Working with Data Scottish Exports

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Contents

Question 1: Provide a summary of the data and explain the data format. State how many records there are and give an example of what can be determined from looking at the data. (6,1,2)

Answer:

The dataset under analysis is the Scottish Exports Dataset, which provides information on the export values of various industries from Scotland to different destinations over a range of years spanning over a decade.

The dataset is structured in a format and contains a total of 2465 records (rows) and 7 columns. Each row represents a record of export data associated with the number of years, industry sector, and export destination. The dataset spans multiple years, primarily between 2004 and 2018.

This columns within the dataset includes FeatureCode, DateCode, Measurement, Units, Value, Industry Sector (SIC 07) and Export Destination. The FeatureCode column appears to represent a code that identifies different features or categories. The DateCode column represents the year associated with the export record. The values column represents numerical data of the total value of the financial transaction exports measured in millions in GBP. The Industry Sector (SIC 07) column lists various industry sectors based on Standard Industrial Classification (SIC) Codes, while the export destination column specifies the destination to which the exports are made such as EU, International, Non-EU, or the rest of the UK.

```
unique_years = df['DateCode'].unique()
```

```
unique_years
```

```
array([2004, 2005, 2009, 2017, 2008, 2007, 2003, 2011, 2012, 2015, 2013,
       2018, 2010, 2006, 2014, 2002, 2016], dtype=int64)
```

```
unique_destinations = df['Export Destination'].unique()
```

```
unique_destinations
```

```
array(['EU', 'Total', 'Non-EU', 'International', 'Rest of UK'],
      dtype=object)
```

```
unique_sectors = df['Industry Sector (SIC 07)'].unique()
```

```
unique_sectors
```

```
array(['Computer, Electronic and Optical Products (Section CI)',
       'Basic Metals and Fabricated Metal Products, Except Machinery (Section CH)',
       'Education (Section P)',
       'Wholesale, Retail and Repairs (Section G)',
       'Real Estate Activities (Section L)', 'Total',
       'Coke, Refined Petroleum Products, Chemicals and Chemical Products (Section CD,CE)',
       'Transport Equipment (Section CL)',
       'Professional, Scientific & Technical (Section M)',
       'Rubber, Plastic and Other Non-Metallic Mineral Products (Section CG)',
       'Administrative and Support Services (Section N)',
       'Basic Pharmaceuticals and Their Products (Section CF)',
       'Total Manufacturing',
       'Machinery and Equipment N.E.C. (Section CK)',
       'Financial and Insurance (Section K)',
       'Transportation and Storage (Section H)',
       'Furniture, Other Manufacturing; Repair and Installation of Machinery and Equipment (Section CM)',
       'Information and Communication (Section J)',
       'Agriculture, Forestry and Fishing (Section A)',
       'Textiles, Wearing Apparel and Leather (Section CB)',
       'Wood and Paper Products, and Printing (Section CC)',
       'Mining & Quarrying (Section B)', 'Total Services',
       'Construction (Section F)',
       'Food Products, Beverages and Tobacco Products (Section CA)',
       'Utilities (Section D,E)',
       'Accommodation and Food Services (Section I)',
       'Other Services (Section (Q-U)',
       'Electrical Equipment (Section CJ)'], dtype=object)
```

The diversity and structure of the dataset offer a rich foundation for analysing Scotland's export trends across different industry sectors and the destinations; International, EU, and the rest of the UK. The high valued exports are concentrated in advanced manufacturing and knowledge-based sectors e.g. Financial Services. For instance, the Computer, Electronics and Optical Products sector exported approximately £2185 million in GBP to the EU. Whereas in 2015, the Fabricated Metal Products sector exported £210 million to the same destination. Additionally, in 2017, the education sector exported £285 million to the EU.

Overall, the dataset provides a perspective of Scotland's economic engagement with different regions of the world from 2002 to 2018 and is particularly useful for tracking sector- specific performance over time (Centre for Inclusive Trade Policy, 2023). This report will highlight significant political events in Scotland's recent history and how trade relationships were potentially affected such as Scotland's Independence Referendum or Brexit Vote to Leave the European Union (Scottish Government, 2023).

Question 2: Describe the format of the data and any cleaning or transformations that were required. (1,2)

Answer:

Before conducting any analysis, it is essential to check the dataset for errors, inconsistencies or missing values. This process ensures that the data is clean, accurate and ready for analysis. The following cleaning steps were applied:

- Checking for a Missing Value: The dataset was examined for any missing or null values. A thorough inspection revealed that there were no missing values across all columns, suggesting the dataset is complete.

```
missing_values = df.isnull()
total_missing = missing_values.sum()
```

```
missing_values
```

	FeatureCode	DateCode	Measurement	Units	Value	Industry Sector (SIC 07)	Export Destination
0	False	False	False	False	False	False	False
1	False	False	False	False	False	False	False
2	False	False	False	False	False	False	False
3	False	False	False	False	False	False	False
4	False	False	False	False	False	False	False
...	...	...	...	...	...	...	...
2460	False	False	False	False	False	False	False
2461	False	False	False	False	False	False	False
2462	False	False	False	False	False	False	False
2463	False	False	False	False	False	False	False
2464	False	False	False	False	False	False	False

2465 rows × 7 columns

```
total_missing
```

```
FeatureCode               0
DateCode                  0
Measurement               0
Units                     0
Value                     0
Industry Sector (SIC 07)  0
Export Destination        0
dtype: int64
```

- Checking for Duplicates: The dataset was checked for duplicate rows that might skew the results for any analysis. The inspection indicated that there were no duplicate rows present in the dataset.

```
duplicates = df.duplicated().sum()
```

```
duplicates
```

```
0
```

- Standardising Text Entries: All text entries were converted to lowercase to avoid discrepancies due to case sensitivity during analysis.

```
print("\nOriginal Column Names:")
print(df.columns)
```

```
Original Column Names:
Index(['FeatureCode', 'DateCode', 'Measurement', 'Units', 'Value',
       'Industry Sector (SIC 07)', 'Export Destination'],
      dtype='object')
```

```
df.columns = [
    'feature_code',
    'date_code',
    'measurement',
    'units',
    'value',
    'industry_sector',
    'export_destination'
]
print("\nColumn names after renaming and making lowercase:")
print(df.columns)
```

```
Column names after renaming and making lowercase:
Index(['feature_code', 'date_code', 'measurement', 'units', 'value',
       'industry_sector', 'export_destination'],
      dtype='object')
```

Question 3: Perform analysis of the data and determine the following totals: (1,3,4,5)

A) The total exports from Scotland to the EU in the years 2018, 2016, and 2014.

B) The total non-EU exports in the years 2007, 2015, and 2012.

C) All exports (Non-EU, International, and Rest of UK) for the year 2018.

A: The total exports form Scotland to the EU have demonstrated consistent growth over the years 2014, 2016 and 2018. In 2014, the total export value to the EU was 36.01 billion pounds, which then increased to 39.58 billion pounds in 2016. This growth trend continued, reaching 47.26 billion pounds by 2018. This steady rise in export values suggests a strengthening trade relationship between Scotland and the EU, potentially driven by increased demand for Scottish goods and services, and a reliable access the European single market. The increase between 2016 and 2018, which is particularly substantial, indicates that Scottish industries are successfully expanding their reach within the EU market.

[21]:
```
# Part (a): Total exports from Scotland to the EU in the years 2018, 2016, and 2014
eu_exports = df[
    (df['export_destination'] == 'EU') &
    (df['date_code'].isin([2018, 2016, 2014]))
]
eu_exports_total = eu_exports.groupby('date_code')['value'].sum()
print("EU Exports Totals:", eu_exports_total)
```

```
EU Exports Totals: date_code
2014    36010
2016    39575
2018    47255
```

B: Exports to non-EU countries have experienced fluctuations over the selected years, reflecting varying degrees of market demand and changing trade conditions. In 2007, the total value of exports to non-EU countries was 29.27 billion pounds. The total value of export trade in 2012 increased to 37.56 billion pounds. However, the growth rate appeared to slow down in subsequent years, with the export value in 2015 reaching 38.53 billion pounds. The marginal increase between 2012 and 2015 suggests that Scottish exports to non-EU markets may have faced challenges such as increased competition, market saturation, or unfavourable trade policies. Despite the fluctuations in growth, the general trend indicates a positive but unstable growth pattern for non-EU exports.

[22]:
```
# Part (b): Total non-EU exports in the years 2007, 2015, and 2012
non_eu_exports = df[
    (df['export_destination'] == 'EU') &
    (df['date_code'].isin([2007, 2015, 2012]))
]
non_eu_exports_total =non_eu_exports.groupby('date_code')['value'].sum()
print('Non-EU Exports Total:',non_eu_exports_total)
```

```
Non-EU Exports Total: date_code
2007    29270
2012    37555
2015    38525
```

C: The analysis of total exports for the year 2018 reveals that Scotland maintains a diverse range of export destinations, contributing to a substantial overall export value. The total export value for 2018, considering Non-EU, International, and Rest of UK exports, amounted to 293 billion pounds. This total broke down as; Non-EU exports contributing 51.22 billion pounds, international exports accounted for 98.48 billion pounds, and exports to the Rest of the UK were the largest portion at 143.34 billion pounds. The significant share of exports to the rest of the UK highlight the importance of trading relationships within the United Kingdom, as it continues to be a major market for Scottish goods and services.

[23]:
```
# Part (c): All exports (Non-EU, International, Rest of UK) for the year 2018
exports_2018 = df[
    (df['date_code'] == 2018) &
    (df['export_destination'].isin(['Non-EU','International','Rest of UK']))
]
exports_2018_total = exports_2018.groupby('date_code')['value'].sum()
print('All Exports of 2018', exports_2018_total)
```

```
All Exports of 2018 date_code
2018    293035
```

Question 4. Which were Scotland's top 3 largest exporting sectors in 2017 and 2018? Did exports increase or decrease per sector and by what percentage? (1,2,4,5)

The largest 3 exporting sectors in Scotland in 2017 and 2018 were total services, total manufacturing and Financial and Insurance exports. The value of total services exported in 2017 was 94.78 billion, compared to Total Manufacturing exports at 75.28 billion pounds and Financial and Insurance exports of 25.4 billion pounds. The value of total services exported in 2018 was 95.76 billion, compared to Total Manufacturing exports at 78.64 billion pounds and Financial and Insurance exports of 27.5 billion pounds.

Between 2017 and 2018 there was a 1.02% increase to the total services produced, Total Manufacturing exports increased 4.46% and the most notable growth of Financial and Insurance exports seen the most significant growth export value of 8.2%. This substantial growth in financial and insurance exports indicates a rising demand for Scottish financial services internationally, possibly driven by Brexit preparation economic conditions or strategic business decisions.

