Statistical Study of Strength of Indian Defense

A Project report submitted in partial fulfillment of requirements for the Degree of M.Sc. (Statistics) with specialization in Industrial Statistics

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CERTIFICATE

This is to certify that Mr. Atul Dilip Salunke and Mr. Vishal Rajendra Motirale students of M.Sc. (Statistics) with specialization in Industrial Statistics, at kavayitri Bahinabai Chaudhari, North Maharashtra University, Jalgaon have successfully completed their project work entitled Statistical study of Strength of Indian Defense as a part of M.Sc. (Statistics) program under my guidance and supervision during the academic year 2022-2023.

(Dr. R. D. Koshti)
Project Guide

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We are grateful to our friends and the entire non-teaching staff of the Department of Statistics for their assistance and for providing us with the necessary laboratory and other facilities.

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CHAPTER 1: OVERVIEW OF THE PROJECT

INTRODUCTION

Over the years, either openly or covertly, weapons have been traded across borders, despite multiple domestic and international regulations aiming to control, forbid, prohibit or protect such arms commerce. During the Cold War, arms trade and transfers were mainly considered and commented on from an ideological point of view. After the fall of the Berlin Wall economic drivers gained importance in conferring meaning to the motives and consequences underlying arms transfers. From then on, access to foreign markets has been regarded essential for a thriving domestic arms industry in the long run.

"Only the equal power ensures the peace'' it is the reason why every country is focusing more on advancement and increasing the defense power of itself and defense power of a country depends particularly on how advanced weapons is used by the defense of that particular country, So it's become necessary for every country to have great source of arms and weapons. Many countries try to produce their required weapons by their own but to have variety of weapons or sometimes due to lack of production facilities countries imports the required arms and weapons from different countries and countries who have those weapons exports it for economic betterment and also leads to good international relationships, as it's been a observation that the countries having deal of exchange of arms and weapons seems to have good relation among them.

Strength of defense of a country not only depends on how much and how advanced weapons the country is using but also depends on some other factors such as the budget provided to the defense by the country, number of personals working as a professionals in different sector of defense of the country, quantity of weapons they are producing i.e. exports to other countries and how much arms and weapons it's importing.

Study of Indian defense and its import and export of arms and weapons is main objective of this project, Since India has been biggest importer of arms and weapons, have great man power, good budget but lagging behind in producing the arms and weapons by its own and exporting it to other countries and as we are importing maximum of the required weapons, Analyzing it will make it easier to study and will help to strengthen India.

Objective / Aim of the project:

1) To be familiar with import and export of different countries and use statistical techniques to make its study simplified.
2) To make index which shows strength of the countries using parameters Import, Export, Defense personals and Budget.
3) To predict the values of Import and Export using Time series analysis for next few years.
4) To formulate the India's index score for few years using regression analysis.
5) To get experience of how to handle the real life datasets.

Motivation:

Being a student of M.Sc –II (statistics) with specialization in Industrial Statistics, we were interested in study of how statistical technique can make the difficult study simplified and can make conclusion for real life data. Our one of the motivation of this project is to apply some of the relevant statistical techniques to real life data.

Chapter 2: Statistical tools

1) ARIMA Model:

- p (order of Autoregressive component): It represents the number of lagged values of the time series that are considered for predicting the current value. The autoregressive component captures the linear relationship between the current value and the past values. For example, an $ARIMA(2,1,0)$ model considers the two most recent lagged values.
- d (order of Differencing component): It indicates the number of differencing operations applied to the time series to make it stationary. Differencing is performed to remove trends and make the series more stationary, which simplifies the modeling process. Differencing can be applied multiple times until the series becomes stationary.
- q (order of Moving Average component): It represents the number of lagged forecast errors (residuals) that are considered for predicting the current value. The moving average component captures the dependency between the current value and the residual errors from previous predictions. For example, an $ARIMA(0,1,2)$ model considers the two most recent forecast errors.

By combining these three components (AR, I, MA), ARIMA models can capture a wide range of time series patterns. The order values (p, d, q) are determined based on the characteristics of the specific time series being modeled. These values can be estimated through methods such as autocorrelation function (ACF) and partial autocorrelation function (PACF) analysis. It's important to note that ARIMA models assume that the underlying time series is stationary, meaning its statistical properties, such as mean and variance, do not change over time. If the time series is non-stationary, differencing (d) is applied to make it stationary before fitting the ARIMA model.

ARIMA models have been widely used in various fields, including economics, finance, sales forecasting, and weather prediction, among others. They provide a flexible framework for analyzing and forecasting time series data.

