Coursework

Applied Statistics and Data Visualisation

MSc Data Science

University of Salford MANCHESTER

STATISTICAL ANALYSIS AND INTERACTIVE DASHBOARD DESIGN

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Table of Contents

Part One: Interactive Dashboard Design

1. Introduction

Trade is an heart of growth that increases economic opportunity, creates jobs and reduces poverty, and generates jobs as a driver of growth.. Since 1990, economic growth supported by improved trade standards has helped more than 1 billion people escape poverty. However, more than 1.2 billion people currently live in poverty, **95%** of which live (primarily) in developing countries (WHO). Based on this, we see the advantages of trade and the need to strengthen the global trading system to help countries address trade-related constraints to growth. Trade between industrialised and developing countries frequently leads to challenging problems. Most developing countries' economies are reliant on agriculture. As many of them are tropical, they frequently depend on the revenue from exporting just one or two goods, such as coffee, chocolate, or sugar. These products' markets are highly competitive (in the sense that economists use the term), resulting in extremely responsive prices to shifts in supply or demand. The prices of manufactured goods, which make up the majority of exports from wealthy countries, are often far more constant. The tropical nation's "terms of commerce" as a result undergo significant adjustments. price differential between exported and imported goods when export price changes. These changes typically hurt the domestic economy. There have been attempts to stabilise prices and cap production for almost all vital primary commodities. These initiatives have varied in their levels of success (Schneider, 2005).

Trade between industrialised and less developed countries has generated much discussion. As multinational corporations from industrialized nations move their operations to countries with relatively inexpensive labour markets. As a result, critics of the WTO have become more vocal recently. The most severe criticisms of the WTO's authority and scope focused on the environment, the appropriateness of fostering commercialism and free trade at the expense of other principles, domestic workers' rights, the WTO's democracy, national sovereignty, and the importance of health and safety. These critics also raised many other issues with the organisation (Busch and Reinhardt, 2003). A number of factors affects trade in countries, such as imports, merchandise, export etc. Hence, The object of my research is to produce a single screen interactive dashboard which shows a comparative analysis of trade between Developed and Under developed countries based on certain indicators.

2. Background Research

Stephen Few says in his 2012 book "Show Me the Numbers: Designing Tables and Graphs to Enlighten, Second Edition (Analytics Press)" that some visual components of a display "jump out" and are readily recognized by our brains. Differences in colour hue (e.g., red stands out in a sea of blue) and colour intensity are two factors that enable this quick detection (e.g., a darker shade of blue stands out in a sea of light blue). Contrasts in shape (such as a rectangle among a sea of circles), size (such as a small circle next to larger circles), line length, line width, enclosure, and object position are further eye-catching components.. A challenging component of data visualisation is dashboard design. It is very simple to create a dashboard that would fail to transmit the intended message to the user, which makes the design process difficult. Data visualisation capitalises on our innate visual processing talents by utilising these features to enable individuals to process data more quickly and effectively.

Effective data visualization's primary goal is to illustrate the quantitative correlations that exist in the data. Nominal comparisons, time series, ranking, part to whole (percentages), deviation, distribution, and correlation are examples of quantitative relationships. Nominal comparisons show differences in specific values, whereas time series show how values change over time (whether two different values change together). Selecting the most efficient method for displaying one piece of data is essential, as different graphs express distinct quantitative relationships. For example, scatter plots are great for exhibiting distribution or deviation; line charts are best for illustrating time series; pie charts are best for illustrating a portion relative to the whole; and bar charts are best for illustrating ranking, portion relative to the whole, deviation, or distribution. This article focuses on best practices for presenting data more effectively, emphasising infographics and dashboards.

In business intelligence and financial analysis, dashboards handle data, arrange crucial information, and produce a display that enables users to comprehend what is occurring throughout the firm. Dashboard tools utilise various data sources to obtain, collect, and present information. By displaying data sources visually on a single, user-friendly interface, it is possible to comprehend deep linkages between data sources.

Behind the enterprise's data bars, data dashboards make a connection between unique yet related indicators, uncover loopholes, explore trends, and reveal potential difficulties. A secure, individualised, and simple-to-understand dashboard provides a comprehensive view of the organisation. They are adroit. They demonstrate mobile phone, tablet, and portable device interoperability. Audiences, third-party vendors, and suppliers, as well as the Board of Directors, receive the appropriate information and may access it whenever it is required.

Using various, highly contrasted colours to display various types of data Use a bold or dark colour, for instance, to draw attention to a data element.. One can colour the bars from lightest to darkest to make it easier to compare them. Since red means "loss" in business, it should not be used for positive numbers. If one use red and green or blue and yellow together, remember that people who are colourblind will not be able to read them because of the lack of lightness contrast. The greatest colour schemes use colours that are adjacent to one other on the colour wheel, colours that contrast sharply on the opposing sides of the colour wheel, or only one colour (when colours are all across a single hue to achieve visual cohesion).

Before putting data on a chart, it is also essential to group, prioritise, sort, and order it. Otherwise, the information will be put on the chart randomly. At most four lines should be present in a line chart, and they should be evenly spaced apart to make counting them easier. A pie chart should only contain five segments, and the lesser segments should be listed under "Other." The most important slice should be at 12 o'clock, and the remaining slices should be ordered clockwise from most important to least important. To balance the data in bar charts, the Y axis must begin at zero.The study uses the dashboard to explore the GDP growth by year and country. The Map of the trade is displayed to give us an insight into how the countries of the world are fearing in terms of their trade. From the chart, we can see that the developed nation has more trade (The Map). The column bar chart also sees the contribution of GDP per year. The year with the highest GDP is 2019, and the projection will continue in a trending manner over the years. A positive linear relationship between gross savings and trade can also be seen. This indicates that countries that save more also trade more. However, the difference is the case for developing countries as they tend to import goods and services more than export. These criteria reduce their trade strength, and it affects their economy.

3. Exploration of Data Set

The World Bank Data is where the study's dataset was taken from, which has 85 Databases. The particular database selected is the World Development Indicators which has 266 countries, 1442 series and data from 1960 to 2021. I used the filter function to select 12 countries in developed and underdeveloped nations and 16 key indicators. The dataset contains different data types such as numeric data (US dollars, and percentages). The dataset was then downloaded and imported into Power Bi.

3.1 Data Preparation

With its robust visualization and data analytics for the trading dashboard between developed and underdeveloped countries, Power BI enables us to make immediate, growth-driven

decisions. However, since the data is relevant or limited to some extent, more is needed to aid in developing accurate reports. Eventually, we may be unable to make effective decisions if our data and reporting skills are compromised. In order to begin cleaning and organizing our data, we selected "Transform Data" upon importation of the dataset into Power Bi rather than loading the dataset.

Our manipulated data from our select query will be shown in the Power Query Editor's main body, and you can quickly peruse the available queries in the tool's left-hand sidebar. In addition, all data modifications and transformation stages are seamlessly documented in the Query Setting Pane. At the initial stage I clicked on view tap in the Power Query and proceeded to select column quality which provides you with the quality details in percentages. Please see figure below;

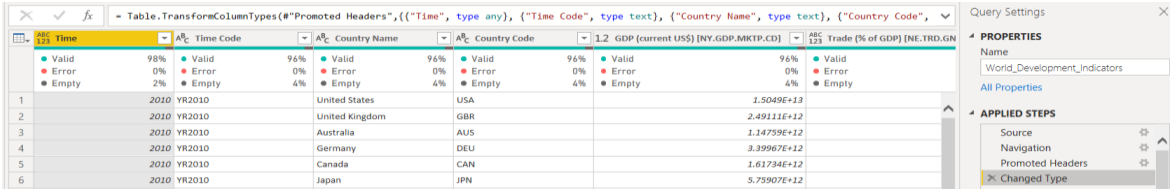

Figure 1: Power Query showing the quality of the data

The next step is to determine whether or not the Column Headers & Names are structured. You could also see from the figure above that there were some empty data in the different columns, this was taken care of by removing last 5 bottom rows which were not required in the dataset. We are required to examine our data and begin the necessary transformations. Ensure that each column is positioned correctly.

The first shows sample data for the indicators, displaying product categories and subcategories over time. Thus, the outcome is displayed. It is evident how data is imported; if column headings and names are not maintained, the dashboard will not be adequate.

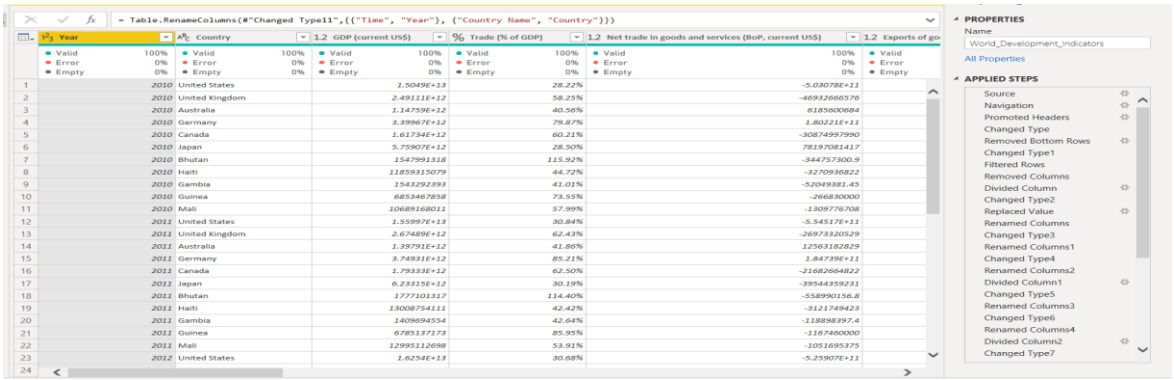

Figure 2: Power Query showing the quality of the datase after preparation

From the figure above, you can now see that the column quality indicates 100% for each column.