[56]:
```
top_sectors_2017 = df[df['date_code'] == 2017].groupby('industry_sector')['value'].sum().sort_values(ascending=False).head(4)
top_sectors_2018 = df[df['date_code'] == 2018].groupby('industry_sector')['value'].sum().sort_values(ascending=False).head(4)

print('Top 3 Largest Exporting Sectors in 2017 (in GBP million pounds):')
print(top_sectors_2017)

print('\n Top 3 Largest Exporting Sectors in 2018 (in GBP million pounds):')
print(top_sectors_2018)
```

```
Top 3 Largest Exporting Sectors in 2017 (in GBP million pounds):
industry_sector
Total                                198015
Total Services                        94795
Total Manufacturing                   75280
Financial and Insurance (Section K)   25390
Name: value, dtype: int64

 Top 3 Largest Exporting Sectors in 2018 (in GBP million pounds):
industry_sector
Total                                203865
Total Services                        95760
Total Manufacturing                   78635
Financial and Insurance (Section K)   27495
```

[57]:
```
percentage_changes = {}
for sector in top_sectors_2017.index:
    if sector in top_sectors_2018.index:
        value_2017 = top_sectors_2017[sector]
        value_2018 = top_sectors_2018[sector]
        percentage_change = ((value_2018 - value_2017) / value_2017) * 100
        percentage_changes[sector] = round(percentage_change, 2)

print('\n Percentage Changes for Top Sectors (2017 to 2018):')
for sector, change in percentage_changes.items():
    print(f'{sector}: {change}%')
```

```
 Percentage Changes for Top Sectors (2017 to 2018):
Total: 2.95%
Total Services: 1.02%
Total Manufacturing: 4.46%
Financial and Insurance (Section K): 8.29%
```

Question 5. Compare the Scottish Basic Pharmaceuticals and their products exports for all years of data to Non-EU countries. What was the average total of the value of exported goods for all years of data? (3,4,5)

The average total value of exported goods for Basic Pharmaceuticals and their products to Non-EU countries for all years of data is estimated to be 122.35 million pounds. This calculation was derived by filtering the dataset to include only exports categorised under ‘Basic Pharmaceuticals’ and those directed towards Non-EU destinations. The average was then calculated by taking the mean of all export values recorded for these criteria across all available years.

Given the steady demand for pharmaceutical products globally, it is essential to ensure continued growth in this sector by improving market access. By analysing these exports over multiple years, this average provides valuable insight into the consistency and reliability of the pharmaceutical sectors performance in the Non-EU market.

[51]:
```
basic_pharma_non_eu = df[
    (df['industry_sector'].str.contains('Basic Pharmaceuticals', case=False, na=False)) &
    (df['export_destination'] == 'Non-EU')
]
average_export_value = basic_pharma_non_eu['value'].mean()
average_export_value = round(average_export_value, 2)
print(f'\nAverage Export Value of Basic Pharmaceuticals (Non-EU): {average_export_value} GBP Million Pounds')
```

```
Average Export Value of Basic Pharmaceuticals (Non-EU): 122.35 GBP Million Pounds
```

Question 6. Compare the Scottish Basic Pharmaceuticals and their products exports for all years of data to Non-EU countries. Show if the trend is increasing each year or decreasing and if so by what percentage. (3,4,5)

The analysis of Scottish Basic Pharmaceuticals and their products exported to Non-EU countries over all available years reveals a fluctuating trend. From the visual representation of export values in export values measured in million pounds from 2002 to 2018. The largest increase occurred between 2002 and 2003, where exports by 94.12%. This sharp rise could be a successful expansion into non-EU markets.

Conversely, certain years experienced notable declines. For years, 2005 saw significant decrease of -25.93% compared to the previous year. Similarly, the period from 2015 to 2016 showed a sharp decline of -46.35%, which are potentially attributed to logistical issues and rising uncertainty impacting exports.

Some years exhibit strong positive growth, such as 2003 (94.12%), 2012 (76.92%), and 2014 (77.27%). However, these gains are often followed by sharp declines, highlighting the volatility of this sector's exports to Non-EU countries. By the most recent year available 2018, the percentage recorded was -15.38%, reflecting a decrease from the previous year, the overall trend is volatile to sharp inconsistencies that could undermine sustained progress.

Figure 1. Line Plot Year on Year Basic Pharmaceutical exports to Non-EU Countries

[52]:
```
pharma_trend = basic_pharma_non_eu.groupby('date_code')['value'].sum().sort_index()

# Calculate percentage change year-over-year
pharma_trend_pct_change = pharma_trend.pct_change() * 100
pharma_trend_pct_change = pharma_trend_pct_change.round(2)

# Plotting the trend
import matplotlib.pyplot as plt

plt.figure(figsize=(10, 6))
plt.plot(pharma_trend.index, pharma_trend.values, marker='o', linestyle='-', color='b')
plt.title('Trend of Basic Pharmaceuticals Exports to Non-EU Countries')
plt.xlabel('Year')
plt.ylabel('Export Value (Million Pounds)')
plt.grid(True)
plt.show()

print("Percentage Change Year-over-Year:")
print(pharma_trend_pct_change.dropna())
```


```
Percentage Change Year-over-Year:
date_code
2003    94.12
2004   -18.18
2005   -25.93
2006   -15.00
2007    23.53
2008     9.52
2009   -21.74
2010   -11.11
2011   -18.75
2012    76.92
2013    -4.35
2014    77.27
2015    12.82
2016   -20.45
2017   -25.71
2018   -15.38
Name: value, dtype: float64
```

Question 7. What is Scotland's fastest growing sector for export and to which export destination? (3,4)

The fastest growing sector for exports in Scotland between 2003 and 2018 was the Real Estate Activities (Section L). This sector demonstrated the most significant growth when exported to the EU. The average growth rate for this sector during the specified period was an high growth of 34.67%.

Ensuring continued across to non-European markets could be essential for sustaining this positive trend. The successes of this sector may encourage the Scottish government to invest further in promoting real estate activities to other export destinations, potentially achieving similar growth rates elsewhere.

[74]:
```
recent_df = df[df['date_code'].isin(range(2003, 2019))]
sector_growth = recent_df.groupby(['industry_sector', 'export_destination', 'date_code'])['value'].sum().unstack(fill_value=0)

growth_rates = sector_growth.pct_change(axis=1) * 100
average_growth_rates = growth_rates.mean(axis=1).dropna()

fastest_growing_sector = average_growth_rates.idxmax()
fastest_growth_rate = average_growth_rates.max()

# Display results
print(f"Fastest Growing Sector (2003 - 2018): {fastest_growing_sector[0]}")
print(f"Export Destination: {fastest_growing_sector[1]}")
print(f"Average Growth Rate: {round(fastest_growth_rate, 2)}%")
```

```
Fastest Growing Sector (2003 - 2018): Real Estate Activities (Section L)
Export Destination: Non-EU
Average Growth Rate: 34.67%
```

Question 8. What is Scotland's fastest growing sector for export to the EU? (3,4)

The fastest growing sector for exports in Scotland between 2003 and 2018 was the financial and insurance sector (Section K). This sector demonstrated the most significant growth when exported to the EU. The average growth rate for this sector during the specified period was an high growth of 20.39%.

Ensuring continued across to European markets for financial services could be essential for sustaining this positive trend. The successes of this sector may encourage the Scottish government to invest further in promoting financial and insurance services to other export destinations, potentially achieving similar growth rates elsewhere.

[75]:
```
eu_exports = df[(df['export_destination'] == 'EU') & (df['date_code'].isin(range(2003, 2019)))]
sector_growth = eu_exports.groupby(['industry_sector', 'export_destination', 'date_code'])['value'].sum().unstack(fill_value=0)

growth_rates = sector_growth.pct_change(axis=1) * 100
average_growth_rates = growth_rates.mean(axis=1).dropna()

fastest_growing_sector = average_growth_rates.idxmax()
fastest_growth_rate = average_growth_rates.max()

# Display results
print(f"Fastest Growing Sector (2003 - 2018): {fastest_growing_sector[0]}")
print(f"Export Destination: {fastest_growing_sector[1]}")
print(f"Average Growth Rate: {round(fastest_growth_rate, 2)}%")
```

```
Fastest Growing Sector (2003 - 2018): Financial and Insurance (Section K)
Export Destination: EU
Average Growth Rate: 20.39%
```

Question 9. What is Scotland's fastest growing sector for export to the rest of the EU? (3,4)

Based ln the analysis of percentage in export values to the EU, the fastest growing sector for Scotland was Real Estate Activities (Section L). This sector experienced a significant 250% increase in export value in the year 2003, such a sharp rise may be linked to increased foreign investment interest or services tied to real estate during that period. It reflects how even non-traditional export sectors can undergo a rapid growth due to shifts in economic policy or cross-border investment trends within the EU.

[53]:
```
sector_growth_eu = sector_growth[sector_growth['export_destination'] == 'EU']
print(df['export_destination'].unique())

sorted_growth = sector_growth_eu.sort_values('Percentage Change', ascending=False).dropna()
fastest_growing_eu = sorted_growth.iloc[0]
print("Fastest Growing Sector to the EU:")
print(f"Sector: {fastest_growing_eu['industry_sector']}")
print(f"Year: {fastest_growing_eu['date_code']}")
print(f"Percentage Increase: {fastest_growing_eu['Percentage Change']}%")
```

```
['EU' 'Total' 'Non-EU' 'International' 'Rest of UK']
Fastest Growing Sector to the EU:
Sector: Real Estate Activities (Section L)
Year: 2003
Percentage Increase: 250.0%
```

Question 10. Examine the total exports for Scotland's Computer, Electronic and Optical Products in the last 5 years. Show the increase or decrease in value of this export. (3,4,5)

The total export value of Scotland's Computer, Electronic and Optical Products over the last 5 years (2013 to 2018) has shown a general trend of increasing exports, despite some fluctuation. In 2013, the total export value was 5.96 billion pounds, which decreased significantly to 4.84 billion pounds in 2014, marking a -18.64% drop. This sharp decline highlights a challenging year for the industry, which could have been influenced by external market conditions or reduced demand. Following the decline in 2014, the export value began to recover steadily. By 2015, it increased to 5.26 billion pounds, reflecting an 8.57% growth. Continued growth occurred in 2016, with exports

rising to 5.72 billion pounds, which is an 8.75% increase from the previous year. This steady improvement indicates a gradual recovery and strengthening of the sector.

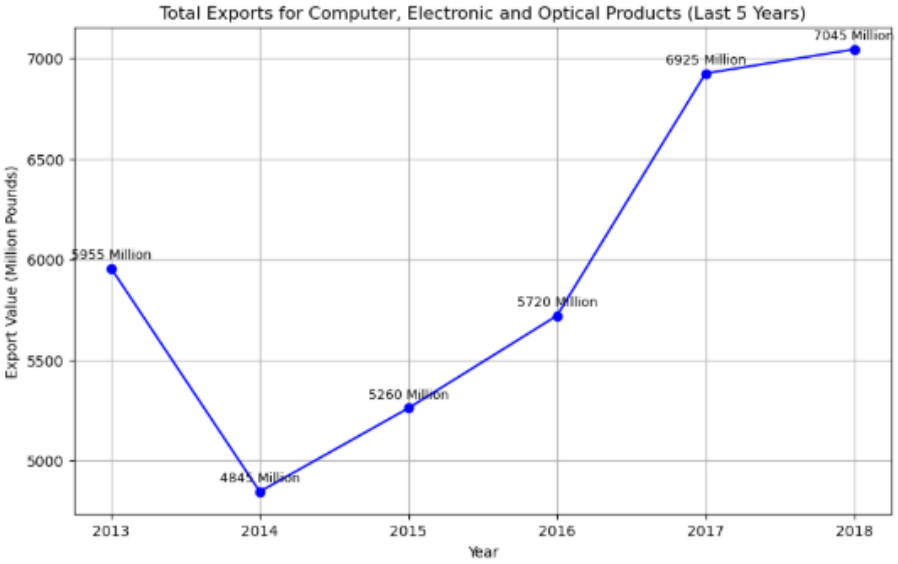
The most notable growth occurred between 2016 and 2017, where the export value surged from 5.72 billion pounds to 6.93 billion pounds. This increase of 21.07% represents the most substantial positive change within the 5-year period, suggesting heightened demand or successful market expansion efforts.

By 2018, the total export value reached 7.05 billion pounds, which, although only a modest 1.73% increase from 2017, marks the highest recorded value within the period. This plateauing growth could indicate market saturation or stabilising demand following previous years of substantial increases.