2) Exponential Smoothing:

Exponential smoothing is a popular time series forecasting technique that assigns exponentially decreasing weights to past observations while generating predictions. The

basic idea behind exponential smoothing is to calculate a weighted average of past observations, with the weights decreasing exponentially as the observations become more distant in the past.

There are several variations of exponential smoothing models, including:

- Simple Exponential Smoothing (SES): In SES, each observation is given a weight, and the forecast for the next period is calculated as a weighted average of the previous observations. The weights decrease exponentially over time, and there is a smoothing parameter (often denoted as alpha) that controls the rate of decay. SES is suitable for time series data without any trend or seasonality.
- Holt's Linear Exponential Smoothing: Holt's linear method extends SES by incorporating trend information. It uses two components: level (the current value of the series) and trend (the rate of change). The forecast is generated by adding the level and trend components. Holt's linear method is useful when there is a trend in the time series but no seasonality.
- Holt-Winters' Exponential Smoothing: Holt-Winters' method expands on Holt's linear method by considering both trend and seasonality. It incorporates three components: level, trend, and seasonality. Seasonal patterns are captured using seasonal indices or dummies. Holt-Winters' method is suitable for time series data with both trend and seasonality.

Exponential smoothing models can be easily implemented and are computationally efficient. They are particularly useful when there are no complex patterns in the time series or when the data exhibit a smooth trend or seasonality.

The choice of the appropriate exponential smoothing method depends on the characteristics of the time series data and the specific forecasting requirements. Different smoothing methods can be selected based on whether the data exhibit trend, seasonality, or both. Additionally, the smoothing parameters need to be appropriately tuned, which is often done through optimization techniques or cross-validation.

3) Principal Component Analysis (PCA):

Principal Component Analysis (PCA) is a widely used technique for dimensionality reduction and data analysis. It is used to identify patterns and structures in high-dimensional data by transforming the original variables into a new set of uncorrelated variables called principal components.

The main objective of PCA is to reduce the dimensionality of the data while retaining as much information as possible. The principal components are ordered in such a way that the first component captures the maximum amount of variance in the data, followed by the second component capturing the next highest amount of variance, and so on.

Here's an overview of the PCA process:

- Standardize the data: PCA requires the data to be standardized so that each variable has zero mean and unit variance. This is done to ensure that variables with larger scales do not dominate the analysis.
- Compute the covariance matrix or correlation matrix: PCA analyzes the relationships between variables. The covariance matrix measures the covariances between pairs of variables, while the correlation matrix measures the correlations between pairs of variables. The choice between covariance and correlation depends on the nature of the data and the objective of the analysis.
- Compute the eigenvectors and eigen values: The eigenvectors and eigen values of the covariance or correlation matrix provide information about the principal components. The eigenvectors represent the directions or axes in the original feature space, while the eigen values indicate the amount of variance explained by each eigenvector.
- Sort the eigen values and select the principal components: Sort the eigen values in descending order. The eigenvector corresponding to the largest eigen value represents the first principal component, the one with the second largest eigen value represents the second principal component, and so on. Typically, you would select a subset of the principal components that capture a significant amount of variance, aiming to retain most of the information.
- Transform the data: Multiply the original data by the eigenvectors of the selected principal components. This transformation maps the data from the original feature space to the new feature space defined by the principal components.

PCA has various applications in fields such as data analysis, image processing, signal processing, and feature extraction. It is a powerful tool for understanding and analyzing complex datasets and is often used as a pre-processing step in machine learning tasks.

4) Factor Analysis:

Factor Analysis is a statistical technique used to identify underlying factors or latent variables that explain the interrelationships among a set of observed variables. It aims to reduce the dimensionality of the data by grouping variables that are highly correlated into a smaller number of factors.

The main goal of factor analysis is to understand the structure of the data and to determine the underlying factors that explain the observed patterns. It assumes that the observed variables are influenced by a smaller number of unobserved factors that are not directly measurable.

It's important to note that factor analysis has assumptions, such as the linearity and normality of the data, and it may not be appropriate for all types of data or research questions. Additionally, interpretation of the factors requires careful consideration and should be guided by theory and prior knowledge.

5) Multiple linear regression :

Multiple linear regression is a statistical technique used to model the relationship between a dependent variable and multiple independent variables

n multiple linear regression, the goal is to estimate the coefficients (slope) of the independent variables to determine their impact on the dependent variable, while accounting for their collective effects. The model assumes a linear relationship between the dependent variable and the independent variables.