3.2 Relationships

There are some correlations among the indicators, some of which are displayed below:

1. **Trade-in services (% GDP)** = By dividing service exports and imports by GDP
2. **Imports of goods & services (BoP, current US$)** = Goods imports + Service imports
3. **Exports of goods &services (BoP, current US$)** = Goods exports + Service exports
4. **Trade (% of GDP)** = Imports of goods & services (% of GDP) + Exports of goods and services (% of GDP)

Two indicators were created with the help of DAX in Power Bi.

5. **Trade (goods & services)** = Imports of goods and services + Exports of goods & services
6. **Net Trade** = Exports of goods and services - Imports of goods and services

4. Investigation of Data Workflows & Proposal for Design of Dashboard

Designing a dashboard frequently involves following a specific procedure that is specific to the data being presented. The technique put out by (Chittaro, 2006) would be used in this proposal, with a small alteration being made by adding the "business understanding" stage and removing the "assessment" and "human aspects" steps from the methodology. The following sections of the report will be separated into this section:

- Business Understanding
- Selection
- Mapping
- Presentation
- Interaction

4.1 BUSINESS UNDERSTANDING

An understanding of the research is required prior to designing a dashboard.

- Trade boosts economic opportunity, eliminates poverty, and creates jobs. Given that it is an exchange of goods and services, it unquestionably has a big influence on how well a nation's economy is doing.

4.2 SELECTION

- **Net Trade** - This is the difference in current $US between the imports and exports of goods and services. The true value is displayed in US dollars. This metric aids in determining if a nation is a consumer or a producer. When importation is more than exportation, the country has a trade deficit, however, when the exportation are more, the country has a trade syrplus. Due to the fact that a trade surplus is preferable to a trade deficit, this can be used to gauge the health of an economy. This is indicator is derived from the difference between two indicators
  Net Trade = Exports of goods and services - Imports of goods and services
- **Trade in Services (% of GDP)** – The amount of service exports and imports divided by GDP represents the value of trade in services in current U.S. dollars.. This indicator displays how much of the GDP is contributed by services. While some nations are major service importers, others are major service exporters. This will aid in determining what type of economy a country has in terms of services as a part of commerce.
- **Merchandise Trade (% of GDP)** - All the many types of goods that are traded between nations are referred to as merchandise. This is the GDP divided by the total value of goods exported and imported. This indicator displays the types of goods and services that different nations exchange with one another. It also includes many other indicators from the dataset. Some of the ingredients of the merchandise trade are food exports and imports, fuel exports and imports, ores& metals exports and imports, and agricultural raw materials imports and exports.
- **Trade in goods and services** - The total of goods and service exports and imports is shown here. This is indicator is derived from the addition between two indicators
  Trade in goods and services = Imports of goods and services + Exports of goods and services
- **Trade (% of GDP)** It is determined by dividing the sum of all imported and exported goods and services. This relative statistic displays the proportion of trade activities that make up the GDP.

4.3 MAPPING

In order to present a story to the user, a dashboard must merge many chart kinds into one screen. When doing so, some guidelines for transforming the data into a visual form must be followed. This section will go into great detail about how the data will be represented visually and the reasoning behind the choices.

Trade data is of the quantitative variety, making it valuable for comparing differences between nations as well as links between nations and years. When dealing with quantitative data, charts are a useful tool for examining two properties: variation and relationships. (Few, 2016). We can observe differences between values and potentially significant patterns in the data thanks to variation. (Few, 2016). However, when we compare years and countries which are categorical, it becomes quanlitative. We can examine how variables interact through relationships. (Few, 2016). The trade data collection is a set of quantitative data, but when we compare nations or years, it changes from being quantitative to qualitative because those are categorical elements. The following attributes should be taken into account while mapping categorical data: (Few, 2016)

Points: These indicate values based on their 2D position in relation to a quantitative scale along one or both axes. They can take the shape of tiny circles or polygons.

Circles or polygons that indicate values depending on their areas are referred to as areas.

In order to depict a sequence of values relative to a quantitative scale on one of the axes, lines are employed to connect a number of 2D places.

Rectangles: These are used to symbolise values by changing in size in accordance with a scale along one of the axes.

The Graphs chosen to visualise this data are Map, Line graph, Stacked bar chart, Clustered bar chart and Scatter Chart.

Clustered bar chart

When displaying numerous instances of one or more important variables rather than just one, bar charts can be useful. Depending on how many factors are compared, the chart may have one or more bars. By simply comparing the bar heights, they make it simple to compare

categories of the same data side by side. In this dashboard, the clustered bar chart was used to view the GDP growth per year.

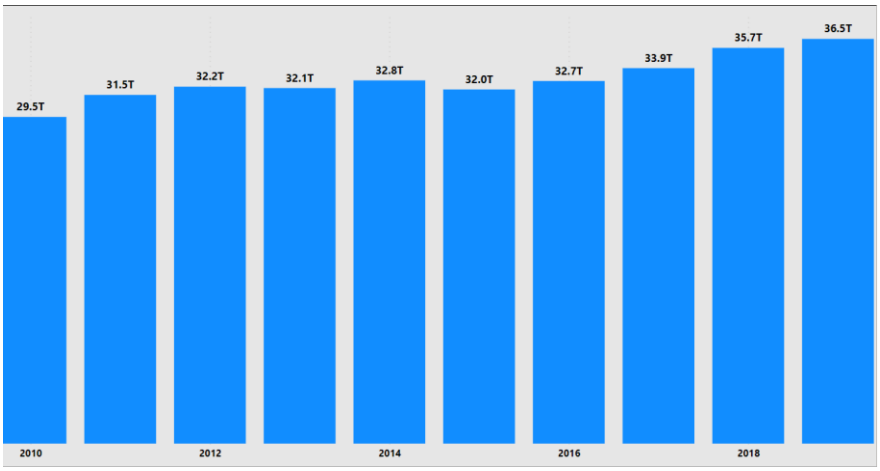

Figure 3: Clustered bar chart showing GDP growth per year

It would be interactive in that the user could choose multiple indicators for a country to be compared head-to-head, by the year or compare the same indicator between two countries.

Line Graph

Line graphs are excellent in comparing numerical data between countries over the years.

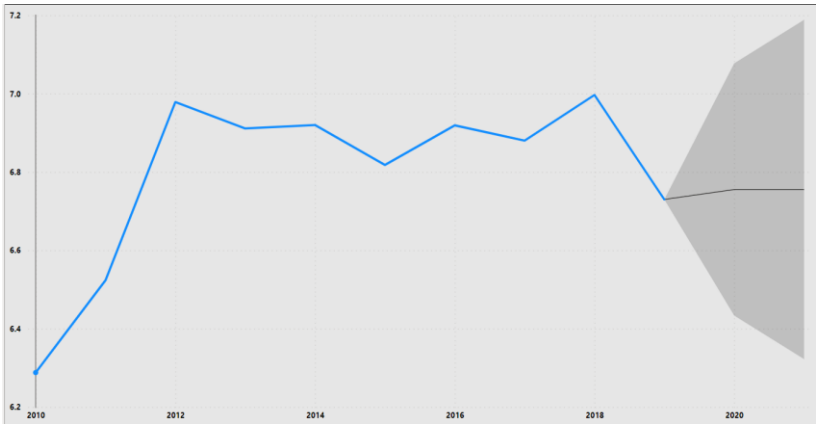

Figure 4: Line chart showing Trade(%GDP) by Gross savings chart showing GDP growth per year

The line chart was used to measure trade% of GDP against the year and a forecast was included. It will provide interactions with the help of slicers to view trade for the different countries and forecast into the future.

Stacked Bar chart(Diverging bar chart)

We can also use a stacked bar chart to compare categories side by side. This is a variation of a stackedbar chart, where the stacks diverge from a central baseline.

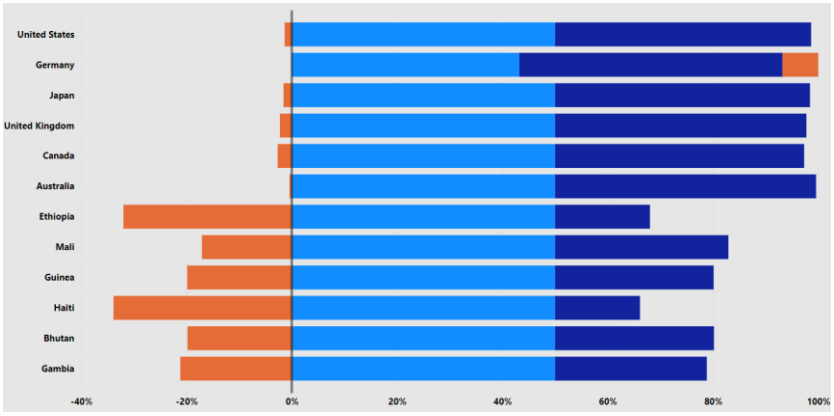

Figure 5: Diverging bar chart showing Import and export and Net Trade

This chart was used to compare the import , export and net trade which enables you to see countries with a trade deficit and trade surplus. This is also interactive with the help of slicers, as you can compare trend over the years.

