and ended up 15.8% in 2022. For the export sector, the main

categories ‘Food and live animals’, ‘ Crude materials, inedible, except fuels’, and ‘Mineral fuels, lubricants, and related materials’ shared the top three positions with around 20% for the percentage. This situation continued till 2005 when high demands in commodities for industrialisation and urbanisation led to the main categories relating to minerals and fuels increasing sharply and lowering the percentage of the main category ‘Food and live animal’. The main category, ‘Crude material, inedible, except fuels’ has reached the highest percentage in the export sector with 43.11% in 2021, after the Covid-19 when all countries needed resources and materials to boost the economy.

The following story point guides the reader to the change trend of total values, then compares it to the main categories' trend to identify which main categories share the same patterns.

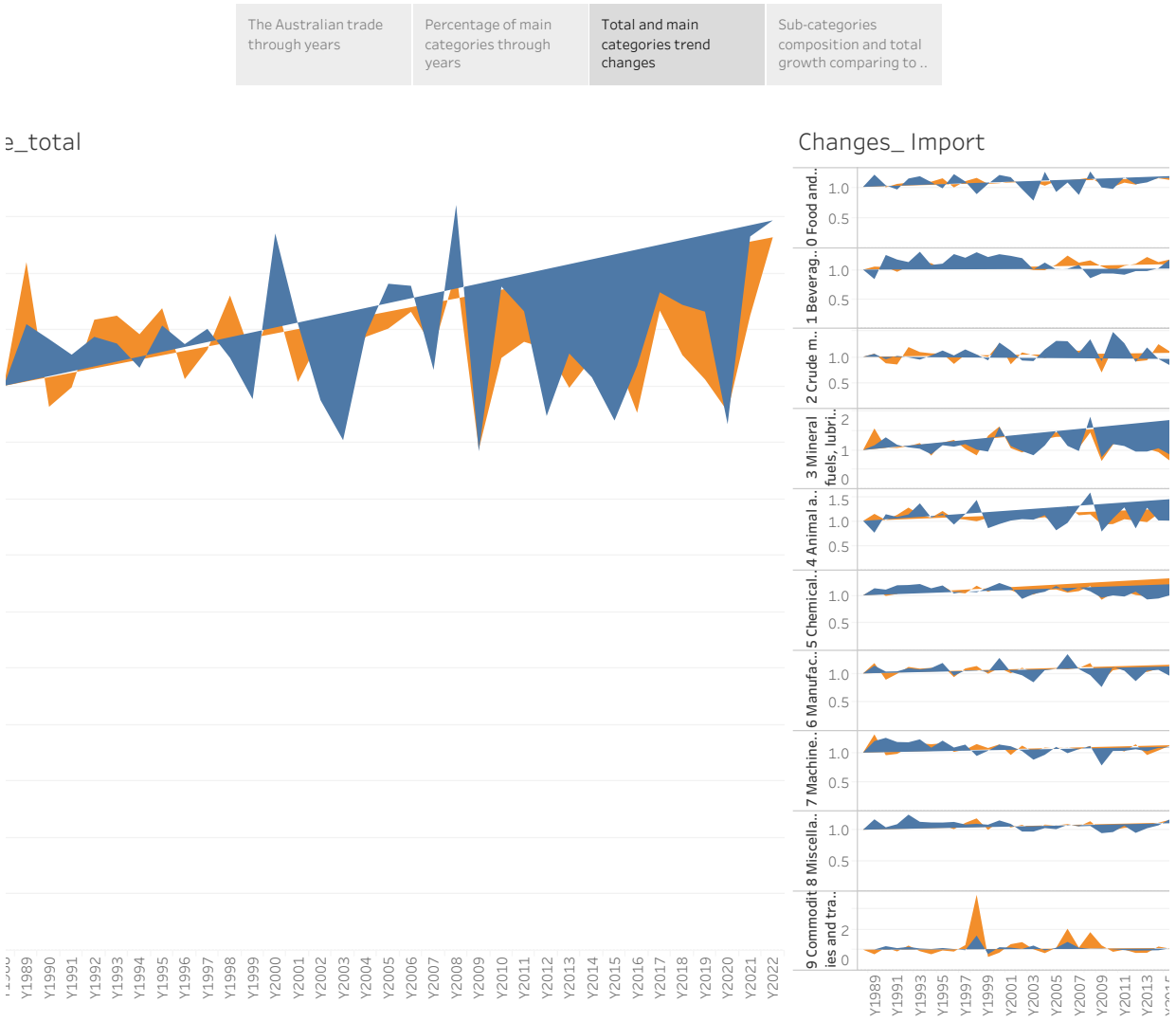

Fig.13: The main categories and total values change trend with regard to export and import