Here's an overview of the multiple linear regression process:

- Formulate the research question: Clearly define the research question and identify the dependent variable and the independent variables to be included in the model.
- Collect and prepare the data
- Specify the model: Define the mathematical equation that represents the multiple linear regression model. The equation takes the form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon$$

  where Y is the dependent variable, β_0 is the intercept term, $\beta_1, \beta_2, \ldots, \beta_k$ are the coefficients of the independent variables $X_1, X_2, \ldots, X_k$, and ε is the error term representing the unexplained variation.
- Estimate the model coefficients: Use a suitable method, such as ordinary least squares

(OLS), to estimate the coefficients of the model. The estimation process aims to find the best-fitting line that minimizes the sum of squared differences between the observed values and the predicted values.

- Assess the model fit: Evaluate the goodness of fit of the model to determine how well it explains the variation in the dependent variable. Common metrics include the coefficient of determination (R-squared), adjusted R-squared, and F-test.
- Interpret the coefficient estimates: Examine the estimated coefficients to understand the relationships between the independent variables and the dependent variable. Positive coefficients indicate a positive relationship, while negative coefficients indicate a negative relationship. The magnitude of the coefficients represents the strength of the relationship, holding other variables constant.
- Check assumptions and perform diagnostics: Perform diagnostic checks, such as residual analysis, to ensure the model assumptions are met.
- Make predictions and inference: Use the estimated regression equation to make predictions of the dependent variable for new observations. Conduct hypothesis tests or confidence interval estimation to make inferences about the coefficients and assess their statistical significance.

Multiple linear regression provides insights into the direction and magnitude of the effects of the independent variables on the dependent variable, allowing for data-driven decision-making and understanding of complex relationships.

CHAPTER 3: IMPORT OF ARMS AND WEAPONS

SIPRI i.e. Stockholm International Peace and research Institute releases data every year for arms and weapons transfers and their trades. Studying specifically on the import's dataset provided by the SIPRI as import is a necessary for any country to have variety of weapons as no country can have the every required technology and to provide their defense with maximum variety of technology of weapons. Though import of arms and weapons is necessary factor for defense technology advancement, still countries are trying to cut off maximum of their import from other countries as importing the weapons from other countries takes greater loss of money and depending mostly on other countries for import of arms and weapons takes higher part of our economy, instead of that of many countries started producing arms and weapons by its own its reduces their extra expenditures on taxes and other facilities and also provide country chance to export that weapons to other countries and can add great part to its economy and also maintains good relation with those countries.

In this study we have undertaken import of 50 countries under study and have used statistical techniques to study it, our main objective is to study the import of India from 1990 to 2022 and trend India following for decades as India is the largest importer in world of arms and weapons shares a large part of its economy for importing the weapons and India's choice of arms trade partners has changed significantly over time as the country strives to reduce dependence on old partners such as Russia. India spends around 2.3 per cent of its Gross Domestic Product (GDP) on defense and accounts for 15 per cent of the global arms import. The Indian government had planned to spend USD 64.4 billion to equip and modernize the second largest armed forces in the world in the current financial year.

1. Worldwide import of arms and weapons.

The following Table 1 showing the top 50 importers of world and their total import of weapons from 1990 to 2022.

Table 1: Worldwide Top 50 weapon Importers

Rank	Country	Total import (1990-22)	Rank	Country	Total import (1990-22)	rank	Country	Total import (1990-22)
1	India	74777	18	Qatar	12833	35	Morocco	6676
2	Saudi Arabia	52313	19	Kuwait	10665	36	Poland	6618
3	China	49703	20	Canada	10096	37	Finland	6572
4	South Korea	36567	21	Indonesia	9868	38	Myanmar	6357
5	Turkey	32369	22	Iraq	9868	39	Venezuela	6313
7	Egypt	31109	23	Viet Nam	9272	40	Bangladesh	5500
6	Japan	30343	24	Norway	9009	41	Oman	5158
9	Pakistan	26288	25	Italy	8741	42	Syria	4935
8	UAE	26220	26	Thailand	8619	43	Jordan	4333
10	Australia	25668	27	Iran	8532	44	Portugal	4279
11	Taiwan	23727	28	Spain	8301	45	Switzerland	4265
12	Greece	22906	29	Netherlands	7678	46	Azerbaijan	4213
13	United States	21727	30	Brazil	7602	47	South Africa	4155
14	Algeria	19257	31	Germany	7536	48	Mexico	3986
15	United Kingdom	19108	32	Afghanistan	7471	49	France	3941
16	Israel	18457	33	Chile	7146	50	Colombia	3485
17	Singapore	15124	34	Malaysia	6955			

India is the largest importer of world for import of 1990-2022 followed by Saudi Arabia, China, South Korea and Turkey. India alone is importing 8.89% of total import of the world and top 5 importers are importing 32.47% of world's import which is huge part to import.