Map

This is useful for showing geographical data and bubble plots are included as it helps in visualizing multivariate data.

Figure 6: Map visual showing Trade by Country

The Map was used to visualise the created DAX(Trade) which is the sum of the Imports of goods and services + Exports of goods and services . The Trade is represented by the bubbles. This is also interactive as it enables the user visualize the trade over the years and you can see the difference in the size of the bubbles.

Scatter Chart

In a controlled experiment, the independent variable is the variable we are changing, while the dependent variable is wha twe are observing in response to the change in the independent variable.

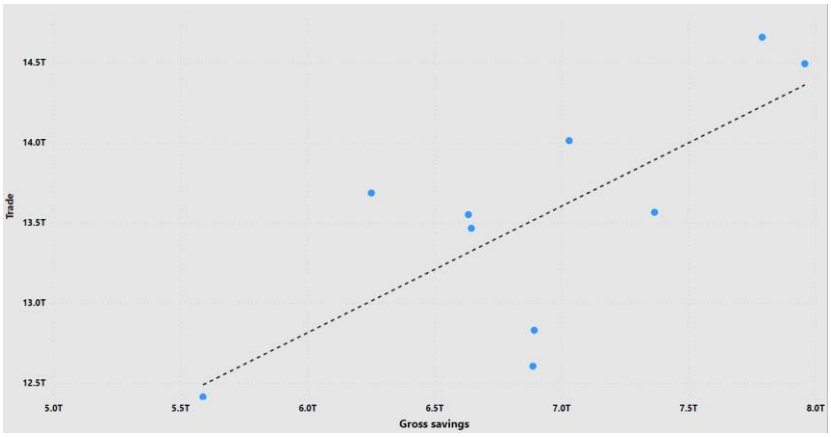

Figure 7: Scatter Chart showing Corelation between Trade and Gross savings

In this case, we plot the independent variable(Gross Savings) on the horizontal axis and the dependent variable(Trade in goods and services) on the vertical axis. You can see there is a positive correlation between Trade and gross savings. As trade increase, a countries savings increase.

Card Visual

Finally, Card visuals were also created to show the Trade in services(% of GDP) and Merchandise trade(% of GDP). This is also interactive as it changes over the years and for each country with the help of slicers in Power Bi.

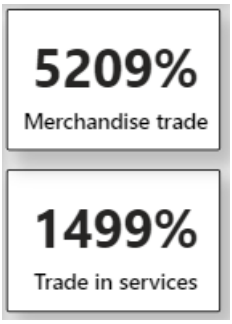

Figure 8: Card visual showing Merchandise Trade and Trade in services (%GDP)

4.4 PRESENTATION: DASHBOARD ENVIRONMENT

A difficult part of data visualisation is dashboard design, which calls for careful planning and adherence to a variety of standards and regulations. Effective dashboards present the most

crucial information that has to be tracked in a style that can be quickly and easily read and absorbed (Few, 2005). Because of this, dashboards should only take up one screen to prevent the user from losing any comparisons they have made between other displays. (2011) Ganapti To prevent interfering with the user's vision, dashboards should be kept as basic as possible by optimising the data-ink ratio and avoiding chart clutter (Ganapti, 2011)

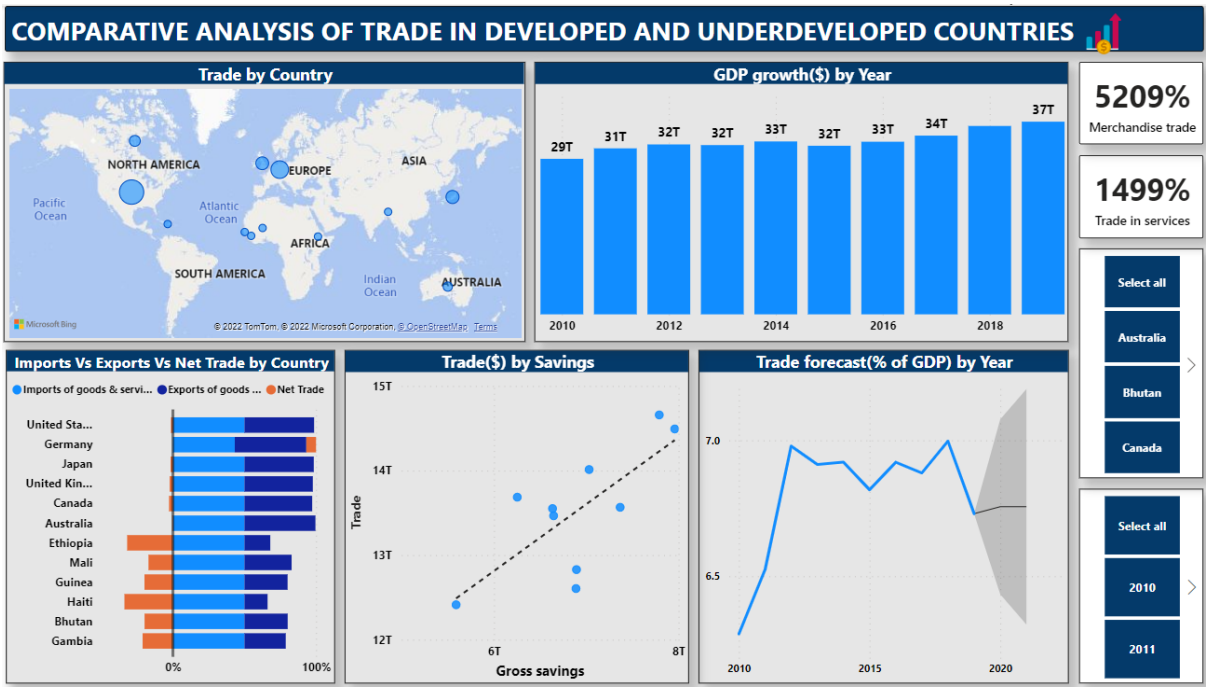

Figure 9: Completed Dashboard Design

To avoid losing concentration, the data on the dashboard must be deliberately and carefully arranged. The dashboard is made up of 7 visualisations that have been organised so that the user can begin with the conceptual view before focusing on other elements of the data. The dashboard above starts with the Map view enabling you see how the sizes of trade in goods and services are for different countries and then proceeds to indicate the GDP growth per year. The 3rd chart then compares the imports and exports of goods and services and net trade for different countries. Next to that is a scatter plot to show correlation and finally a forecast of the Trade which is our main focus of this research. Card visuals are indicated ontop due to their sizes where they can be easily seen. The slicers are on the bottom left away from the main display.

4.5 INTERACTIVITY

Filtering approaches provide interaction for the user. Filters are offered in this dashboard, allowing the user to choose the data of interest, interact with the dashboard, and control the amount of data displayed.

5. Discussion

This suggestion does not constitute a thorough examination of how the trade data would be represented on a dashboard. In order to create the finest dashboard possible, the most crucial factors have been taken into account when laying out the data in a visual format. Because it might change the true meaning of the data, restoring missing values is a highly important issue in data pre-processing, according to the data exploration. Trade data is inherently sensitive since incorrect imputations can create an inaccurate impression of a nation's economic health.

The value of a nation's currency and international trade are intricately linked, making it challenging to determine how imports and exports and the exchange rate relate to one another and the exchange rate International trade and the value of a country's currency are inextricably interwoven, making it challenging to examine how imports and exports are related ports and the exchange rate. The magnitude of the trade surplus or deficit is influenced by the exchange rate, which in turn affects the exchange rate. In general, a weaker domestic currency promotes exports while increasing the cost of imported items. A strong domestic currency, on the other hand, diminishes export market competitiveness while increasing import prices (Sanusi et al., 2020).

A trade deficit is the amount of money a country spends purchasing goods from another. This is because corporations in the country of importation pay exporters in the country of supply. The huge amount of imports reflects the robust consumer demand and increasing economy. Consider that the majority of these imports consist of productive assets, such as machinery and equipment. This is even more advantageous for the importing nation because productive assets will increase economic output over time (Awan and Mukhtar, 2019).

Exports and imports on the rise indicate a strong economy. This signals a strong economy and a sustainable trade surplus or deficit. In contrast, a rise in exports coupled by a decline in imports could imply that other countries are in better shape than the U.S. economy. Nevertheless, if imports are rising while exports are declining, this may signal that local economic conditions are improving at the expense of those on international markets.

Power BI enables us to make rapid, growth-driven decisions with its sophisticated data visualisation and analytics for the trading dashboard between developed and underdeveloped countries. Inasmuch as the data is useful or limited, further information is required to aid in the development of reliable reports. If our data and reporting skills are undermined, we may

eventually be unable to make effective decisions. On the Power BI desktop's homepage, we selected "Transform Data" to begin cleaning and organising our data.

Our altered data from the select query will be displayed in the Power Query Editor's main body, and you can quickly browse the available questions in the tool's sidebar on the left. In addition, the Query Setting Pane contains a complete record of all data modification and transformation phases.

6. Conclusions

Overall, the methods applied and the dashboard developed for this study are consistent with the scientific method and use a wide range of procedures and techniques to provide an exciting and helpful dashboard. The final proposal is well put together, shows the data clearly and excitingly, and could be helpful to many countries and years by using a map, column bar charts, line charts, stacked bar charts, and scatter plots.

This solution meets the criteria outlined in the project brief by delivering a concise and understandable visual representation of the data. Users can use the dashboard's interactive features to delve deeper into the data and gain valuable insights about recurring trends and patterns. This addresses the need for the data to be readily available and understandable, and it also allows users to go deeper into the data if they so choose. The provided answer is sufficient in that it satisfies all the criteria listed in the task description.