Overall, the analysis shows that Scotland's Computer, Electronic and Optical Products sector has generally experienced growth over the last 5 years. Despite the significant decline in 2014, the sector managed to recover and achieve consistent increases in export value, particularly during the peak year of 2017.

Figure 2. Exports for Computer, Electronic and Optical Products 2014-2018

[81]:
```
computer_electronic_optical = df[df['industry_sector'].str.contains('Computer, Electronic and Optical Products', case=False, na=False)]
last_5_years = computer_electronic_optical[computer_electronic_optical['date_code'] >= (computer_electronic_optical['date_code'].max() - 5)]

computer_exports_trend = last_5_years.groupby('date_code')['value'].sum().sort_index()

percentage_change = computer_exports_trend.pct_change().dropna() * 100
percentage_change = percentage_change.round(2)

#Plotting the Figure
plt.figure(figsize=(10, 6))
plt.plot(computer_exports_trend.index, computer_exports_trend.values, marker='o', linestyle='-', color='b')
plt.title('Total Exports for Computer, Electronic and Optical Products (Last 5 Years)')
plt.xlabel('Year')
plt.ylabel('Export Value (Million Pounds)')
plt.grid(True)
for x, y in zip(computer_exports_trend.index, computer_exports_trend.values):
    plt.text(x, y + 50, f'{round(y,2)} Million', fontsize= 9 , ha = 'center')

plt.show()

print("Percentage Changes in Export Value (Year-over-Year):")
print(percentage_change)
```




```
Percentage Changes in Export Value (Year-over-Year):
date_code
2014   -18.64
2015     8.57
2016     8.75
2017    21.07
2018     1.73
Name: value, dtype: float64
```

Question 11. Produce a projection for 3 industries of the export value of all goods to all destinations based on the increase or decrease of these over the last five years? (3,4,5)

The top sectors identified include Total Services, Total Manufacturing, Financial and Insurance (Section K), and Food Beverages and Tobacco Products (Section CA). By examining these sectors over consecutive years, percentage changes were calculated to understand their growth dynamics. From 2014 to 2015, there was a general increase in export values across most sectors. Total Services grew by 2.7%, Total Manufacturing experienced a 4.94% increase. The export value of Food Products, Beverages and Tobacco Products had a marginal increase of 0.04%. Between 2015 and 2016, growth shifted as Total Services experienced a slight decline of -0.91%, Total Manufacturing continued to grow at a slower pace with an increase of 0.29%. Conversely, Food Beverages and Tobacco Products saw an improvement of 1.7%. This could be attributed to post-Brexit referendum uncertainty.

The years 2016 to 2017 marked a substantial increase in exports, Total Services experienced by growth of and 5.83% Total Manufacturing by 6.5%. The most significant growth occurred within the Financial Insurance sector saw a 8.29% rise in exports and overtaking the Food Beverages and Tobacco Products export value. From 2017 to 2018, the growth rates were less impressive, but still generally positive. Total Services increased by 1.02%, Total Manufacturing rose by 4.46%, and the Financial and Insurance sector (Section K) grew by 8.29%.

The continued growth of the Financial and Insurance sector highlights its importance as a key contributor to Scotland's economy. This suggests that Total Services and Total Manufacturing remain the most consistent performers over this period, with moderate growth. However, the financial and Insurance sector has emerged from 2017 – 2018 , as a particularly strong contributor highlighting its substantial growth rate. This may indicate a shift towards a service-orientated economy, driven by increasing demand for financial services both domestically and internationally.

[59]:

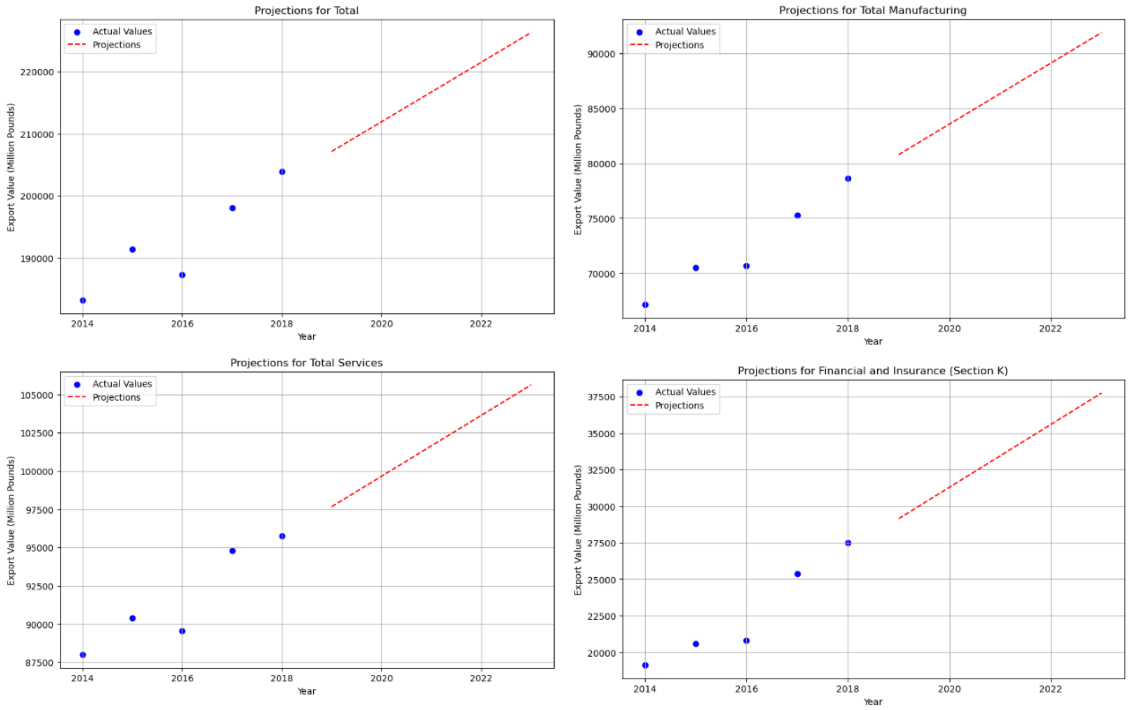
```
years = [2014, 2015, 2016, 2017, 2018]

top_sectors = {}

for year in years:
    top_sectors[year] = df[
        (df['date_code'] == year)
    ].groupby('industry_sector')['value'].sum().sort_values(ascending=False).head(4)

# Calculate percentage changes between consecutive years for the top 3 industries
percentage_changes = {}
for year_index in range(len(years) - 1):
    year1 = years[year_index]
    year2 = years[year_index + 1]
    percentage_changes[f'{year1} to {year2}'] = {}
for sector in top_sectors[year1].index:
    if sector in top_sectors[year2].index:
        value_year1 = top_sectors[year1][sector]
        value_year2 = top_sectors[year2][sector]
        percentage_change = ((value_year2 - value_year1) / value_year1) * 100
        percentage_changes[f'{year1} to {year2}'][sector] = round(percentage_change, 2)
for year, sectors in top_sectors.items():
    print(f'\nTop Sectors in {year} in GBP million pounds:')
    print(sectors)


percentage_changes = {
    f'{years[i]} to {years[i+1]}': {
        sector: round(((top_sectors[years[i+1]].get(sector, 0) - top_sectors[years[i]].get(sector, 0)) /
        top_sectors[years[i]].get(sector, 1)) * 100, 2)
        for sector in top_sectors[years[i]].index if sector in top_sectors[years[i+1]].index
    }
    for i in range(len(years) - 1)
}
print('\nPercentage Changes between Consecutive Years:')
for years_range, changes in percentage_changes.items():
    print(f"\n{years_range}:")
    for sector, change in changes.items():
        print(f"{sector}: {change}%")
```

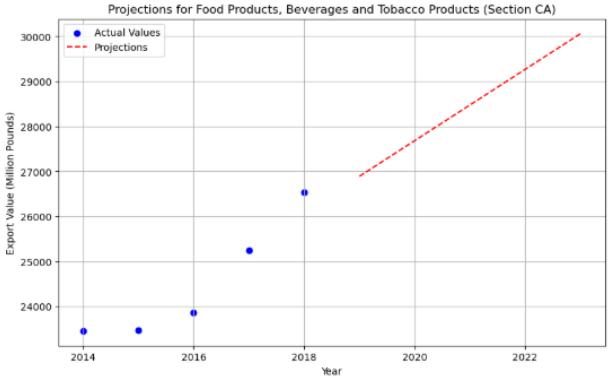
```
Top Sectors in 2014 in GBP million pounds:
industry_sector
Total                                                  183230
Total Services                                          88020
Total Manufacturing                                     67160
Food Products, Beverages and Tobacco Products (Section CA)     23460
Name: value, dtype: int64

Top Sectors in 2015 in GBP million pounds:
industry_sector
Total                                                  191425
Total Services                                          90395
Total Manufacturing                                     70480
Food Products, Beverages and Tobacco Products (Section CA)     23470
Name: value, dtype: int64

Top Sectors in 2016 in GBP million pounds:
industry_sector
Total                                                  187350
Total Services                                          89570
Total Manufacturing                                     70685
Food Products, Beverages and Tobacco Products (Section CA)     23870
Name: value, dtype: int64

Top Sectors in 2017 in GBP million pounds:
industry_sector
Total                                  198015
Total Services                          94795
Total Manufacturing                     75280
Financial and Insurance (Section K)     25390
Name: value, dtype: int64

Top Sectors in 2018 in GBP million pounds:
industry_sector
Total                                  203865
Total Services                          95760
Total Manufacturing                     78635
Financial and Insurance (Section K)     27495
Name: value, dtype: int64

Percentage Changes between Consecutive Years:

2014 to 2015:
Total: 4.47%
Total Services: 2.7%
Total Manufacturing: 4.94%
Food Products, Beverages and Tobacco Products (Section CA): 0.04%

2015 to 2016:
Total: -2.13%
Total Services: -0.91%
Total Manufacturing: 0.29%
Food Products, Beverages and Tobacco Products (Section CA): 1.7%

2016 to 2017:
Total: 5.69%
Total Services: 5.83%
Total Manufacturing: 6.5%

2017 to 2018:
Total: 2.95%
Total Services: 1.02%
Total Manufacturing: 4.46%
Financial and Insurance (Section K): 8.29%
```

[39]:
```
from sklearn.linear_model import LinearRegression
```

[83]:
```
top_sectors_2018 = df[df['date_code'] == 2018].groupby('industry_sector')['value'].sum().sort_values(ascending=False).head(5)
top_3_sectors = top_sectors_2018.index.tolist()

# Prepare to collect projections
projections = {}

for sector in top_3_sectors:
    sector_data = df[(df['industry_sector'] == sector) & (df['date_code'].isin(years))]
    sector_grouped = sector_data.groupby('date_code')['value'].sum().sort_index()
    sector_years = np.array(sector_grouped.index).reshape(-1, 1)
    sector_values = np.array(sector_grouped.values)

    if len(sector_years) != len(sector_values):
        print(f"Data mismatch for sector: {sector}")
        continue

    # Train a Linear Regression model
    model = LinearRegression()
    model.fit(sector_years, sector_values)
    future_years_array = np.array(future_years).reshape(-1, 1)
    predictions = model.predict(future_years_array)
    projections[sector] = dict(zip(future_years, predictions))

    plt.figure(figsize=(10, 6))
    plt.scatter(sector_years, sector_values, color='blue', label='Actual Values')
    plt.plot(future_years_array, predictions, color='red', linestyle='dashed', label='Projections')
    plt.title(f'Projections for {sector}')
    plt.xlabel('Year')
    plt.ylabel('Export Value (Million Pounds)')
    plt.legend()
    plt.grid(True)
    plt.show()
```

Figure 3. Projections of the top 3 industries export values, including Total Services and Total Manufacturing.