2. STUDY OF TOP 10 IMPORTERS.

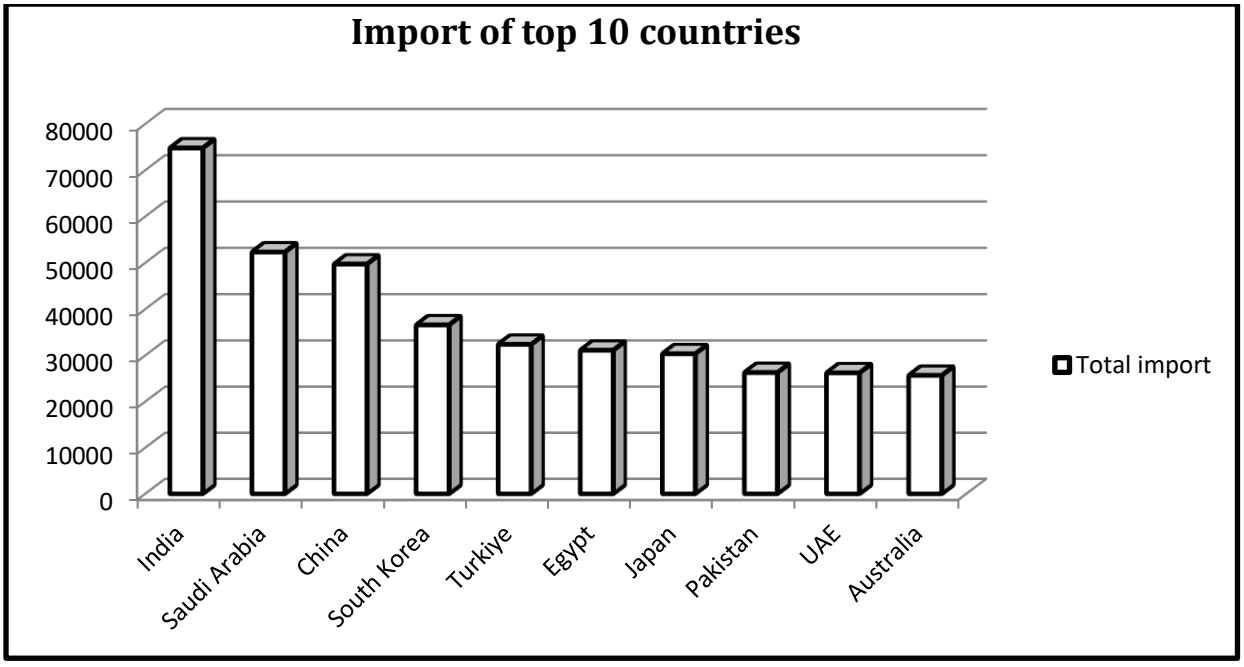
The following Table 2 shows the top 10 countries, their total import from year 1990-2022 and their contribution percentage in worlds total import of arms and weapons (Contribution percentage is calculated considering all 50 countries under study).

Table 2: Top 10 weapon importers and their Contribution

Rank	Country	Total import (1990-22)	Contribution (in %)
1	India	74777	9.8828
2	Saudi Arabia	52313	6.9138
3	China	49703	6.5689
4	South Korea	36567	4.8328
5	Turkey	32369	4.2780
7	Egypt	31109	4.1115
6	Japan	30343	4.0102
9	Pakistan	26288	3.4743
8	UAE	26220	3.4653
10	Australia	25668	3.3924

Contribution percentage is calculated from the formula:

(Country's import/756641)*100 where 756641 is the total import by all 50 countries.



The above simple bar diagram shows the behavior of top 10 countries with respect to their imports of weapons. This graph shows that, globally India is the largest importer of weapons.