Part Two: Statistical Analysis

1. Introduction

The trade balance of a nation, which is determined by its net exports, is impacted by all aspects of global trade (difference between the export and the import). Such influences include, but are not limited to, demand, inflation, exchange rates, and trade policy.A country has a trade balance for products (ocassionaly called the goods trade balance) and a balance of trade for services since both items and services are included in the tally of exports and imports. A nation has a trade surplus when its exportation are more significant than its importation and a trade deficit when the opposite is true (Kira, 2013).

In this project, we shall be looking at the factors affecting trade between developed and under developed countries and the factors that is affecting GDP. This study will utilize a secondary data, that is extracted from World Bank Indicator database. Factor endowments are things like labour, land, and money. The word "labour" refers to the people who work in a country. The land is a term for natural resources like wood or oil. Infrastructure and the ability to make things are examples of capital resources.

The Heckscher-Ohlin model of international trade shows how trade patterns are affected by a country's labour, land, and capital. For example, a country with cheap, unskilled labour tends to make things that require cheap labour, while a country with many natural resources is more likely to sell them (Baskaran, 2011).

Making these parts is also very important. For example, let us say that two countries have the same amount of labour and land. However, while one country has low-skilled workers and resources with low productivity, the other has skilled workers.

Because skilled workers can make more per worker than unskilled workers, this affects the areas where each has a comparative advantage. For example, a country with skilled workers can design complex electronics, while a country with unskilled workers may focus on making simple things.

Aims and Objective

This project aimed to study the effect of indicators such as export, import and gross savings on current GDP in 12 different countries. Below are the specific objectives of the study:

- Extract data from the world bank indicator including all the indicators for trade factors in 12 different countries
- Apply data cleaning and manipulation to transform the dataset for analytical purposes.

- Understand the underlying assumption of the dataset to detect the best model to fit.
- Developed two time series and two regression models based on the underlying assumption of the dataset.
- Compare the result derived to other publications and journals.

2. Background Research

In today's global economy, people are used to seeing goods from all over the world in their neighbourhood shops and supermarkets. Imports from other countries expand the possibilities available to customers. In addition, imports help consumers manage their tight household budgets because they are often produced at a lesser price than equivalent American-made products (Hart, 2013).

To accomplish the goals outlined for the job, various statistical techniques will be applied in this study. First and foremost, a straightforward linear regression will be fitted to demonstrate a connection with the analysed countries' GDP. After this, a multiple regression for two independent and three independent variables will be fitted, respectively. Lastly, Three-Step Simple Moving Average (SMA3) and the Holt-Winters method will be used to forecast. We needed to understand all these variables before diving deep into the statistical method one after the other (Awel, 2013).

When a country's imports are disproportionately higher than its exports, its trade balance may become unbalanced, and its currency may lose value. When a nation's currency loses value, it can substantially affect its residents' daily life. Because one of the most important indices of economic performance and GDP is currency value, this is the case (GDP). Therefore, a nation must guarantee that the ratio between its imports and exports is appropriate (Jane et al., 2015).

When a nation buys commodities from other nations, it sends funds abroad. Companies within their own country are importers, whereas companies from other countries are exporters. The economy expands when there are numerous imports and domestic demand is strong. If most of these imports are productive assets, such as machinery and equipment, this is even more advantageous for a nation, as productive assets contribute to long-term economic growth (Abduh and Omar, 2012).

When both exports and imports rise, the economy thrives. This indicates a healthy economy with a constant trade surplus or deficit. If exports are increasing while imports are declining dramatically, this may signal that economies outside the country perform better than the

domestic economy. A sharp fall in exports coupled with an increase in imports may signal that the home economy is performing better than overseas markets (Jordaan and Eita, 2007).

Regression models describe the relationship between variables by constructing a line that fits the observed data. While logistic and nonlinear regression models use a curved line, linear regression methods use a straight line. We can estimate a dependent variable's variation as a function of an independent variable using regression (s). Both basic and multivariate linear regression are utilised in this investigation (Tranmer and Elliot, 2008).The statistical method for forecasting that is unquestionably the most well-liked and frequently applied is called ARIMA (Autoregressive Integrated Moving Average). As suggested by its name, ARIMA is made up of three parts:

- an Autoregressive component, which depicts the relationship between the series and its lag values
- a Moving Average component, which makes predictions based on lags in prediction errors
- a final, Integrated component, which makes the series stationary

Another collection of methods that uses historical values is Holt-Winters. However, the so-called "exponential smoothing" is a key distinguishing feature.

Three elements of a time series can be distinguished: White noise, seasonality, and trend (i.e., random data points). We can foresee the predictable factors (such as trend and seasonality) for forecasting purposes, but not the unpredictable ones random elements. Extraction smoothing can control this kind of volatility within a series by removing white noise. Likewise, a moving average can smooth training data by initially averaging and equally weighting values. In contrast, the past data are weighted in an exponentially decreasing order using Exponential Smoothing. In other words, more importance is placed on recent observations than on historical data.

Descriptive statistics, in a nutshell, are used to help characterise and make sense of by giving succinct descriptions of the sample and data measures. The mean, median, and mode are the most popular descriptive statistics and are employed at almost all levels of math and statistics.

Differences across data sets can be examined using metrics of central tendency and variability. These two methods employ visuals, tabular displays, and verbal explanations to help people grasp the meaning of the data under consideration.

Central tendency measurements characterize the location of the center of a distribution for a certain data set. The mean, median, and mode are statistical measures of central tendencies that are applied to every data point in the distribution to determine how often they occur.

Measures of variability allow us to calculate the spread of a data set's distribution (also known as spread). For instance, a measure of central tendency can tell you the average value for a set of data, but it doesn't tell you much about the distribution of the data inside that set.

Although 65 may represent the average of the data, there may still be data points at both 1 and 100. Measures of variability serve in conveying the shape and distribution of the data set. Range, quartiles, absolute deviation, and variance can all be used to assess levels of dispersion.

3. Exploration of Data Set

The World Development Indicator website provided the data set for this study. The World Development Indicators are the most important set of development indicators maintained by the World Bank (WDI). It was put together from official sources from around the world. It gives the most accurate and up-to-date information on changes around the world and estimates at the national, regional, and global levels. Unfortunately, global Development Finance (GDF) is no longer part of the name of the WDI database, but all of the statistics about external debt and financial flows are still there.

In this dataset, information on GDP, GDP current, Export goods, Import goods, gross savings, trade, and other financial indicators were extracted from the WDI database.

Indicator Name	Long definition
GDP (current US$)	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.
Trade (% of GDP)	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.
Net trade in goods and services (BoP, current US$)	Net trade in goods and services is derived by offsetting imports of goods and services against exports of goods and services. Exports and imports of goods and services comprise all transactions involving a change of ownership of goods and services between residents of one country and the rest of the world. Data are in current U.S. dollars.
Exports of goods and services (current US$)	Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in current U.S. dollars.
Goods exports (BoP, current US$)	Goods exports refer to all movable goods (including nonmonetary gold and net exports of goods under merchanting) involved in a change of ownership from residents to nonresidents. Data are in current U.S. dollars.
Service exports (BoP, current US$)	Services refer to economic output of intangible commodities that may be produced, transferred, and consumed at the same time. Data are in current U.S. dollars.
Imports of goods and services (% of GDP)	Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments.
Imports of goods and services (current US$)	Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in current U.S. dollars.
Service imports (BoP, current US$)	Services refer to economic output of intangible commodities that may be produced, transferred, and consumed at the same time. Data are in current U.S. dollars.
Trade in services (% of GDP)	Trade in services is the sum of service exports and imports divided by the value of GDP, all in current U.S. dollars.
Merchandise trade (% of GDP)	Merchandise trade as a share of GDP is the sum of merchandise exports and imports divided by the value of GDP, all in current U.S. dollars.
Exports of goods and services (annual % growth)	Annual growth rate of exports of goods and services based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars. Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments.
Imports of goods and services (annual % growth)	Annual growth rate of imports of goods and services based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars. Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments.
Gross savings (current US$)	Gross savings are calculated as gross national income less total consumption, plus net transfers. Data are in current U.S. dollars.
Gross savings (% of GDP)	Gross savings are calculated as gross national income less total consumption, plus net transfers.

Table 1: Dataset Metadata

The dataset was read into R. glimpse, head and names were tools used to explore the data. We then proceeded to check for missing values using the is.na function. A few missing values appeared and this was taken care of by the na.omit function.