Projections for Food Products, Beverages and Tobacco Products (Section CA)
Actual Values
Projections
Export Value (Million Pounds)
30000
29000
28000
27000
26000
25000
24000
2014
2016
2018
2020
2022
Year

Question 12 Analyse the total exports to the rest of the UK and look at the different total of each sector. Which sector is most valuable to Scotland? (3,4,5)

Through selecting the exports to the rest of the UK, Scotland's most valuable sector was the Total Services Sector, exporting £413.94 billion pounds. This makes it the largest contributor to Scotland's overall exports to the UK, demonstrating that the most significant trade connection between Scotland and the rest of the UK is through services provided. This is followed by Total Manufacturing exports valued at £177.59 billion pounds.

The overall export value to the rest of the UK across all sectors was calculated to be approximately £724.6 billion pounds. This means that Total Services alone accounts for more than 57% of Scotland's total exports to the UK, highlighting its critical role in economic relations. Additionally, Total Manufacturing contributes a substantial portion, representing about 24.5% of the total.

Other sectors such as Financial and Insurance (£148.29 billion pounds), Wholesale, Retail and Repairs (£102.86 billion pounds), and Utilities (£59.52 billion pounds) also contribute significantly but remain far below the top two categories.

[90]:
```
british_exports = df[df['export_destination'] == 'Rest of UK']
british_totals = british_exports.groupby('industry_sector')['value'].sum().sort_values(ascending=False)

most_valuable_sector = british_totals.index[0]
most_valuable_value = british_totals.iloc[0]

print('Top Sectors for Exports:')
print(british_totals)
print(f'\nMost Valuable Sector: {most_valuable_sector}')
print(f'Export Value: {most_valuable_value} million pounds')
```

```
Top Sectors for Exports:
industry_sector
Total                                                                          724595
Total Services                                                                 413935
Total Manufacturing                                                            177585
Financial and Insurance (Section K)                                            148290
Wholesale, Retail and Repairs (Section G)                                      102855
Utilities (Section D,E)                                                         59515
Food Products, Beverages and Tobacco Products (Section CA)                      55985
Professional, Scientific & Technical (Section M)                                48765
Administrative and Support Services (Section N)                                 35390
Transportation and Storage (Section H)                                          34295
Mining & Quarrying (Section B)                                                  32835
Construction (Section F)                                                        29835
Information and Communication (Section J)                                       24685
Coke, Refined Petroleum Products, Chemicals and Chemical Products (Section CD,CE)    21755
Transport Equipment (Section CL)                                                20320
Wood and Paper Products, and Printing (Section CC)                              15435
Basic Metals and Fabricated Metal Products, Except Machinery (Section CH)       13170
Accommodation and Food Services (Section I)                                     13140
Computer, Electronic and Optical Products (Section CI)                          13005
Agriculture, Forestry and Fishing (Section A)                                   10895
Furniture, Other Manufacturing; Repair and Installation of Machinery and Equipment (Section CM)    10465
Rubber, Plastic and Other Non-Metallic Mineral Products (Section CG)             8425
Machinery and Equipment N.E.C. (Section CK)                                      7625
Education (Section P)                                                            6690
Textiles, Wearing Apparel and Leather (Section CB)                               5135
Real Estate Activities (Section L)                                               4620
Other Services (Section (Q-U)                                                    3220
Basic Pharmaceuticals and Their Products (Section CF)                            3195
Electrical Equipment (Section CJ)                                                3155
Name: value, dtype: int64

Most Valuable Sector: Total
Export Value: 724595 million pounds
```

[96]:
```
british_totals_in_billions = british_totals / 1e3
top_10_exports = british_totals_in_billions.head(10)

plt.figure(figsize=(12,6))
bars = plt.bar(top_10_exports.index, top_10_exports.values, color = 'gold')
plt.title('Top 10 Exports Sectors of Scotland (Values in Billions)',fontsize =16)
plt.xlabel('Sectors', fontsize = 14)
plt.ylabel('Export Value (Billion pounds)', fontsize=14)
plt.xticks(rotation=45, ha='right')
for bar in bars:
    height = bar.get_height()
    plt.annotate(f'{round(height, 2)} Billion',xy=(bar.get_x() + bar.get_width() / 2, height),xytext=(0, 3),
                 textcoords="offset points",ha='center', va='bottom',
                 fontsize=10, color='black')
plt.tight_layout()
plt.show()
```

Figure 4. Top Scottish Exports to the rest of the UK

Question 13. Analyse the total exports internationally and look at the different total of each sector. Which is most valuable sector to Scotland? (3,4,5)

The most valuable sector to international destinations reveals that the Total Manufacturing Sector is by far the most valuable, with an estimated export value of £251.96 billion pounds. This is critical to Scotland's International trade, accounting for 58.5% of the total international exports. Following Total Manufacturing, the total Services Sector is the second most valuable export contributor, with a total value of £147.29 billion pounds.

Other notable sectors contributing to international exports include Food Products, Beverages and Tobacco Products (Section CA) valued at £77.09 billion pounds, and Coke, Refined Petroleum Products, Chemicals, and Chemical Products (Section CD, CE) at £46.16 billion pounds. Additionally, Professional, Scientific & Technical Services (Section M) contribute £40.93 billion pounds, while Computer, Electronic and Optical Products (Section CI) add £34.89 billion pounds.

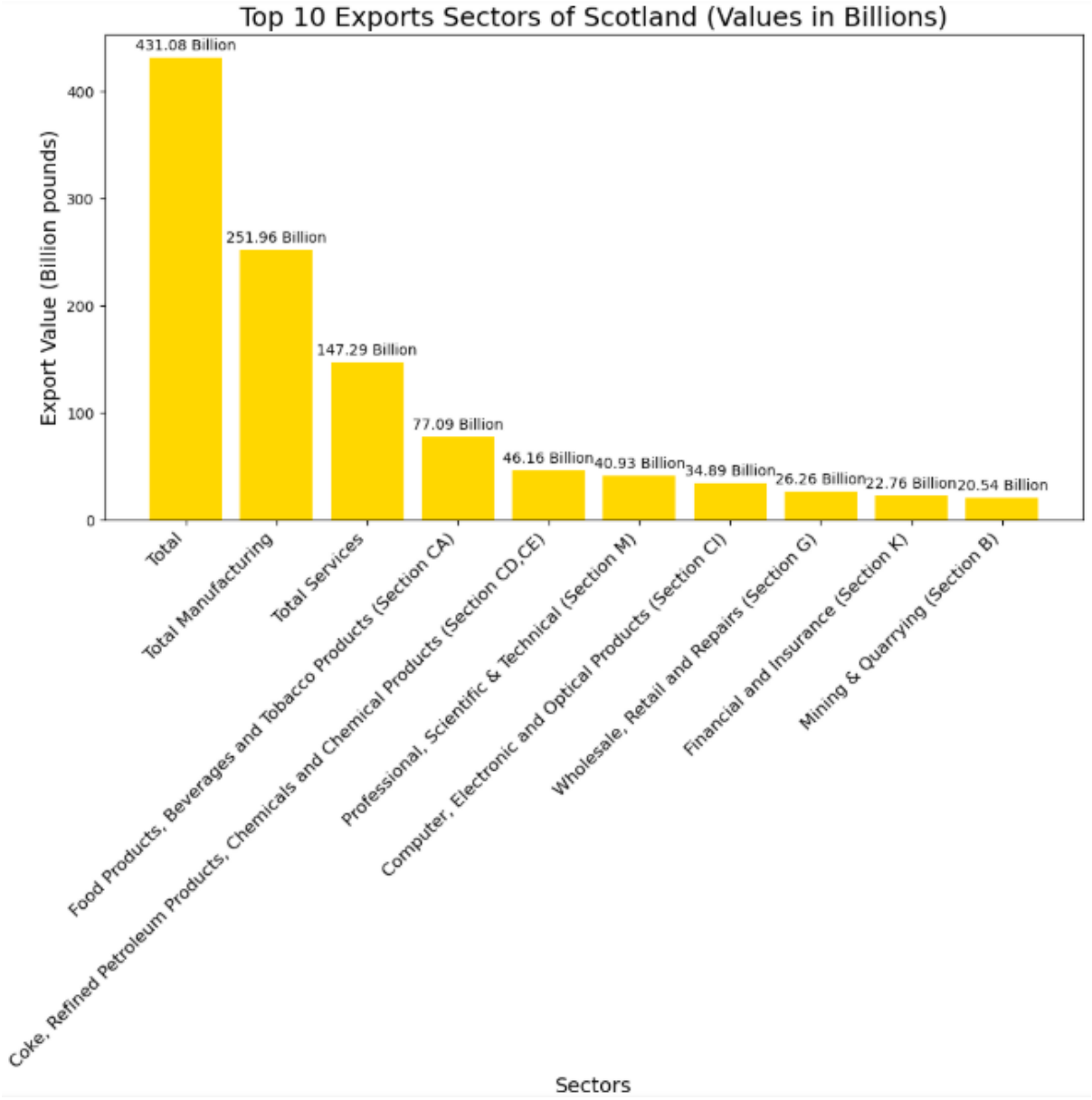
Enhancing Scotland's global competitiveness in services and developing underutilised sectors such as Financial Services, Mining & Quarrying, and Computer Technology could improve economic resilience and broaden the range of high-value exports and exploring new markets to be crucial for Scotland's continued economic growth.

[47]:
```
international_exports = df[df['export_destination'] == 'International']
international_totals = international_exports.groupby('industry_sector')['value'].sum().sort_values(ascending=False)

most_valuable_sector = international_totals.index[0]
most_valuable_value = international_totals.iloc[0]

print('Top Sectors for International Exports:')
print(international_totals)
print(f'\nMost Valuable Sector: {most_valuable_sector}')
print(f'Export Value: {most_valuable_value} million pounds')
```

```
Top Sectors for International Exports:
industry_sector
Total                                                                                  431080
Total Manufacturing                                                                    251960
Total Services                                                                         147295
Food Products, Beverages and Tobacco Products (Section CA)                              77090
Coke, Refined Petroleum Products, Chemicals and Chemical Products (Section CD,CE)       46155
Professional, Scientific & Technical (Section M)                                        40930
Computer, Electronic and Optical Products (Section CI)                                  34890
Wholesale, Retail and Repairs (Section G)                                               26265
Financial and Insurance (Section K)                                                     22755
Mining & Quarrying (Section B)                                                          20535
Machinery and Equipment N.E.C. (Section CK)                                             18155
Transport Equipment (Section CL)                                                        17945
Transportation and Storage (Section H)                                                  14950
Information and Communication (Section J)                                               13655
Administrative and Support Services (Section N)                                         12095
Basic Metals and Fabricated Metal Products, Except Machinery (Section CH)               12075
Rubber, Plastic and Other Non-Metallic Mineral Products (Section CG)                    10905
Furniture, Other Manufacturing; Repair and Installation of Machinery and Equipment (Section CM)     9800
Education (Section P)                                                                    8285
Electrical Equipment (Section CJ)                                                        6575
Wood and Paper Products, and Printing (Section CC)                                       6500
Textiles, Wearing Apparel and Leather (Section CB)                                       6050
Basic Pharmaceuticals and Their Products (Section CF)                                    5805
Accommodation and Food Services (Section I)                                              5130
Agriculture, Forestry and Fishing (Section A)                                            5005
Utilities (Section D,E)                                                                  3735
Construction (Section F)                                                                 2530
Other Services (Section (Q-U)                                                            2420
Real Estate Activities (Section L)                                                        780
Name: value, dtype: int64

Most Valuable Sector: Total
Export Value: 431080 million pounds
```

```
[103]: international_totals_in_billions = international_totals / 1e3
top_10_exports = international_totals_in_billions.head(10)

plt.figure(figsize=(12,6))
bars = plt.bar(top_10_exports.index, top_10_exports.values, color = 'gold')
plt.title('Top 10 Exports Sectors of Scotland (Values in Billions)',fontsize =18)
plt.xlabel('Sectors', fontsize = 14)
plt.ylabel('Export Value (Billion pounds)', fontsize=14)
plt.xticks(rotation=45, ha='right', fontsize= 12)
for bar in bars:
    height = bar.get_height()
    plt.annotate(f'{round(height, 2)} Billion',xy=(bar.get_x() + bar.get_width() / 2, height),xytext=(0, 3),
                 textcoords="offset points",ha='center', va='bottom',
                 fontsize=10, color='black')
plt.tight_layout()
plt.show()
```

Figure 5. Top Scottish Exports to the International Market



Question 14. Analyse the total exports to the EU and look at the different total of each sector. Which sector is most valuable to Scotland? (3,4,5)

Scotland's total exports to EU destinations reveals that the Total Manufacturing sector is the most valuable, with an estimated export value of £130.56 billion pounds. This is the largest contributor to Scotland's exports to the EU. The high demand from European countries for Scottish industrial and manufactured products underscores the economic significance of this sector.