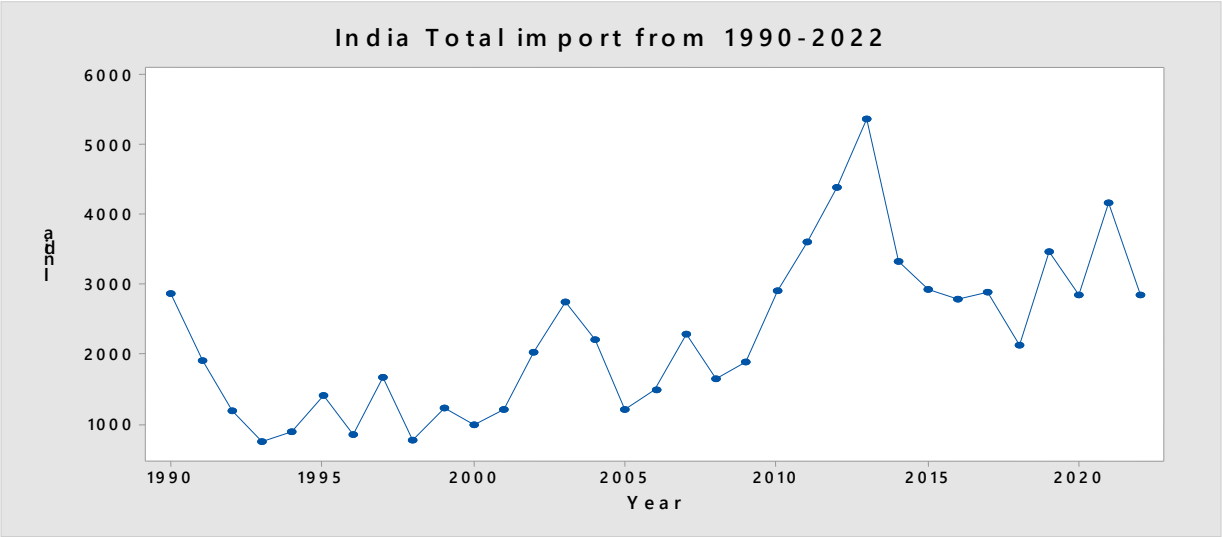
3. STUDY OF INDIA'S IMPORT.

The following Table 3 shows the data for India's year wise imports of arms and weapons from the year 1990 to 2022 which is in million US dollar.

Table 3: India's year wise imports of arms and weapon

Year	Import (in US $)	Year	Import (in US $)
1990	2861	2007	2281
1991	1896	2008	1644
1992	1190	2009	1884
1993	740	2010	2898
1994	886	2011	3610
1995	1403	2012	4396
1996	851	2013	5367
1997	1673	2014	3330
1998	757	2015	2928
1999	1215	2016	2782
2000	983	2017	2892
2001	1201	2018	2118
2002	2031	2019	3470
2003	2743	2020	2847
2004	2214	2021	4167
2005	1198	2022	2846
2006	1475		

- **Time Series Plot of Import of India**



From above time series plot we observed that overall trend of India's arms import has increasing trend upto year 2013 and after that trend is decreasing. Specifically, from 1990 to 2022 trend attained its peak in 2013 and shows downwards movement from 2013 to

2018 and had a lowest import in year 1993. So overall India is trying to reduce its import and producing weapons by own and inaugurated many new project in direction of "Atmanirbharta".

4. WEAPONS IMPORTERS TO INDIA

As India is the highest importer of arms and weapons in the world but there are some specific countries which exports arms and weapons to India on a higher scale and on which India is highly dependable for its weapons import.

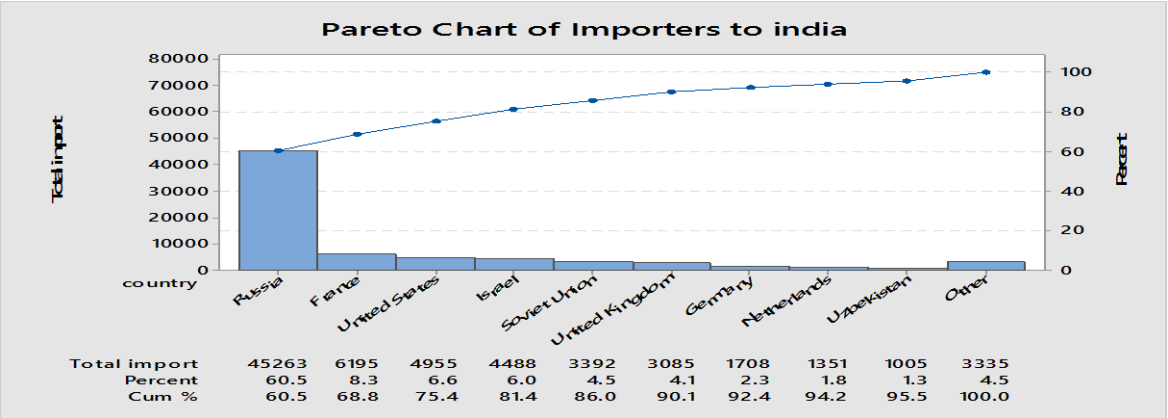
The following Table 4 shows the countries which exports their arms and weapons to India and their total exports to India from 1990 to 2022.