The variables names from the dataset are long, hence I decided to rename the colums with shorter names to aid for easy coding. The figure below indicates how the data was processed.

```
# Checking missing values
print("Position of missing values by column wise----")
sapply(worlddevelopment, function(x) which(is.na(x)))

# Removing the rows that contain missing values
worlddevelopment <- na.omit(worlddevelopment)
print("Position of missing values by column wise----")
sapply(worlddevelopment, function(x) which(is.na(x)))

# Renaming columns for easy coding

worlddevelopment<- worlddevelopment %>%
  rename(
    'year' = 'Time',
    'country' = 'Country.Name',
    'gdp_current' = 'GDP..current.US....NY.GDP.MKTP.CD.',
    'trade'='Trade..Sum.of.Imports.and.Exports.of.Goods.and.Services.',
    'trade_gdp'='Trade....of.GDP...NE.TRD.GNFS.ZS.',
    'net_trade'='Net.trade.in.goods.and.services..BoP..current.US....BN.GSR.GNFS.CD.',
    'import_goods_services' = 'Imports.of.goods.and.services..current.US....NE.IMP.GNFS.CD.',
    'export_goods_services' = 'Exports.of.goods.and.services..current.US....NE.EXP.GNFS.CD.',
```

4. Analysis

Descriptive Statistics

The descriptive statistics we considered for all the variables in this study are the mean, the standard deviation, the median, the minimum values, the maximum value, the skewness and the kurtosis. As explained in the background of the study section. The mean and median measure central tendency, while standard deviation, skewness, and kurtosis are measures of spread. For most of the variables, the median and mean are very close. Hence there is no suspicion of the presence of outliers in the dataset. However, the "is.na" function in R helps us get the number of missing values per variable. After the check, it was observed that there were some significant missing observations in the dataset. Since the numbers were not much, a complete case analysis was conducted. The descriptive statistics table for all the variables is given below.

Table: Descriptive Statistics table

	mean	sd	median	min	max	skew	kurtosis
Time	2.014500e+03	2.884324e+00	2.014500e+03	2.010000e+03	2.019000e+03	0.000000	-1.253715
Time.Code*	5.500000e+00	2.884324e+00	5.500000e+00	1.000000e+00	1.000000e+01	0.000000	-1.253715

Country.Name*	6.500000e+00	3.466527e+00	6.500000e+00	1.000000e+00	1.200000e+01	0.000000	-1.246397
Country.Code*	6.500000e+00	3.466527e+00	6.500000e+00	1.000000e+00	1.200000e+01	0.000000	-1.246397
GDP..current.US….NY.GDP.MKTP.CD.	2.742585e+12	4.943421e+12	6.229563e+11	1.229461e+09	2.140000e+13	2.48481	5.327678
Trade..Sum.of.Imports.and.Exports.of.Goods.and.Services.	1.125928e+12	1.553095e+12	4.650000e+11	6.010896e+08	5.660000e+12	1.46027	1.200097
Trade….of.GDP…NE.TRD.GNFS.ZS.	5.751962e+01	2.216535e+01	5.798385e+01	2.636892e+01	1.159245e+02	0.62203	-0.404426
Net.trade.in.goods.and.services..BoP..current.US….BN.GSR.GNFS.CD.	-3.315405e+10	1.630969e+11	-2.752387e+09	-5.810000e+11	2.610000e+11	-1.84002	4.279937

Exports.of.goods.and.services..current.US….NE.EXP.GNFS.CD.	5.450169e+11	7.332148e+11	2.270000e+11	2.263673e+08	2.530000e+12	1.28462	0.486981
Goods.exports..BoP..current.US….BX.GSR.MRCH.CD.	3.983836e+11	5.337832e+11	9.629751e+10	9.120488e+07	1.680000e+12	1.20223	0.060986
Service.exports..BoP..current.US….BX.GSR.NFSV.CD.	1.443959e+11	2.219728e+11	2.567955e+10	5.236000e+07	8.760000e+11	1.79340	2.462460
Imports.of.goods.and.services….of.GDP…NE.IMP.GNFS.ZS.	3.337954e+01	1.360064e+01	3.180783e+01	1.357997e+01	8.246795e+01	0.98856	1.180867
Imports.of.goods.and.services..current.US….NE.IMP.GNFS.CD.	5.811968e+11	8.267694e+11	2.380000e+11	3.634235e+08	3.130000e+12	1.65643	1.992753
Service.imports..BoP..current.US….BM.GSR.NFSV.CD.	1.188018e+11	1.576561e+11	2.889638e+10	6.211579e+07	5.910000e+11	1.29315	0.696260

Trade.in.services….of.GDP…BG.GSR.NFSV.GD.ZS.	1.278568e+01	4.678388e+00	1.239958e+01	5.077524e+00	2.379473e+01	0.30341 95	-0.902719 8
Merchandise.trade….of.GDP…TG.VAL.TOTL.GD.ZS.	4.401817e+01	1.801398e+01	4.001551e+01	1.803204e+01	9.667429e+01	0.85073 06	0.03 80242
Exports.of.goods.and.services..annual…growth…NE.EXP.GNFS.KD.ZG.	4.578822e+00	1.084981e+01	3.350044e+00	-1.573328e+01	7.883376e+01	3.31518 25	18.6 25979 1
Imports.of.goods.and.services..annual…growth…NE.IMP.GNFS.KD.ZG.	5.579071e+00	1.010726e+01	4.012262e+00	-1.762924e+01	7.095780e+01	2.46007 06	13.4 02661 5
Gross.savings..current.US….NY.GNS.ICTR.CD.	5.803751e+11	9.792027e+11	2.500000e+11	-6.516410e+08	4.180000e+12	2.19476 92	4.20 84479
Gross.savings….of.GDP…NY.GNS.ICTR.ZS.	1.971142e+01	9.075189e+00	1.971735e+01	-7.779289e+00	4.869864e+01	-0.35018 28	1.06 61758

Table 2: Descriptive Statistics table

Correlation Analysis

Correlation analysis is a statistical method used in research to determine how closely two variables are connected and their relationship. For example, it tells how much one variable has changed because the other variable has changed. Strong correlation between the two variables is indicated by a high correlation., while a low correlation shows a weak relationship. In the case of statistical surveying, experts use this method to analyse quantitative data collected through reviews, live surveys, and other research methods. They look for patterns and meaningful connections between two variables or sets of data. For the correlation analysis in this section, we will be looking at correlation plots, the plot shows indicators for high, low and medium linear relationships. In the correlation plot below, the current GDP has high correlation with export, goods export, service export, service import good and others because the indicator linking those pairs of variables shows.

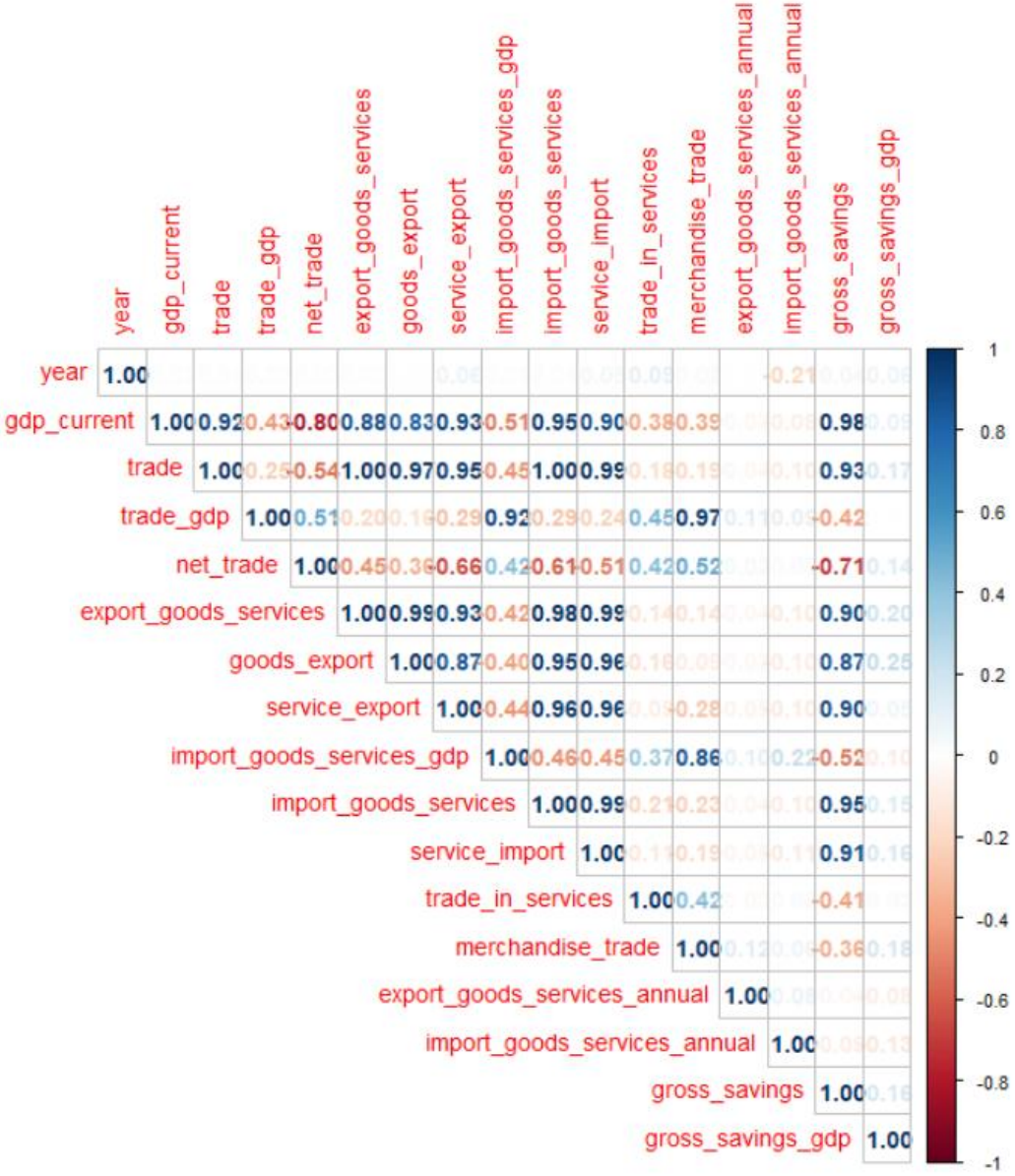

Figure 1: Corellation Analysis

Regression Analysis

In this section, we use simple and multiple linear regression to check for the factors that significantly affect GDP. The first regression model has a single dependent variable and one independent variable. The total number of observations after removing rows with missing values is 118. The F-test is statistically significant f(1,116)=396.37, p<0.001. This shows that the model is robust, and we can interpret the regression coefficient. The R-square is also estimated to be 0.77. The R-square can be interesting in that 77% of the total variability of GDP can be explained by export goods. The result of the R-squared shows that exporting goods is a significant factor while studying the GDP of any nation.