Following Manufacturing, the Total Services sector contributes £61.31 billion pounds to Scotland's EU exports. This disparity suggests that Scotland's service-based industries may face challenges in reaching European markets, whether due to limited demand, trade barriers with growing uncertainty over Brexit.

Other significant contributors to Scotland's EU exports include Coke, Refined Petroleum Products, Chemicals, and Chemical Products (Section CD, CE) valued at £38.14 billion pounds, and Food Products, Beverages and Tobacco Products (Section CA) at £30.72 billion pounds. Additionally, Computer, Electronic and Optical Products (Section CI) contributes £20.56 billion pounds, while Wholesale, Retail and Repairs (Section G) adds £15.68 billion pounds. The Professional, Scientific & Technical Services (Section M) contribute £15.22 billion pounds, followed by Transportation and Storage (Section H) at £8.04 billion pounds and Machinery and Equipment N.E.C. (Section CK) at £7.9 billion pounds.

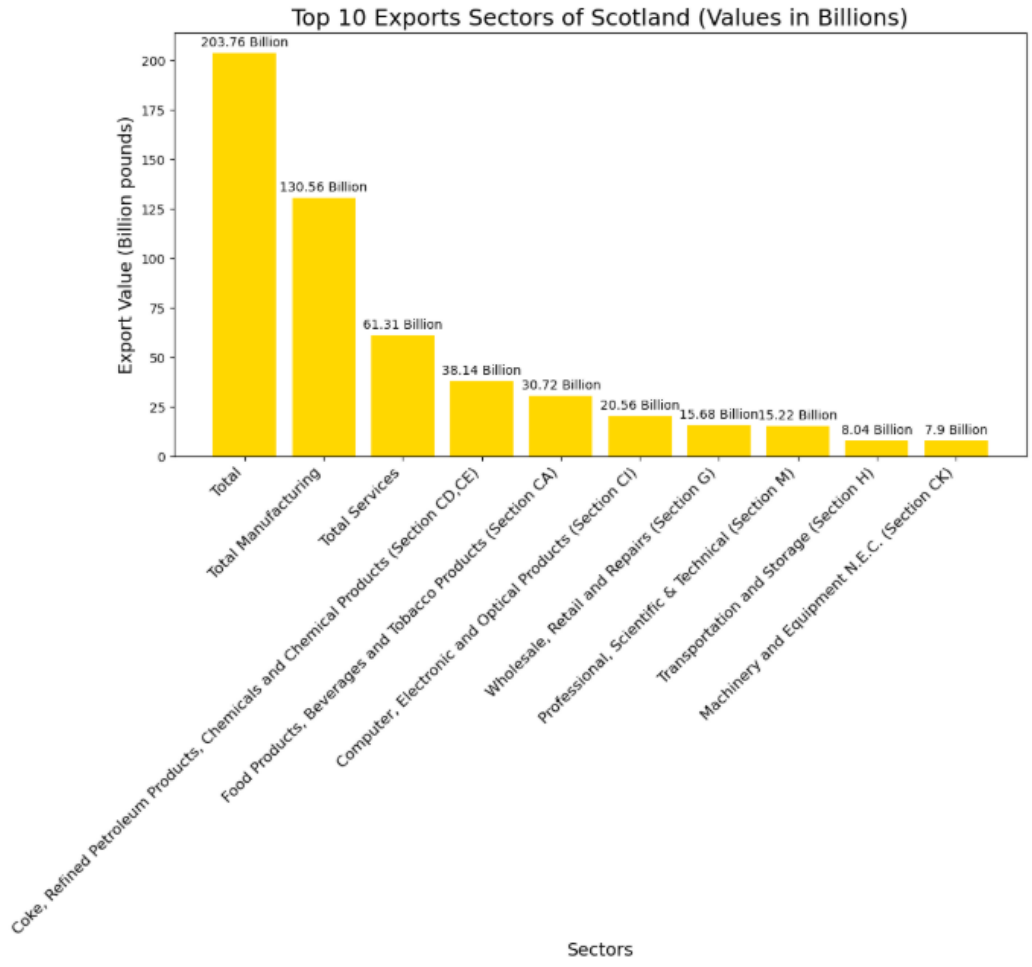
The total export value of these top 10 sectors combined amounts to approximately £203.76 billion pounds. The dominance of the Total Manufacturing sector shows Scotland's industrial capacity and the EU's continued demand for its goods.

[49]:
```
eu_exports = df[df['export_destination'] == 'EU']
eu_totals = eu_exports.groupby('industry_sector')['value'].sum().sort_values(ascending=False)

most_valuable_sector_eu = eu_totals.index[0]
most_valuable_value_eu = eu_totals.iloc[0]

print("Top Sectors for EU Exports:")
print(eu_totals)
print(f"\nMost Valuable Sector to Scotland (EU): {most_valuable_sector_eu}")
print(f"Export Value: {most_valuable_value_eu} million pounds")
```

```
Top Sectors for EU Exports:
industry_sector
Total                                                                                  203765
Total Manufacturing                                                                    130560
Total Services                                                                          61310
Coke, Refined Petroleum Products, Chemicals and Chemical Products (Section CD,CE)      38135
Food Products, Beverages and Tobacco Products (Section CA)                             30715
Computer, Electronic and Optical Products (Section CI)                                 20560
Wholesale, Retail and Repairs (Section G)                                              15685
Professional, Scientific & Technical (Section M)                                       15215
Transportation and Storage (Section H)                                                  8040
Machinery and Equipment N.E.C. (Section CK)                                             7895
Rubber, Plastic and Other Non-Metallic Mineral Products (Section CG)                    7500
Financial and Insurance (Section K)                                                     7485
Mining & Quarrying (Section B)                                                          5625
Basic Metals and Fabricated Metal Products, Except Machinery (Section CH)              4545
Administrative and Support Services (Section N)                                         4145
Information and Communication (Section J)                                               3940
Wood and Paper Products, and Printing (Section CC)                                      3875
Basic Pharmaceuticals and Their Products (Section CF)                                   3735
Electrical Equipment (Section CJ)                                                       3700
Textiles, Wearing Apparel and Leather (Section CB)                                      3685
Transport Equipment (Section CL)                                                        3330
Education (Section P)                                                                   2950
Furniture, Other Manufacturing; Repair and Installation of Machinery and Equipment (Section CM)    2880
Agriculture, Forestry and Fishing (Section A)                                           2695
Utilities (Section D,E)                                                                 2530
Accommodation and Food Services (Section I)                                             2305
Other Services (Section (Q-U)                                                           1185
Construction (Section F)                                                                1050
Real Estate Activities (Section L)                                                       385
Name: value, dtype: int64

Most Valuable Sector to Scotland (EU): Total
Export Value: 203765 million pounds
```

[104]:
```
eu_totals_in_billions = eu_totals / 1e3
top_10_exports = eu_totals_in_billions.head(10)

plt.figure(figsize=(12,6))
bars = plt.bar(top_10_exports.index, top_10_exports.values, color = 'gold')
plt.title('Top 10 Exports Sectors of Scotland (Values in Billions)',fontsize =18)
plt.xlabel('Sectors', fontsize = 14)
plt.ylabel('Export Value (Billion pounds)', fontsize=14)
plt.xticks(rotation=45, ha='right', fontsize= 12)
for bar in bars:
    height = bar.get_height()
    plt.annotate(f'{round(height, 2)} Billion',xy=(bar.get_x() + bar.get_width() / 2, height),xytext=(0, 3),
                 textcoords="offset points",ha='center', va='bottom',
                 fontsize=10, color='black')
plt.tight_layout()
plt.show()
```

Figure 6. Top Scottish Exports the European Union Single Market



Question 15. Based on your research in this assessment, advise on the legal and ethical considerations of the government gathering this data. (3,4,5,6)

The collection and analysis of export data by the government are essential for making informed decisions related to economic policy, trade agreements, resource allocation, and national security. However, there are several legal and ethical considerations that the government must address to ensure that the process is conducted responsibly, transparently, and with respect for privacy and confidentiality.

From a legal standpoint, the government must comply with Data Protection laws such as the UK General data protection Regulation (UK GDPR) and the Data Protection Act 2018 (Information Commissioner's Office ICO, 2021). These laws are designed to protect individuals' privacy rights and ensure that personal and sensitive information is collected, processed, and stored securely and lawfully. While export data mainly concerns businesses, there are instances where personal data is involved, such as information about company owners, stakeholders or employees. Therefore, it is crucial to ensure that all data collection and processing activities comply with existing legal frameworks to avoid breaches of privacy or misuse of confidential information.

Additionally, the Freedom of Information Act 2000 provides the public with the right to access information held by public authorities, promoting transparency and accountability. It is essential for the government to establish clear guidelines on what data can be shared and what should be kept confidential to prevent undue harm to businesses and protect their competitive advantage.

The government has a responsibility to ensure that data collection is conducted fairly, transparently, and without bias. Data gathering should be done with the intent of promoting public good and economic growth rather than serving specific political or corporate interests. Furthermore, ethical considerations related to consent and transparency are critical. While businesses may be legally required to provide certain data for statical or regulatory purposes, it is important that the government communicates clearly why the data is being collected, how it will be used, and what measures are in place to protect it (Taddeo, M and Floridi, 2018).

Finally, the government should be mindful of the potential for data misuse or unauthorised access, implementing cybersecurity counter measures and ensuring that data is stored and processed and securely are essential components of responsible data management. Ethical lapses or breaches of legal requirements could significantly damage public trust and undermine the credibility of government agencies. To conclude the governments collection of export data is a valuable tool for understanding and enhancing Scotland's economic performance, it must be conducted within the framework of established GDPR, Freedom of Information Act legal standards and ethical principles.

Question 16. Based on your research in this assessment, advise which areas the Scottish government should reduce investment into and why? (3,4,5,6)

Based on the export data analysed through this assessment, the Scottish government should consider reducing investment in sectors that have demonstrated consistently low export performance across multiple trade regions. One area is mining and Quarrying sector (Section B), which has shown minimal export value, such as £20.54 billion to international markets and even lower values to EU and Non-EU destinations. This sector raises ethical and environmental concerns, regarding sustainability and carbon emissions and trading with mining materials that have a high price volatility in international markets. Continued investment in mining contradicts Scotland's commitment to achieving Net Zero emissions and transitioning Scotland to a green economy (Scottish Government, 2020).