Table 4: Country wise Total exports of Arms to India from 1990 to 2022

Country	Total Export (in US $)	Country	Total Export (in US $)
Russia	45263	Slovakia	200
France	6195	South Africa	195
United States	4955	Kyrgyzstan	180
Israel	4488	Australia	108
Soviet Union	3392	Canada	106
United Kingdom	3085	Switzerland	94
Germany	1708	Sweden	55
Netherlands	1351	Brazil	21
Uzbekistan	1005	Singapore	19
Ukraine	681	Kazakhstan	17
South Korea	650	Denmark	14
Poland	514	Czechia	5
Italy	471	Unknown supplier(s)	5

India imports most of its weapons from 25 countries, specifically maximum from Russia followed by France, USA, Israel and Soviet Union. There are also some unknown suppliers to India for which we don't have any data other than the value of import.

- **Pareto chart for India's top Importers**



From this Pareto graph we can interpret that Russia and France contribute 68.8% of the total import of arms and weapons so does not follow the Pareto's property.

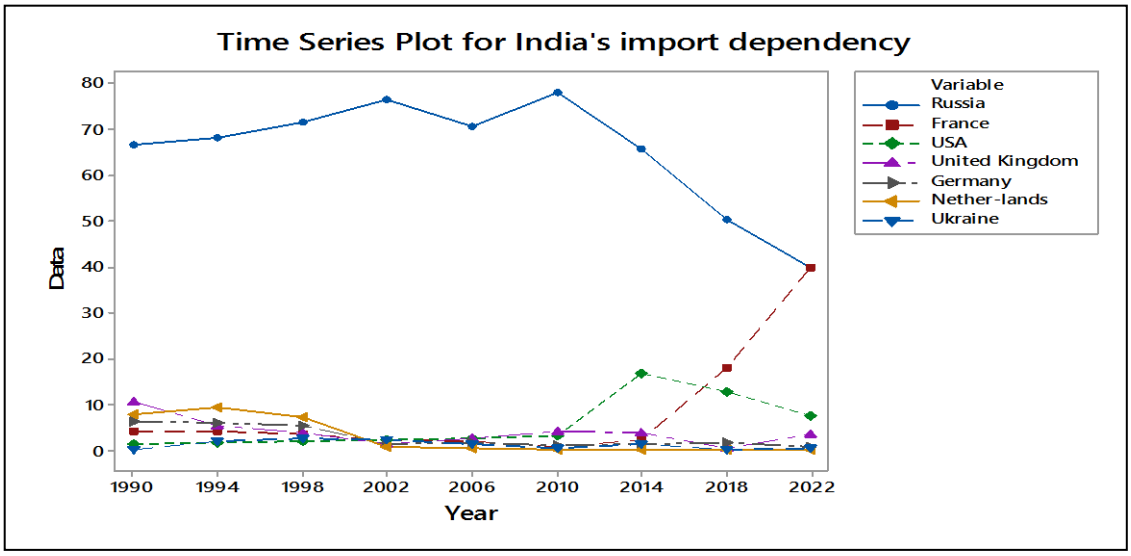
5. India's Dependency on other countries for weapon Import

The following Table 5 represents the India's dependency on other countries from 1990 to 2022.

Table 5: India's dependency on its Exporters from 1990 to 2022

Year\Country	Russia (in %)	France (in %)	USA (in %)	UK (in %)	Germany (in %)	Nether-lands (in %)	Ukraine (in %)
1990-93	66.682	4.038	1.236	10.707	6.206	7.851	0.209
1994-97	68.169	4.007	1.654	5.357	5.876	9.427	1.91
1998-2001	71.456	3.673	2.037	3.781	5.251	7.239	2.593
2002-2005	76.359	2.418	2.366	1.49	1.294	0.659	2.271
2006-2009	70.506	2.016	2.486	2.486	1.652	0.379	1.258
2010-2013	77.893	0.798	3.183	4.16	1.087	0.227	0.454
2014-2017	65.732	2.381	16.638	3.956	1.291	0.208	1.506
2018-2021	50.34	18.028	12.845	0.415	1.739	0.204	0.194
2021-2022	39.883	39.783	7.5	3.679	0.813	0.285	0.57
Average	65.224	8.571	5.549	4.004	2.801	2.942	1.219
Maximum	77.893	39.783	16.638	10.707	6.206	9.427	2.593
Minimum	39.883	0.798	1.236	0.415	0.813	0.204	0.194
Std. Dev.	12.3793	12.7895	5.6038	2.9252	2.2623	3.9653	0.9105