The calculated slope of the simple linear regression is 5.95, which, assuming that all other factors remain constant, can be translated as a unit increase in exports increasing GDP by 5.95 units.

```
summ(model_1)
```

```
## MODEL INFO:
## Observations: 118
## Dependent Variable: gdp_current
## Type: OLS linear regression
##
## MODEL FIT:
## F(1,116) = 396.37, p = 0.00
## R² = 0.77
## Adj. R² = 0.77
##
## Standard errors: OLS
## ------------------------------------------------------------------
-------------
##                                            Est.               S.E.
t val.      p
## --------------------------- ------------------ ----------------- --
------ ------
## (Intercept)                    -483461323599.26   273610291145.40
-1.77   0.08
## export_goods_services                      5.95              0.30
19.91   0.00
## ------------------------------------------------------------------
-------------
```

Figure 2: Model 1 Regression Analysis

The second regression model has one dependent variable and one independent variable. The total number of observations after removing rows with missing values is 118. The F-test is statistically significant f(1,116)=1712.76, p<0.001. This shows that the model is robust, and we can interpret the regression coefficient. The R-square is also estimated to be 0.94. The R-square can be interesting in that 94% of the total variability of trade GDP can be explained by merchandise trade. The result of the R-squared shows that exporting goods is a significant factor while studying the GDP of any nation.

The slope of the simple linear regression is estimated at 1.19, which can be interpreted as a unit increase in merchandise trade increasing the trade GDP by 1.19 units provided that all things remain constant.

```
model_2 <- lm(trade_gdp~merchandise_trade, worlddevelopment_reduced)
summ(model_2)

## MODEL INFO:
## Observations: 118
## Dependent Variable: trade_gdp
## Type: OLS linear regression
##
## MODEL FIT:
## F(1,116) = 1712.76, p = 0.00
## R² = 0.94
## Adj. R² = 0.94
##
## Standard errors: OLS
## ------------------------------------------------------
##                          Est.   S.E.   t val.      p
## ---------------------- ------ ------ -------- ------
## (Intercept)              5.22   1.37     3.82   0.00
## merchandise_trade        1.19   0.03    41.39   0.00
## ------------------------------------------------------
```

Figure 3: Model 2 Regression Analysis

One dependent variable and two independent variables make up the third regression model. The total number of observations after removing rows with missing values is 118. The F-test is statistically significant f(2,115)=2371.23, p<0.001. This shows that the model is robust, and at least one of the independent variables has a coefficient different from zero(0). The R-square is also estimated to be 0.98. The R-square can be interesting in that 98% of the total variability of trade GDP can be explained by export and import goods service. The R-squared result shows that exporting and importing goods and services are significant factors while studying the GDP of any nation.

The slope of the simple linear regression is estimated at -10.53 and 14.86 for export goods service and import goods service, respectively. The slope for the export goods services can be interpreted as a unit increase in export goods services, decreases the GDP by 10.53 units provided that other variables or factors are kept constant. In the same way, a unit increase in import goods services increases the GDP by 14.85 units and vice versa, provided that all other factors are kept constant.

```
summ(model_3)

## MODEL INFO:
## Observations: 118
## Dependent Variable: gdp_current
## Type: OLS linear regression
##
## MODEL FIT:
## F(2,115) = 2371.23, p = 0.00
## R² = 0.98
## Adj. R² = 0.98
##
## Standard errors: OLS
## ------------------------------------------------------------------------
-----
##                                        Est.             S.E.   t val.
p
## -------------------------- ------------------ ---------------- -------- -
-----
## (Intercept)                -134076933307.29   89557174578.85    -1.50
0.14
## export_goods_services                -10.53             0.53   -19.71
0.00
## import_goods_services                 14.86             0.47    31.38
0.00
## ------------------------------------------------------------------------
-----
```

Figure 4: Model 3 Regression Analysis

In conclusion, the residual of the multiple regression model for regression analysis will be assessed by checking the Homogeneity of variance, serial correlation, and normality of the residual. The normal Q-Q plot shows that the points deviate significantly from the starlight line, which indicates the non-normality of the residual. The residual and leverage plot also shows that a particular observation deviates from zero (0) point, which shows heterogeneity of variance in the dataset. In contrast, the scale shows gaps in the distribution. Having noticed the results generated from the residual analysis, A quick check was conducted on the dataset, and the disparity in the residual model is due to the considerable gap in the GDP of the countries considered. The GDP of developed nations is quite different from underdeveloped countries. However, the Large R-square and the robustness of the f-test statistics validate the regression model.

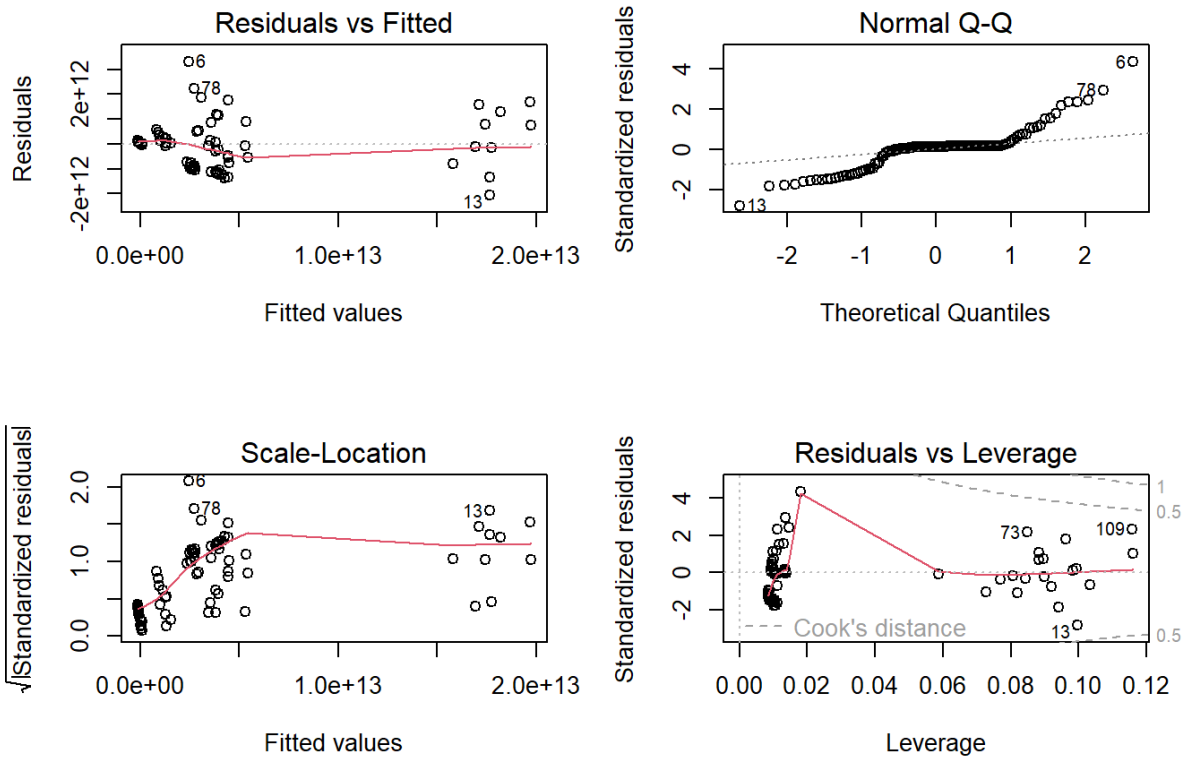

Figure 5: Regression Analysis Results

Time Series Analysis

The dependent variable for this study is the GDP, and we will be applying two forecast models to the GDP of the developed and underdeveloped countries. The Moving average method and the Holt-winter method of forecast will be applied. Firstly, we would plot the time plot to show

possible drift or linear trend in the dataset. The time plot below, does not show any trend from 2016 upward.