The total values show an overall increase trend for both the export and import sectors, with a manner of export spiking in 2000 due to taking advantage of the Asian financial crisis, in 2008 as the consequence of free trade agreements with Singapore, the USA, Thailand and the commodity prices boom from the middle of the 2000s. On the contrary, the trend plummeted in the years 2009 due to the global financial

crisis and 2020 due to the Covid-19. Looking to the trend of ten main categories, 'Mineral fuels, lubricants, and related materials', ' Animal and vegetable oils, fats and waxes', and ' Manufactured goods classified chiefly by material' share trends quite similar to the one of the total values, especially the main category 'Mineral fuels, lubricants and related materials' are pretty identical with two spikes in 2000 and 2008 in the export sector. Other main categories mostly share similar trends to the total trends for the second half of the period, starting from 2008. The main category, 'Commodities and transactions not classified elsewhere in the SITC' had attractive spikes in 1998 for both the export and import sectors. This trait was due to the high change trends in gold import and export for processing when gold became safe-haven asset during the Asian financial crisis.

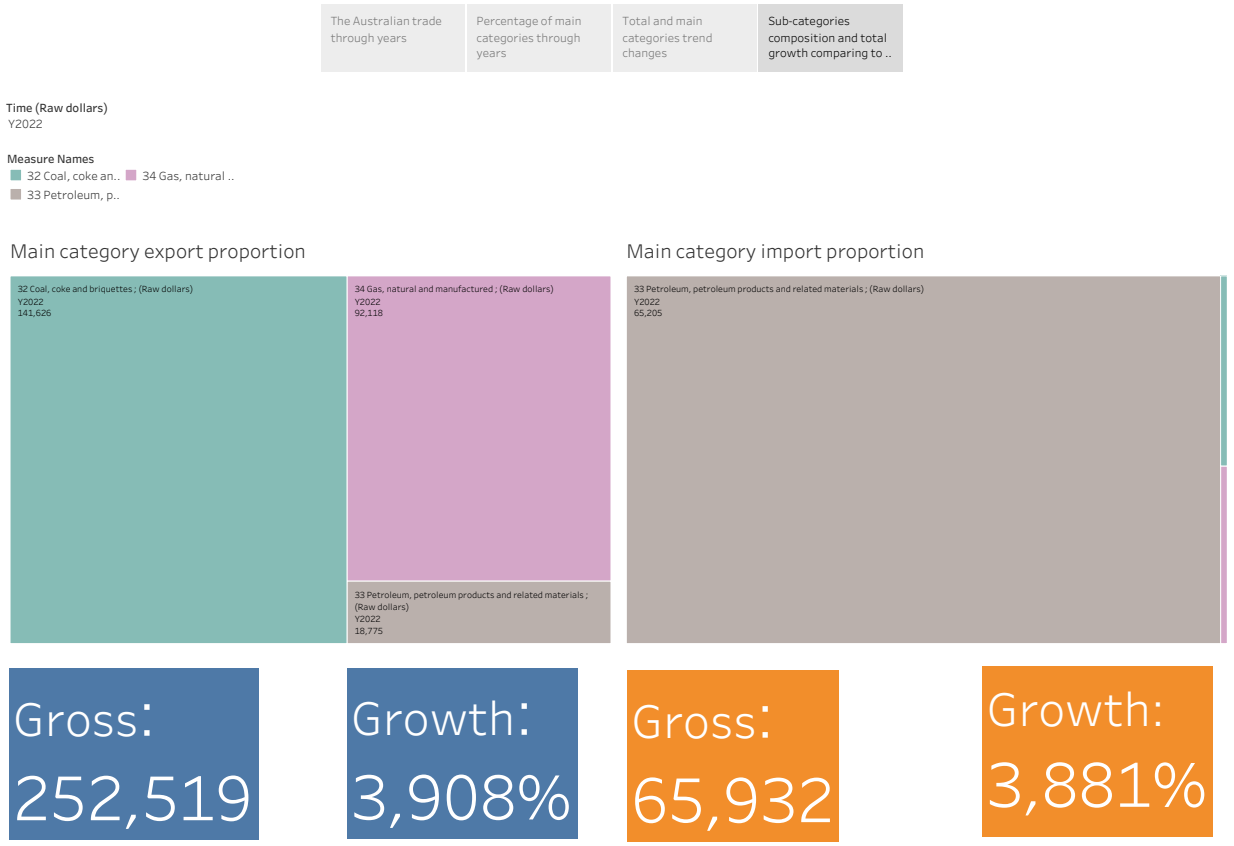

Fig.14: Sub-categories composition of the main category 'Mineral fuels, lubricants, and related materials'

The last story point is about the sub-categories of the main category 'Mineral fuels, lubricants, and related materials', which is the main category having the change trend most similar to the total values trend. Additionally, this main category has occupied a large portion of the Australian trade composition through the years.

This story point has 2 treemap graphs representing the composition of sub-categories in the export and import sectors. Below each treemap, there are two boxes showing the gross values of the sub-categories in each sector and the growth percentage comparing to the values in 1988. Additionally, this story point is an interactive storyboard, meaning year can be explicitly selected for the treemap graphs demonstration. Obviously, in the year 2022, the export values have grown 3,908% since 1988, with $252,519 million. When it comes to the import sector, the gross value was $65,932 million dollars, and 3,881% for the growth percentage since 1988. The 'Coal, coke, and briquettes' is the main product for the export when occupies more than half of the export composition space, followed by the 'Gas, natural or manufactured'. For the import sector, the

'Petroleum, petroleum products, and related materials' is totally dominating, covering almost the import sector, leaving the stick-shaped portions for 'Coal, coke, and briquettes' and 'Gas, natural or manufactured'.