- **Time Series plot for India's dependency on top 7 importers of India**



India is highly dependent on seven countries for weapon import and specifically the Russia has been biggest importer for India. India is continuously trying to reduce its arms dependence on Russia. Overall, arms exports by Russia fell by 22%, which is majorly due to India's cut in arms imports. Arms imports by India fell by 33% between 2011-15 and 2016-20. On the other hand increase its dependency on France and USA from 2014 with major deals are Rafael fighter jets and S-400.

6. Weapon wise Import to India

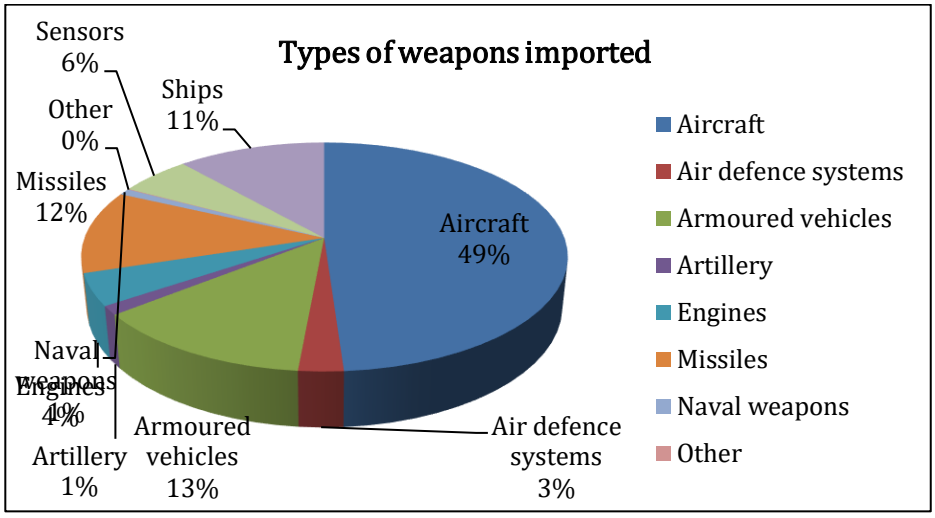
In weapon import India imports variety of weapons from starting period and demands of weapons have been changing decades by decades as per the requirements, So in this topic we will analyze and study the weapon wise import by India.

The following Table 6 gives an idea about different types of weapons and their total import from 1990 to 2021.

Table 6: Imports with respect to different types of weapons

Weapons	Import	Weapons	Import
Aircraft	35175	Missiles	8466
Air defense systems	1843	Naval weapons	637
Armored vehicles	9278	Other	60
Artillery	900	Sensors	4023
Engines	3249	Ships	8301
		Total	71932

- **Pie chart for weapon wise import by India.**



India is spending 49% of its weapons import budget on import of Aircraft, 13% on armored vehicles and 12% on missiles which is necessity of today's meaning of technology advancement. Though now we have high import but India is trying to cut down its import which is only possible if we stars manufacturing by our own and India has taken step for it for projects like "LCA TEJAS", " PROJECT 15A and B", " PROJECT 17A" and "AGNI MISSILES" etc.