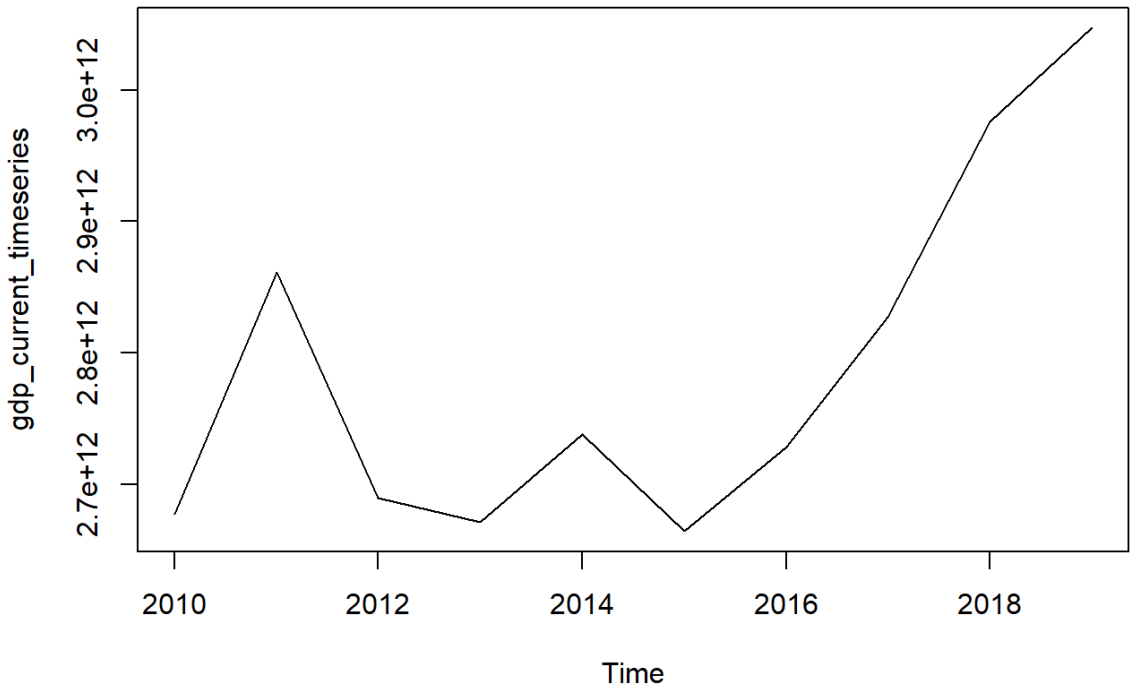

Figure 6: Time plot

3 Step Moving Average Method (SMA3)

A moving average is a way to get an idea of the overall trends in a set of numbers. It is the average of any subset of numbers. A moving average is an excellent tool for figuring out what long-term trends will be like. We can figure it out for any time frame. For example, in our database, GDP data from years back, we can figure out the average for the last five years, four years, three years, and so on. In this study, we will consider the 3 years moving average to smooth the forecast out, and the plot for the GDP is given below.

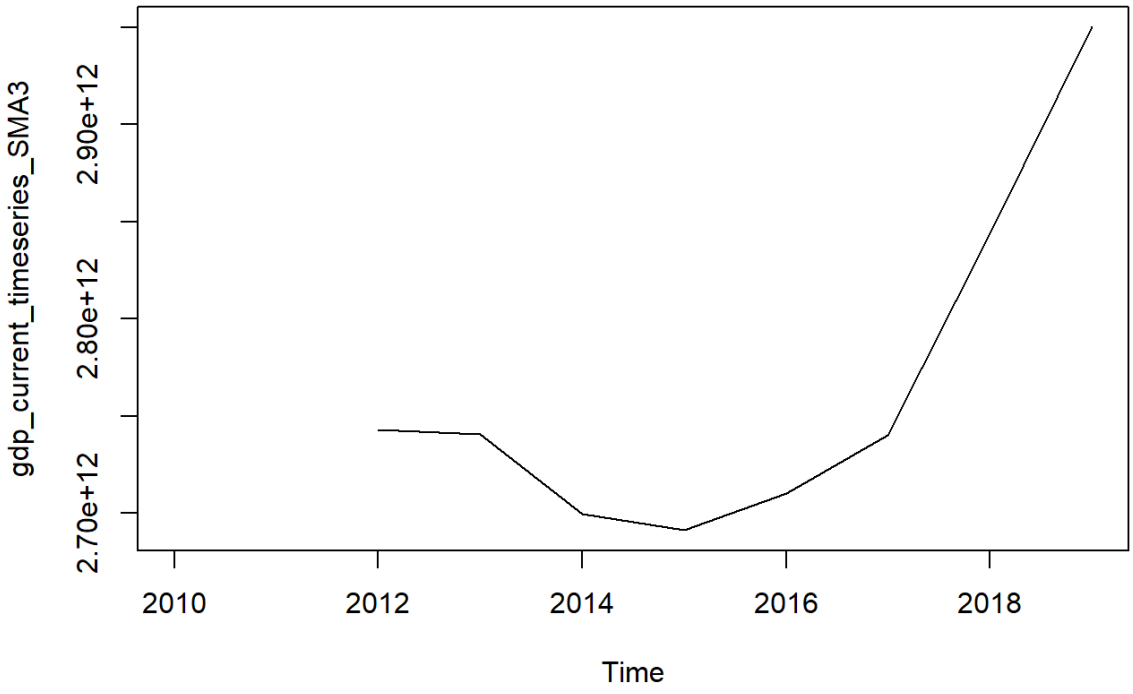

Figure 7: 3 Step Moving Average Method (SMA3)

To have grasp understanding of how smooth the data is, and how effective it is to predict the total GDP in the country, the overlay plot is given below.

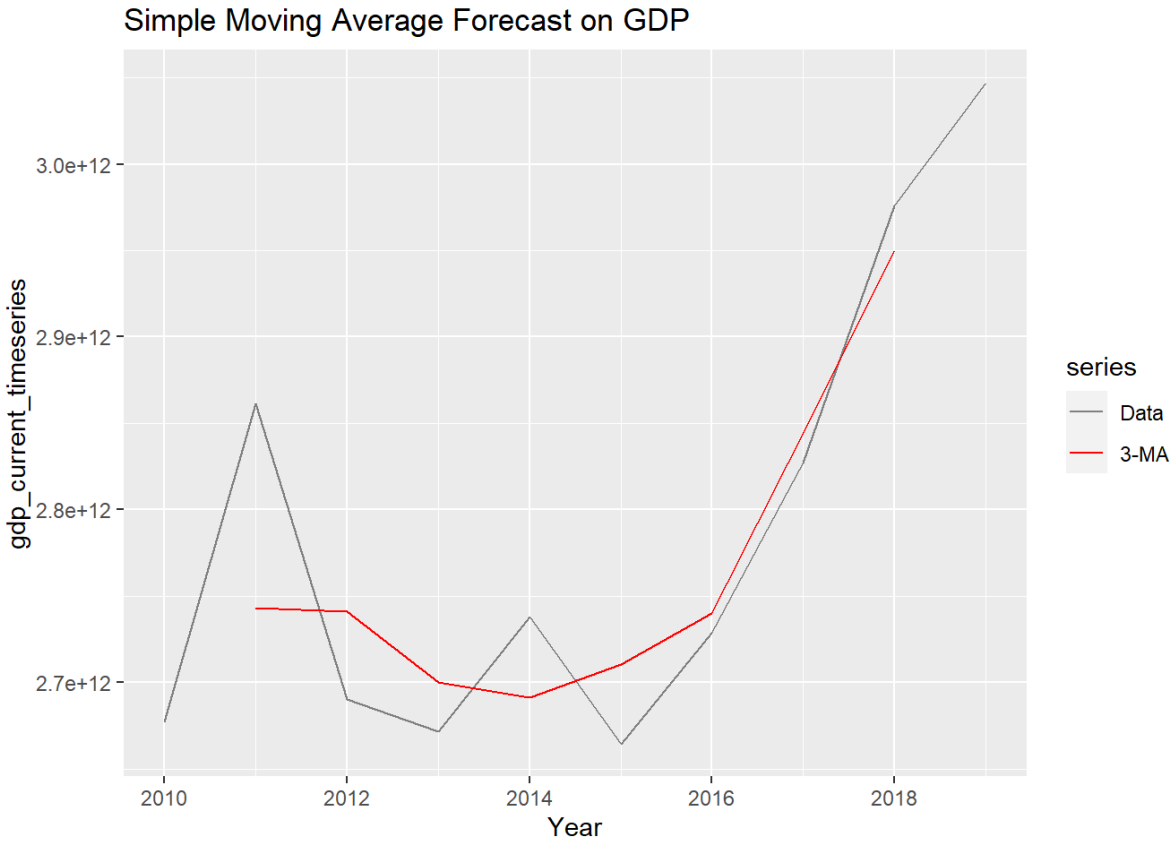

Figure 8: Simple Moving Average Forecast on GDP

Holt-Winters Method

The Exponential smoothing is applied to the GDP, and the forecast was done after that. The smoothing parameter alpha is estimated to be 1, while the beta is estimated as approximately 0.45. The alpha is the general smoothing parameter, while the beta is the trend smoothing parameter.

```
#Forecast using Exponential Soothing
gdp_current_timeseries_forecasts <-
HoltWinters(gdp_current_timeseries,gamma=FALSE)
gdp_current_timeseries_forecasts

## Holt-Winters exponential smoothing with trend and without seasonal
component.
##
## Call:
## HoltWinters(x = gdp_current_timeseries, gamma = FALSE)
##
## Smoothing parameters:
##  alpha: 1
##  beta : 0.4499125
##  gamma: FALSE
##
## Coefficients:
##           [,1]
## a 3.047148e+12
## b 8.563561e+10
```

Figure 9: Forecasting using Exponential Soothing

After the smoothing procedure viz alpha and beta for general and trend respectively is applied. Then, finally, the forecast for 10 years was applied. The fitted (forecast values) and the observed (original dataset) were thus plotted to see if both the forecast and the fitted observation followed the same pattern. The result for the filtering of Holt-winters methods is given in the chart below.