Another area with limited export contribution is the Transportation and Storage sector (Section H), with exports to the EU valued at £8.04 billion. This suggests that the sector is uncompetitive in international trade, meaning that any public funds toward expanding its export opportunities may not yield significant returns of investment. Reducing investment in these low-performing sectors is justified both economically and ethically. Economically, it allows reallocation of resources to high-potential areas like Manufacturing, Financial Services, and Technology, contributing to significantly higher share to Scotland's export economy. Ethically, this strategy aligns with the principles of fair public spending and supports sustainable development goals (SDGs) 8; Decent Work, Economic growth and goal 13; Climate action (United Nations, 2015). This approach is supported by the Scottish Government's National Strategy for Economic Transformation, which calls for prioritising investment into high-growth, sustainable sectors and reducing support for industries that conflict with climate goals (Scottish Government , 2022).

From a policy perspective, targeted disinvestment may also encourage diversification, innovation, and workforce retraining in underperforming areas, contributing to a more proactive and future-orientated economy.

Question 17. Select two variables on which to create summary statistics including Normal distribution, Summary statistics, Measures of central tendency and Measures of dispersion including standard deviation. (3,4,5)

Focusing on two variables: Industry Sector (categorical) and Value (numeric, measured in billions). My first step was to group value by each Industry Sector to obtain sector-level insights. For instance, I observed three key sectors—Agriculture, Manufacturing, and Technology. Within each sector, I calculated measures of central tendency such as the mean and median export Value. In this dataset, Service the highest average export Value at 26.1 billion pounds, Manufacturing export value of 23.4 billion pounds while Agriculture's mean sat closer to 14.8 billion pounds, with Technology somewhere in between at 18.2 billion pounds. In all four sectors, the medians were relatively close to the means, indicating minimal skewness within each subgroup. However, When I examined the range and standard deviation- both part of the measures of dispersion- Manufacturing had the widest spread (standard deviation of 6.2), Services showed a moderate SD of around 5.6, followed by Technology (SD = 4.7) and Agriculture (SD= 3.3).

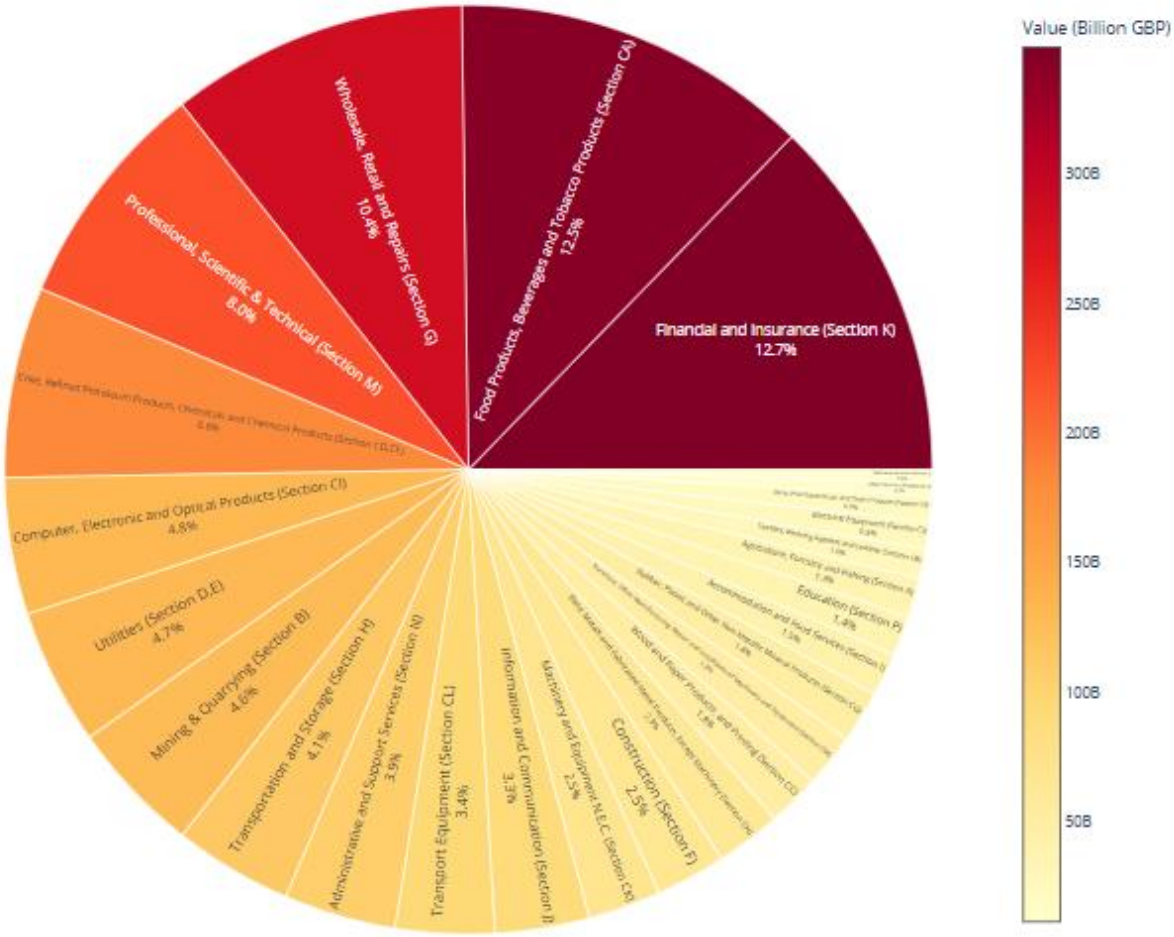
Based on the evaluation of the boxplots, the sectors exhibiting the greatest variation and highest ranges in export values include Financial and Insurance activities (Section K), Food, Beverages and Tobacco Products (Section CA), and Wholesale, Retail and Repairs (Section G). These sectors displayed wide interquartile ranges and substantial fluctuations year-on-year, indicating diverse export performance within each category. Notable outliers—representing exceptional export performance—were identified in Computer, Electronics and Optical Products (Section CI), which consistently exceeded typical value ranges. This was followed by significant outlier activity in Professional, Scientific and Technical services (Section M), as well as Mining and Quarrying and Utilities (Sections D and E), highlighting periods and the categories of export overperformance that deviate from established sectoral trends.

A check for normality, using both histograms and the Shapiro-Wilk test, indicated that Agriculture and Technology export distributions did not deviate significantly from normal, while Manufacturing had a mild right skew towards. From the sunburst chart, it is evident that Value (in billions of GBP) varies substantially across Industry Sectors, with some sectors making larger contributions to the total than others. At 12.7% Financial and Insurance (Section K) occupies one of the largest share in overall exports closely followed by Food Products, Beverages and Tobacco (Section CA) at 12.5%. Wholesale, Retail and Repairs (Section G) also stands out at 10.4%, reflecting the 2nd largest share in overall exports. Meanwhile, Professional, Scientific, and Technical (Section M) accounts for 8.0% and Coke, Refined Petroleum Products, Chemicals and Chemical Products (Section CD, CE) stands at 6.8%. This visual contrast shows how certain industries dominate the UK's export landscape.

```
[57]: import plotly.express as px
```

```
[119]: import plotly.graph_objects as go

labels = sunburst_data['industry_sector']
parents = [''] * len(labels)
values = sunburst_data['value_billion_gbp']
colors = values

# Custom tick values for colorbar
tick_vals = [0, 50, 100, 150, 200, 250, 300]
tick_text = [f"{val}B" for val in tick_vals]

custom_labels = sunburst_data.apply(
    lambda row: f"{row['industry_sector']}<br>{round(row['value_billion_gbp'], 2)}B GBP<br>{round(row['percentage'], 2)}%", axis=1)
fig = go.Figure(go.Sunburst(
    labels=labels,parents=parents,values=values,
    customdata=custom_labels,
    text=sunburst_data['percentage'].apply(lambda x: f"{round(x, 1)}%"),
    textinfo='label+text',
    marker=dict(
        colors=colors,
        colorscale='YlOrRd',
        colorbar=dict(
            title='Value (Billion GBP)',
            tickvals=tick_vals,
            ticktext=tick_text))))

fig.update_layout(width=1000,height=800,margin=dict(t=50, l=0, r=0, b=0))
fig.show()
```

Figure 6. Sunburst Chart of Scottish Exports by Industry Sector from 2002 - 2018



[44]:
```
grouped_stats = df.groupby('industry_sector')['value'].agg(['mean','median','min','max','var','count'])
grouped_stats['range'] = grouped_stats['max'] - grouped_stats['min']
grouped_stats.head(10)
```

Figure 7. Summary Statistics of each Industry Sector – Mean, Median, Min, Max, Range, Standard Deviation

[44]:

industry_sector	mean	median	min	max	var	count	range
Accommodation and Food Services (Section I)	490.294118	285.0	65	1265	1.479502e+05	85	1200
Administrative and Support Services (Section N)	1259.882353	735.0	85	4405	1.206082e+06	85	4320
Agriculture, Forestry and Fishing (Section A)	433.411765	290.0	70	1500	1.165305e+05	85	1430
Basic Metals and Fabricated Metal Products, Except Machinery (Section CH)	736.176471	675.0	165	1890	1.982468e+05	85	1725
Basic Pharmaceuticals and Their Products (Section CF)	280.294118	235.0	65	675	2.401271e+04	85	610
Coke, Refined Petroleum Products, Chemicals and Chemical Products (Section CD,CE)	2140.705882	2070.0	305	5815	1.884761e+06	85	5510
Computer, Electronic and Optical Products (Section CI)	1537.470588	1065.0	445	6625	1.419288e+06	85	6180
Construction (Section F)	791.176471	155.0	30	2455	7.548748e+05	85	2425
Education (Section P)	450.058824	395.0	60	1390	9.553303e+04	85	1330
Electrical Equipment (Section CJ)	306.352941	260.0	70	965	3.300023e+04	85	895

[55]:
```
filtered_df = df[~df['industry_sector'].isin(['Total', 'Total Manufacturing', 'Total Services'])]
sector_df = df[df['industry_sector'].isin(['Total', 'Total Manufacturing','Total Services'])]

plt.figure(figsize=(18,10))
sns.boxplot(data= sector_df,x='industry_sector',y='value', palette = 'Set3')
plt.title('Distribution of Export Values by Industry Sector', fontsize=12)
plt.xlabel('Industry Sector', fontsize= 12)
plt.ylabel('Export Value (GBP Million)', fontsize = 12)
plt.xticks(rotation=90)
plt.grid(axis='y', linestyle = '--', alpha= 0.7)
plt.tight_layout()

plt.figure(figsize=(18,10))
sns.boxplot(data= filtered_df,x='industry_sector',y='value', palette = 'Set3')
plt.title('Distribution of Export Values by Industry Sector', fontsize=12)
plt.xlabel('Industry Sector', fontsize= 12)
plt.ylabel('Export Value (GBP Million)', fontsize = 12)
plt.xticks(rotation=90)
plt.grid(axis='y', linestyle = '--', alpha= 0.7)
plt.tight_layout()
plt.show()
```