6. Conclusion

For 35 years, from 1988-2023, Australian international trade has continued growth for both export and import sectors. Despite a couple of years of witnessing the downturn due to financial crises or the pandemic, Australia has confirmed the thriving of the economy by shifting enormous proportions from food and animal exports to mining and resources exports to meet high demands from emerging markets. This composition brought rapid growth to the Australian economy with a lucrative yearly surplus, but it also poses an unbias in the economy when Australia is heavily relying on mining operations. In the era of gradually adopting sustainable development technologies, Australia is more likely to get adverse with this economic model.

To be honest, this assignment is quite tough to be accomplished without powerful tools like Tableau. The original dataset with only two sheets of clueless import and export values has been transformed and undergone many calculations to extract meaningful stories and patterns. Based on the pre-processed dataset, the Tableau turns numerical values into vivid visualised graphs with shapes, colors, and labelling. Furthermore, the Tableau is also able to connect all separate sheets into coherent dashboards and storyboard to derive a report with the vibe of human-centred design, where the storytelling is appliedto make the report more valuable to the reader. Apart from the advantages, the Tableau still has drawbacks, especially in calculating tasks. Despite a function for calculation editing is available, complex calculations and transformations do need the MS excel for proper handling.

7. Reference

- Anderson, D. (2014, December). *Fifty years of Australia's trade.* Australian Government. https://www.dfat.gov.au/sites/default/files/fifty-years-of-Australias-trade.pdf
- Australian Government (n.d). *ChAFTA fact sheet: Resources, energy and manufacturing.* https://www.dfat.gov.au/trade/agreements/in-force/chafta/fact-sheets/Pages/chafta-fact-sheet-resources-energy-and-manufacturing.
- World Integrated Trade Solution (n.d). *Australia Machinery and Transport Equipment Imports By Country in US$ Thousand 2015-2016.* https://wits.worldbank.org/CountryProfile/en/Country/AUS/StartYear/2015/EndYear/2016/TradeFlow/Import/Indicator/MPRT-TRD-VL/Partner/BY-COUNTRY/Product/Transp.
- Reserve Bank of Australia. (n.d). *Recession.* https://www.rba.gov.au/education/resources/explainers/recession.html.
- Australian Bureau of Statistics. (2001, February 20). *Major commodities traded by Australia, (1991 to 2000).* https://www.abs.gov.au/ausstats/abs@.nsf/61cfc5401332ba40ca2570d60018db27/53c75a489ded8bf2ca2569f8007f5af0/$FILE/ATT8K6IX/feature1_1.pdf.