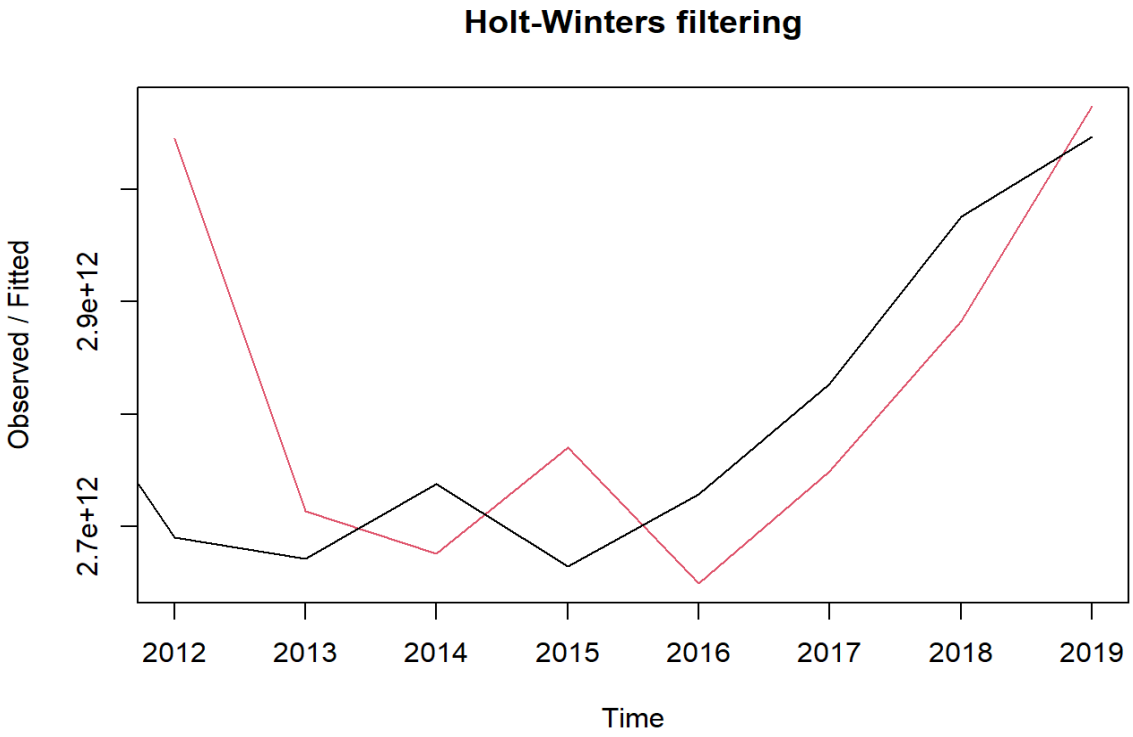

Figure 10: Holt Winters Method

The forecast plot and the steps predicted with 95% confidence interval bandwidth is given below.

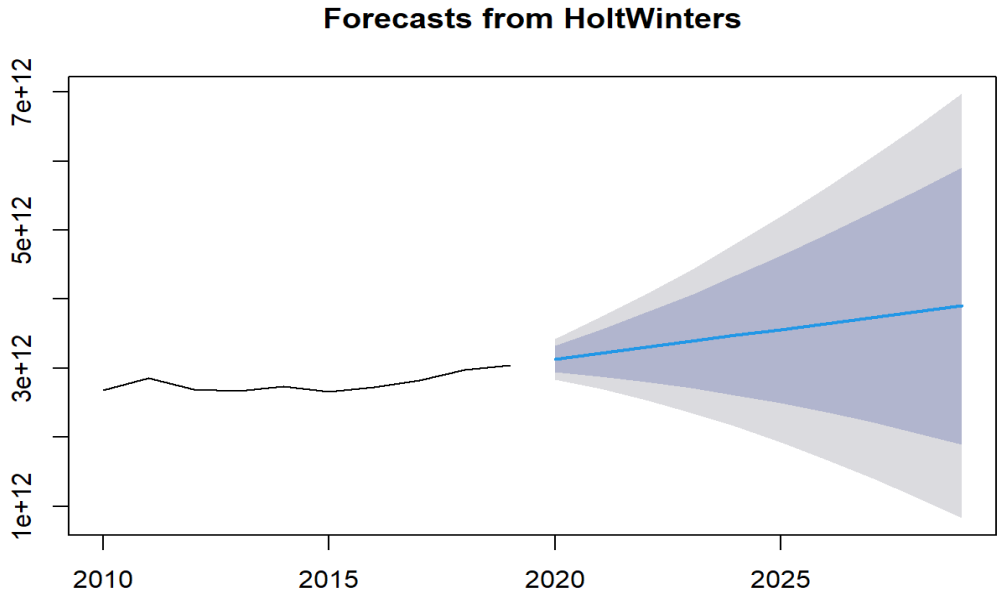

Figure 11: Forecast Plot from Holt Winters Method

Hypothesis testing

Normality Test

Normality assumption is one of the most critical assumption tests for the parametric model. The regression model and the time series model need the basis of the normal assumption test before we can rely on the result generated. As part of the objective of this study, we aimed to check the assumption of the test to see if the model selected is fit for use with the available dataset. The result of the normality test is given below.

Null Hypothesis: The amount of GDP across the country is normally distributed.

Alternate Hypothesis: Total GDP across the country is not normally distributed.

Test statistics: Shapiro-Wilk Test (See result below)

Alpha (Level of significance)= 0.05

Decision Rule: Reject the null hypothesis if the p-value for any of the country is less than 0.05, other

Decision: We fail to reject the null hypothesis for all the countries as the p-value is greater than 0.05. This is because different countries have a normal distribution of their GDP for the period in which we analyse the dataset.

```
byf.shapiro(gdp_current ~ country, data=worlddevelopment)

##
##  Shapiro-Wilk normality tests
##
## data:  gdp_current by country
##
##                     W p-value
## Australia      0.9647  0.8381
## Bhutan         0.9127  0.2998
## Canada         0.9247  0.3977
## Ethiopia       0.9576  0.7867
## Gambia, The    0.9469  0.6315
## Germany        0.9352  0.5012
## Guinea         0.8976  0.2059
## Haiti          0.9436  0.5937
## Japan          0.8830  0.1414
## Mali           0.9486  0.6525
## United Kingdom 0.9769  0.9467
## United States  0.9737  0.9226
```

Figure 12: Hypothesis Test result

Homogeneity test

Null Hypothesis: The variances in the GDP per country is the same .

Alternate Hypothesis: The variances in the amount of DGP of the different country is different

Alpha(Significance level): 0.05

Test Statistics: Bartlett Test of Homogeneity of Variance.

Decision Rule: Reject the null hypothesis if the p-value for the test is less than 0.05.

Decision: We reject the null hypothesis that the variances in the amount of GDP of different countries is the same p-value<0.001.

Therefore, the result of the homogeneity test is in line to check the underlying assumption in this study. First, the leverage versus residual plot indicates that variance is homogeneous in the test. However, we could only deduce that from a model plot. The Bartlett test gives us an inferential test to back our claim.

```
bartlett.test(gdp_current ~ country, data=worlddevelopment)

##
##  Bartlett test of homogeneity of variances
##
## data:  gdp_current by country
## Bartlett's K-squared = 705.67, df = 11, p-value < 2.2e-16
```

Figure 13: Bartlett Test Result

5. Discussion

International trade and the valuation of a country's currency are perpetually intertwined, making the analysis of the correlation between imports and exports and the exchange rate difficult. The magnitude of the trade surplus or deficit influences the exchange rate, which in turn influences the exchange rate. As a rule, a weaker home currency encourages exports while increasing the price of imported goods. A robust native currency, on the other hand, reduces competitiveness in export markets while lowering the cost of imports (Dorosh, 2001).

When a country spends money to buy goods from another, it is called a trade deficit. This is because companies in the importing country pay exporters in the supplying country. Strong consumer demand and an expanding economy are reflected in a high volume of imports. Suppose most of these imports are productive assets, such as machinery and equipment. This is even better for the importing country because productive assets will boost economic output in the long run.

To have rising exports and imports is a sign of a thriving economy. This indicates a healthy economy and a trade surplus or deficit that can be maintained. The opposite trend may rise in exports accompanied by a drop in imports—could indicate that other economies are in better form than the U.S. economy. However, if imports are increasing while exports are falling, it may indicate that local economic circumstances are improving at the expense of those in overseas markets.

The merchandise trade balance report is the most reliable tool for studying a country's foreign trade activities. Most significant countries publish this report monthly (Michelis and Zestos, 2004).

Holt-Exponential Winter's Smoothing, named after the two people who worked on it, Charles Holt and Peter Winters, is one of the oldest techniques for analyzing time series. It forecasts by taking into account the trend and seasonality. This method for making predictions has three main parts. First, with the way things are going and the time of year, it has a mean value. The three parts are three different kinds of exponential smoothing, so winter's method is called triple exponential smoothing.

6. Conclusions

In this study, we extracted 12 countries from developed and underdeveloped countries. First, the regression model helps us ascertain that import goods, services and export goods services, and trade GDP are essential components in predicting the GDP of both developed and underdeveloped countries. Then, a simple moving average and the exponential smoothing time series model were fitted to forecast the total GDP. From the model, the Holt-winter model performs best as it has a lower error term when both fit the observed data with the relevant information. Holt-Exponential Winter's Smoothing, named after the two people who worked on it, Charles Holt and Peter Winters, is one of the oldest techniques for analyzing time series. It forecasts by taking into account the trend and seasonality. This method for making predictions has three main parts. First, with the way things are going and the time of year, it has a mean value. The three parts are three different kinds of exponential smoothing, so winter's method is called triple exponential smoothing.

Part Three: References

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