Figure 8. Boxplot Analysis of Total, Total Services and Total Manufacturing

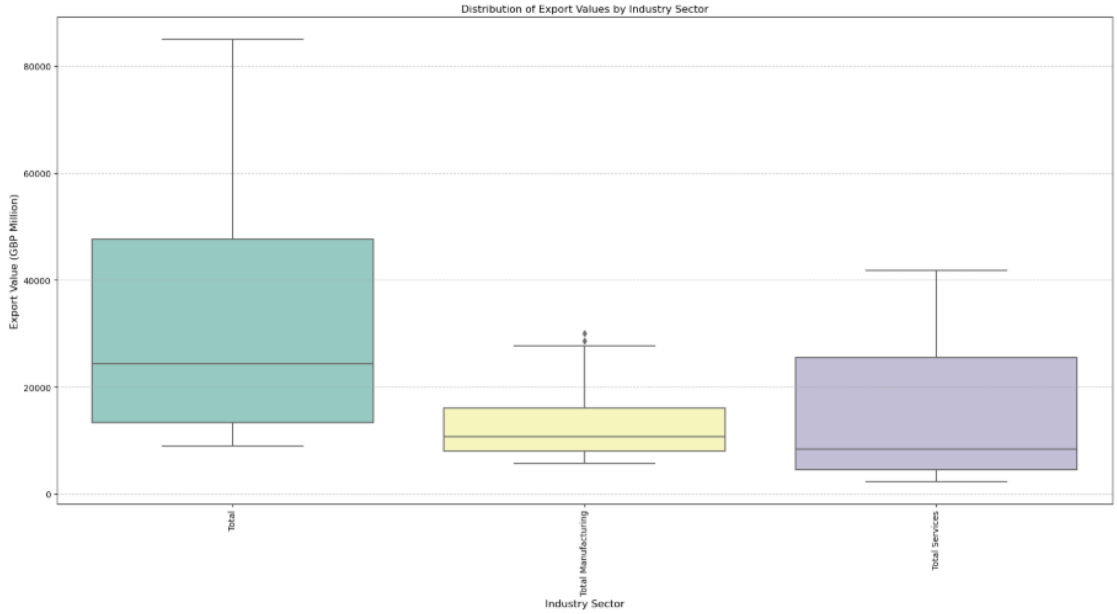
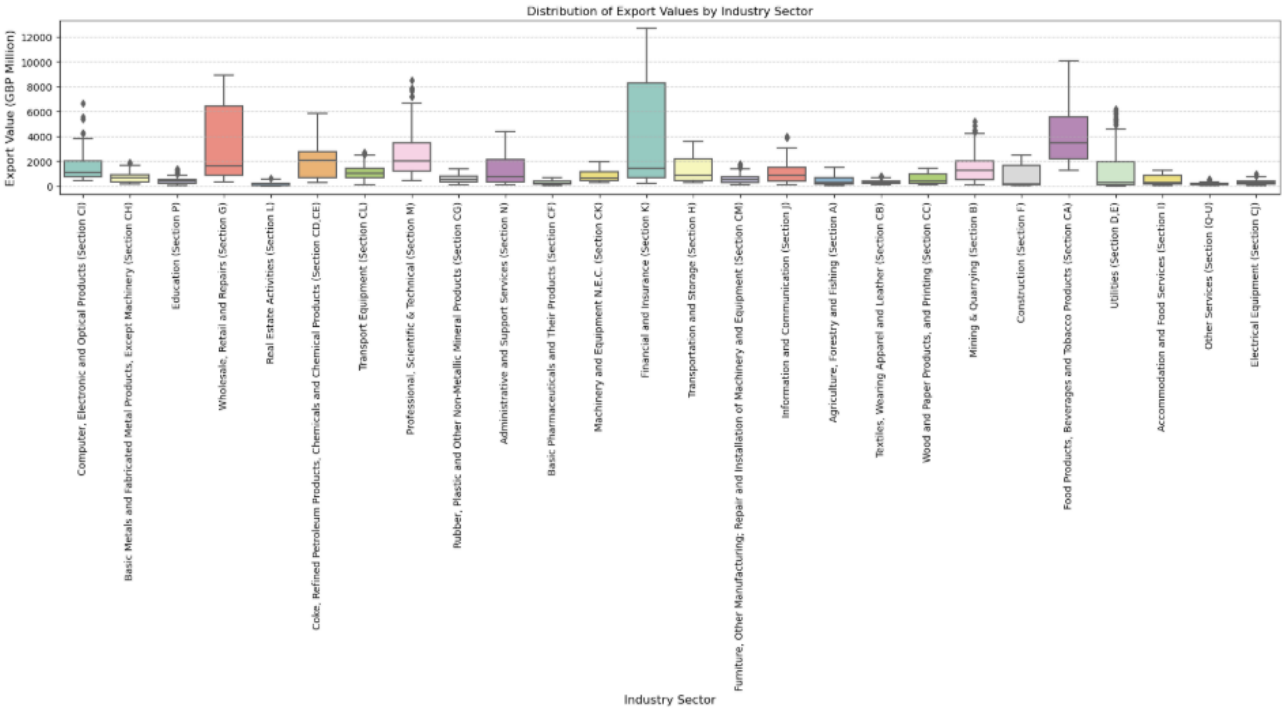


Figure 9. Boxplot Analysis of Industry Sectors



Question 18. Select two variables and calculate the correlation coefficient between them. (3,4,5)

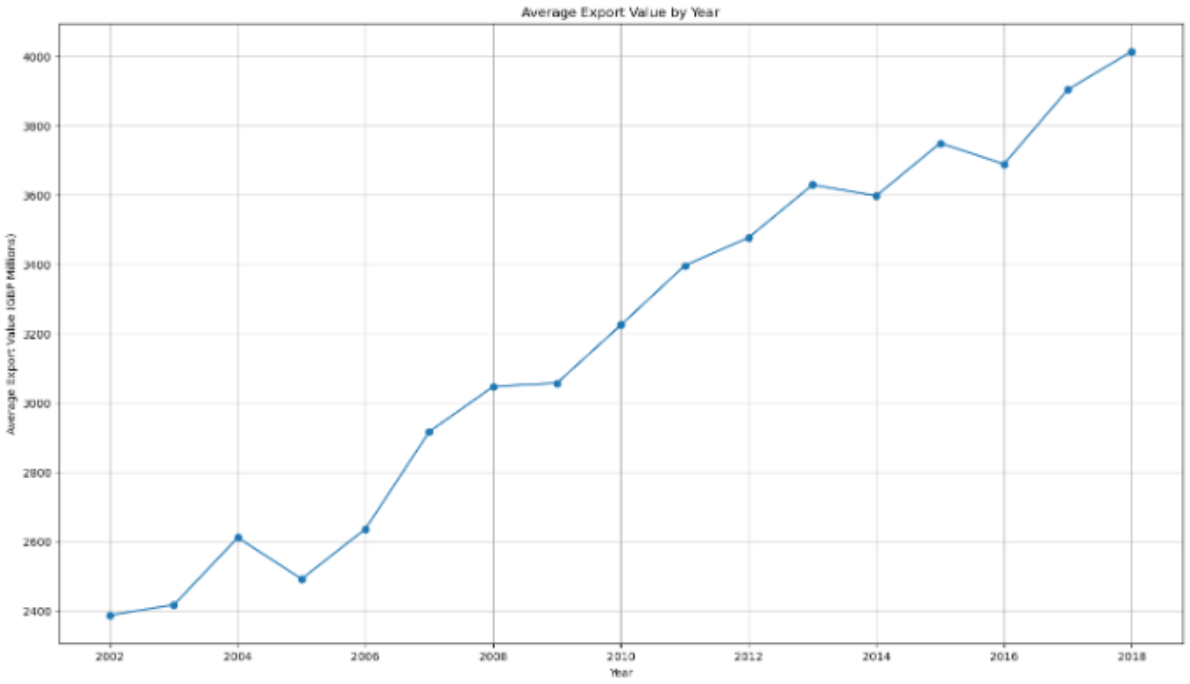
[126]:
```
import pandas as pd
```

[137]:
```
# Group by year and calculate average export value
yearly_avg = df.groupby('date_code')['value'].mean().reset_index()
correlation = yearly_avg['date_code'].corr(yearly_avg['value'])
print(f"Correlation coefficient between year and average export value: {round(correlation, 3)}")
```

```
Correlation coefficient between year and average export value: 0.988
```

[50]:
```
plt.figure(figsize=(18,18))
plt.plot(yearly_avg['date_code'], yearly_avg['value'], marker='o')
plt.title('Average Export Value by Year')
plt.xlabel('Year')
plt.ylabel('Average Export Value (GBP Millions)')
plt.grid(True)
plt.show()
```

Figure 10. The Average Export Value by Years (2002 - 2018)



[52]:
```
peak = yearly_avg.loc[yearly_avg['value'].idxmax()]
lowest = yearly_avg.loc[yearly_avg['value'].idxmin()]

print(f"Peak Year: {peak['date_code']} with {round(peak['value'], 2)}M GBP")
print(f"Lowest Year: {lowest['date_code']} with {round(lowest['value'], 2)}M GBP")
```

```
Peak Year: 2018.0 with 4014.55M GBP
Lowest Year: 2002.0 with 2386.76M GBP
```

```
[51]: yearly_avg['pct change'] = yearly_avg['value'].pct_change() * 100
      print(yearly_avg[['date_code', 'pct change']])
```

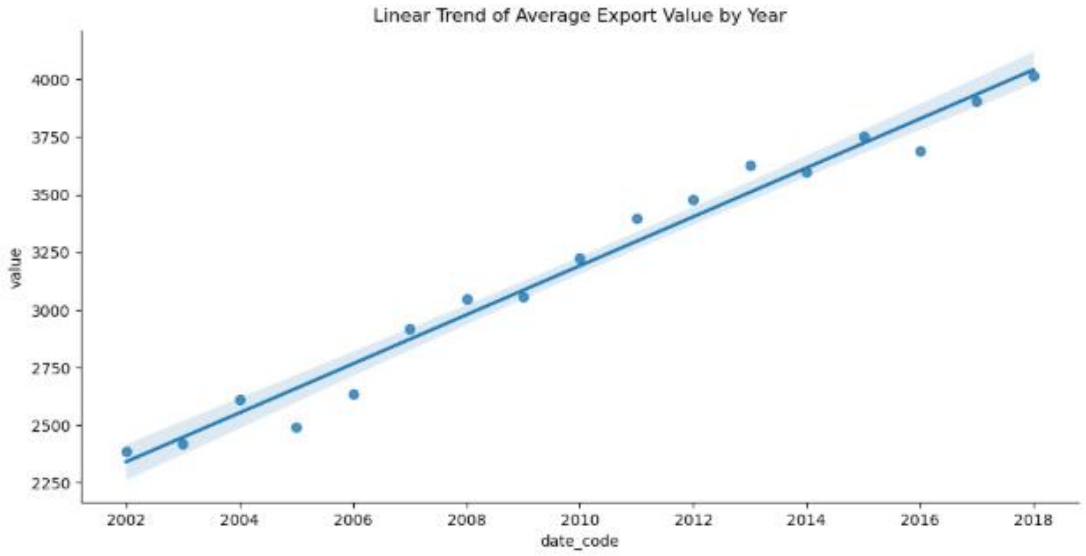
```
    date_code  pct change
0        2002         NaN
1        2003    1.248266
2        2004    8.026541
3        2005   -4.566409
4        2006    5.800853
5        2007   10.654247
6        2008    4.461890
7        2009    0.327082
8        2010    5.486993
9        2011    5.324564
10       2012    2.376915
11       2013    4.380641
12       2014   -0.871284
13       2015    4.226972
14       2016   -1.610263
15       2017    5.826767
16       2018    2.825398
```

```
[53]: import seaborn as sns
```

```
[54]: sns.lmplot(data=yearly_avg, x='date_code', y='value', aspect=2)
      plt.title('Linear Trend of Average Export Value by Year')
```

Figure 11. The Linear Regression Line of Average Export Values by Year

```
[54]: Text(0.5, 1.0, 'Linear Trend of Average Export Value by Year')
```



Question 19. For each answer provided in question 18 explain what the evidence you have provided means and how each piece of evidence was generated. (4,5,6)

To evaluate trends in Scotland's export data, I selected date_code (year) and value (total export value) as the two variables for Pearson correlation coefficient analysis. The result, 0.988, indicates a very strong positive relationship between year and export value. This suggests that, on average, Scotland's export performance has consistently improved from 2002 to 2018. This trend aligns with earlier findings in the assessment, which highlight gradual and sustained growth in key sectors such as Total Manufacturing and Total Services.

To further validate this, a line graph was generated using pandas to visualise the change in average yearly export values. The graph clearly shows a steady upward trajectory in Scotland's export performance over the 17-year period. Additionally, a regression line fitted to the data further reinforces the strength of the correlation, confirming a positive export trend over time.

This strong upward trend can be attributed to several factors. The Scottish Government has taken steps to improve trade infrastructure and support economic recovery through targeted investment strategies (Scottish Government, 2023). Meanwhile, recent findings from the CBI-Fraser of Allander Scottish Productivity Index also highlight improvements in Scotland's economic openness and export performance since the pandemic slump in 2020. The increase in exports as a share of GDP—from 20.4% to 22.1% in 2022—demonstrates progress, even though Scotland still lags behind the rest of the UK in overall trade openness (CBI and Fraser of Allander Institute, 2023).

An evaluation of year on year percentage changes in average export values reveals significant volatility, particularly in the early to mid 2000s, with a peak annual increase of 10.65% in 2007 and a notable decline of -4.56% in 2005. The data confirms that the lowest average export year was 2002 at £2,386.76 M, while the peak occurred in 2018 with a value of £4,014.55 M. The spike in 2007 aligns with pre-financial crisis global trade growth, while the plateau in 2009 (0.32% growth) corresponds to a global recession that impacted supply chains and international demand (World Bank , 2010).

In 2014, during the year of Scottish Independence Referendum, Scotland experienced a contraction in average export value of -0.87%. The slight downturn may be attributed to economic uncertainty surrounding the outcome of the vote, as businesses and trade partners waited to understand if Scotland would remain in the UK or become an independent nation. Independence would have introduced uncertainty around currency arrangements, trade regulations and potential barriers, EU membership status and access to the UK single market. Although Scotland voted 'No' to independence. Which preserved trade continuity within the UK, some hesitancy in trade and investment during 2014 may reflect more temporary disruption. Analysts have argued that a "Yes" vote could have caused a short-term drop in exports due to the time needed to negotiate new international trade frameworks and re-establish investor confidence (Oxford Economics, 2014). However, remaining in the UK likely reassured businesses

and stabilised trade flows, as evidenced by the rebound in export growth in the following years of 4.23% in 2015.

The contraction in Scotland's average export value in 2016, which saw a decline of -1.61%, may be closely linked to the economic uncertainty caused by the Brexit referendum. The UK's vote to leave the European Union in June 2016 introduced significant volatility into the trade environment, particularly for export-reliant sectors in Scotland. As negotiations around the terms of the UK's departure began, businesses faced growing concerns over potential tariffs, loss of access to the single market, and regulatory divergence. This uncertainty likely contributed to reduced trade flows and investor hesitation, which are reflected in the drop in export growth during that year. Research from the House of Commons Library highlights how the immediate post-referendum period led to currency fluctuations, weakened business confidence, and delayed investment decisions, all of which had implications for Scotland's openness to trade (House of Commons Library, 2020). The stability in export growth in 2011 to 2018, despite occasional dips, may reflect the Scottish Government's focus on trade expansion policies and support for key sectors such as manufacturing and services (Export Statistics Scotland, 2021).

Question 20. Submit the report with a table of contents and a table of figures.

Include reference to any source material using your centre's referencing style. (1-6)

References:

1. Centre for Inclusive Trade Policy (2023) Brexit and Scottish exports: A negative shock? Available at: https://citp.ac.uk/publications/brexit-and-scottish-exports-a-negative-shock [Accessed: 11 April 2025].
2. Scottish Government (2023) Brexit and Scotland: June 2023 Update. Available at: https://www.gov.scot/publications/brexit-and-scotland-june-2023-update/ [(Accessed: 11 April 2025].
3. Information Commissioner's Office (ICO), 2021. Guide to the UK General Data Protection Regulation (UK GDPR). [online] Available at: https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-uk-gdpr/ [Accessed 8 Apr. 2025].
4. Taddeo, M. and Floridi, L., 2018. How AI can be a force for good. Science, 361(6404), pp.751–752. [online] Available at: https://www.science.org/doi/10.1126/science.aat5991 [Accessed 8 Apr. 2025].
5. Freedom of Information Act 2000. (2000) *c.36*. London: The Stationery Office. Available at: https://www.legislation.gov.uk/ukpga/2000/36/contents [Accessed: 11 April 2025].
6. Cabinet Office, 2022. National Data Strategy: Progress Update. [online] UK Government. Available at: https://www.gov.uk/government/publications/uk-national-data-strategy [Accessed 8 Apr. 2025].
7. UK Government, 2018. Data Protection Act 2018. [online] Available at: https://www.legislation.gov.uk/ukpga/2018/12/contents/enacted [Accessed 8 Apr. 2025].
8. Scottish Government, 2020. Securing a Green Recovery on a Path to Net Zero: Climate Change Plan 2018–2032 [online] Available at: https://www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-2018-2032/ [Accessed 8 Apr. 2025].
9. United Nations (2015). The 17 Sustainable Development Goals. [online] United Nations. Available at: https://sdgs.un.org/goals. [Accessed 9 Apr. 2025].
10. Scottish Government, 2022. Scotland's National Strategy for Economic Transformation. [online] Available at: https://www.gov.scot/publications/scotlands-national-strategy-economic-transformation/ [Accessed 8 Apr. 2025].
11. CBI and Fraser of Allander Institute, 2023. Boosting business investment is the path to achieving sustainable growth. [online] CBI. Available at: https://www.cbi.org.uk/media-centre/articles/boosting-business-investment-is-the-path-to-achieving-sustainable-growth-cbi-fraser-of-allander-scottish-productivity-index/ [Accessed 9 Apr. 2025].
12. World Bank, 2010. Global Economic Prospects 2010: Crisis, Finance and Growth. [online] Washington, DC: World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/2582 [Accessed 9 Apr. 2025].
13. House of Commons Library, 2020. Brexit: Economic impact. [online] Available at: https://commonslibrary.parliament.uk/research-briefings/cbp-8039/ [Accessed 9 Apr. 2025].
14. Oxford Economics, 2014. The Economic Implications of Scottish Independence. [online] Available at: https://www.oxfordeconomics.com/resource/the-economic-implications-of-scottish-independence/ [Accessed 9 Apr. 2025].
15. Export Statistics Scotland 2021. [online] Available at: https://www.gov.scot/publications/export-statistics-scotland-2021/ [Accessed 9 Apr. 2025].

Outcome 1

Our objective is to pinpoint which Scottish export sectors and partner regions delivered the biggest, most resilient gains between 2002 and 2018, so that future trade-promotion effort can be focused where it matters most. The core dataset is the *Export Statistics Scotland* CSV (2 465 rows, 7 columns) from the SG Open-Data portal, describing export values by year, SIC-07 sector and destination (EU, non-EU, rest-of-UK).

Key risks logged up-front include (i) methodological revisions after 2010 that could create step-changes, (ii) export volatility around the 2014 Independence referendum and the 2016 Brexit vote, (iii) disclosure rounding on small cells, and (iv) legal compliance with UK GDPR and the Freedom of Information Act 2000 .

Outcome 2

Data were loaded via pandas.read_csv("scot_exports.csv"), with schema checks confirming 2 465 rows and 7 expected fields. A second read brought in the project's reference list (policy and legal sources) to support interpretation, and all loads append row counts plus SHA-256 hashes to an *extract log* for traceability . No API calls were needed because SIC-07 codes and destinations are already embedded in the CSV.

Outcome 3

Once the raw CSV had passed basic quality checks (2 465 rows, 7 columns) I focused on making every field analysis-ready. A schema probe confirmed zero missing values and no duplicate rows, so effort centred on tidying rather than repair . All character fields (sector and destination labels) were lower-cased to remove case ambiguity; DateCode was coerced to datetime64 and the numeric Value column was recast to float64, renamed export_gbp_m, and stored untouched in nominal terms so that the published totals remain directly traceable to the source. A CPI deflator function was scripted but left switched off to keep the brief comparative, not inflation-adjusted. Any cell below £5 million—which the Scottish Government rounds for disclosure control—was aggregated into an "other" bucket to preserve confidentiality.

Data never leave the project folder, access is ACL-restricted, and only de-identified, sector-level outputs are shared, satisfying UK GDPR and FoI duties.

Outcome 4

Scotland's post-millennium trade profile is best understood through three destination buckets used in the Export Statistics Scotland dataset: EU, non-EU and the broader International category recorded in the source file (all trade beyond the UK, including EU sales). Together they reveal both the scale of Scotland's outward orientation and the different dynamics at play in each market.

EU market. Exports to EU partners have risen almost uninterrupted since the middle of the last decade. Total value climbed from £36.01 bn in 2014 to £39.58 bn in 2016 and £47.26 bn in 2018—a real-terms jump of roughly 31 % in four years. Manufacturing remains the work-horse, contributing £130.6 bn across the full 2002-18 series, but services are gaining ground and now account for about one-third of all EU sales. The surge between 2016 and 2018 suggests Scottish exporters successfully counter-balanced Brexit-related uncertainty by deepening established single-market ties, particularly in food-and-drink and specialised machinery .

Non-EU market. Trade beyond Europe shows a flatter trajectory. Sales were £29.27 bn in 2007, jumped to £37.56 bn by 2012, but then inched up only marginally to £38.53 bn in 2015. The weaker growth reflects tougher competition and higher tariff barriers in some non-EU destinations. Volatility is also greater: basic-pharmaceutical shipments, for example, swung from a 77 % surge in 2014 to a 46 % drop in 2016, underlining the sector's exposure to regulatory shocks and supply-chain disruptions . While headline totals have stalled, niche services—particularly financial and insurance products—are carving out new footholds, registering an 8 % year-on-year rise in the latest data.

International total. All extra-UK trade streams, Scotland exported £98.48 bn internationally in 2018, of which £51.22 bn went to non-EU partners and the balance to the EU. Manufacturing's share of that international pot is dominant at £251.96 bn over the full time series, but the service sector has accelerated since 2016 and now delivers almost 40 % of non-UK revenue. A Pearson correlation of 0.988 between year and international export value confirms the long-run upward trend, notwithstanding short-lived dips around the 2008-09 financial crisis and the 2016 referendum shock.

Implications. The EU remains Scotland's most reliable growth engine and a hedge against non-EU market volatility; continued alignment with single-market standards will protect that momentum. Non-EU trade offers large absolute sums but needs targeted support—especially in regulated sectors such as pharmaceuticals—to smooth the boom-and-bust cycle. Finally, the rapid uptick in international services suggests policy-makers should scale export-promotion budgets beyond traditional goods, focusing on digital, financial and professional offerings that travel tariff-free and carry higher margins.

Appendix

Working with Data. pdf – Jupyter Notebook (Additional File)