7. Study of Top Three Most Imported Weapons:

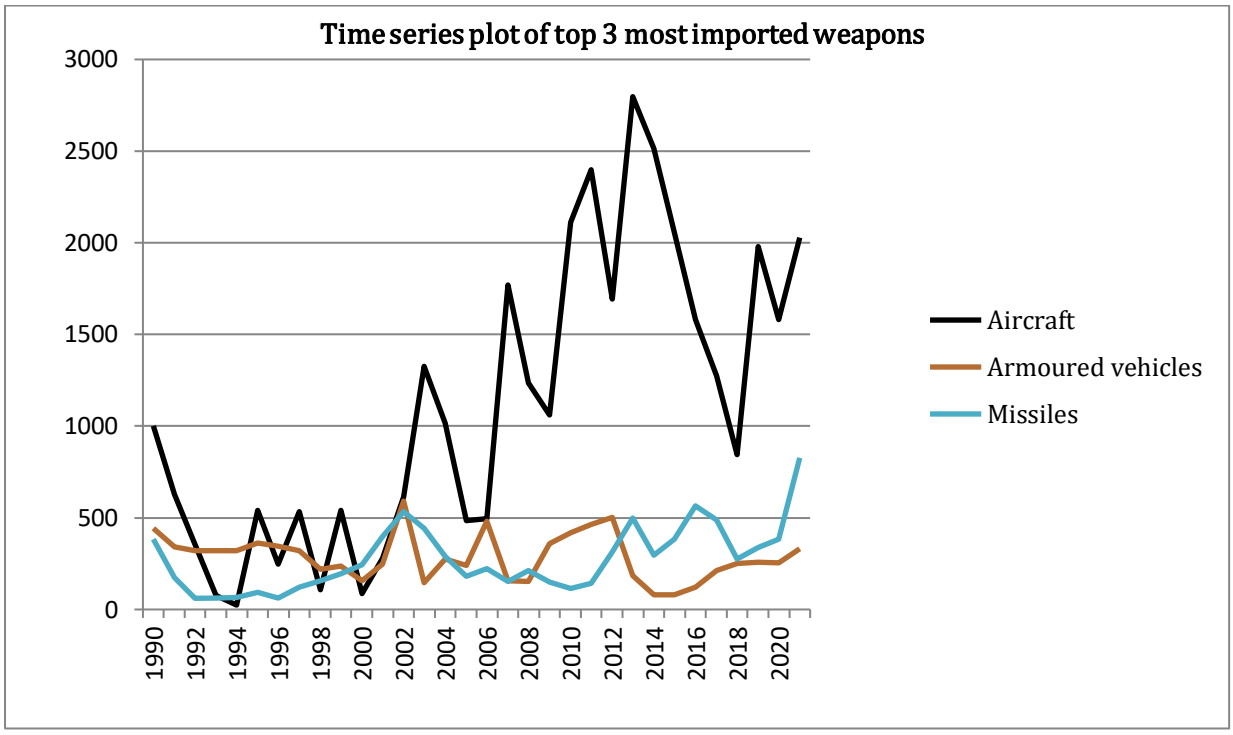
As we have observed that Aircraft, Missiles and Armored vehicles are the most imported weapons by India thus showing high interest in these weapons categories, so in this topic we are going to study changing pattern of these weapons import in the following Table 7.

Table 7: Year wise import of top 3 most imported weapons

Weapon\Year	1990-93	1994-97	1998-2001	2002-05	2006-09	2010-13	2014-17	2018-21
Aircraft	2062	1344	1010	3437	4561	8999	7425	6430
Armored vehicles	1428	1351	859	1253	1150	1570	493	1094
Missiles	682	340	989	1448	740	1071	1733	1823
Percentage	62.61	63.3	69.03	75.06	86.22	71.47	76.92	75.53

These the data showing import of Aircraft, Armored vehicles and Missiles from year 1990 to 2021 consist of percentage row which interprets from total weapons category how many percentage it cost only for Aircraft, Armored vehicles and Missiles in interval of 4 years.

- **TIME SERIES PLOT OF THREE MOST IMPORTED WEAPONS BY INDIA**



As per requirement for advancement in defense sector your air power must be advanced, in this way India shows increment in import of aircrafts spending. India shows high decrement in Aircraft from 2014 to 2018 as India started focusing more on self developing of aircraft and its parts. Similarly India shows decrement in missiles from 2001 as India started focusing more on projects like Agni, Trishul, Prithvi (Surface to air and surface to surface) lacked behind in Air to Air missiles so imported its Air to Air missiles specifically from Russia, France and USA also worked on Bhramhos missile with partnership of Russia, So with import India is also focusing on manufacturing the missiles.

During 1994 to 2000 period, India underwent significant economic reforms, including liberalization, privatization, and globalization. These reforms aimed to open up the Indian economy to international markets and attract foreign direct investment. As a result, domestic industries faced increased competition from foreign companies. This competition may have led to a reduction in imports as domestic industries became more efficient and capable of producing goods and services locally.

CHAPTER 4: DEFENSE STRENGTH INDEX

- **INTRODUCTION TO INDEX**

An index is a method to track the performance of a group of assets in a standardized way. There are numbers of Indices which studies numbers of aspects, such an indices and pattern of our data motivated us to make an index which will define the strength of defense of country based on few important parameters. The parameters of this index are

i) Import
ii) Export
iii) Defense Budget
iv) Defense Personals.

In this index we have taken 48 countries under study, we got the respective data for Import, Export, Budget and Defense personals from official website of SIPRI (Stockholm peace and research institute).

Country is specifically called powerful in terms of defense if it has its own forces to guard the nation and also to manage the security of nation, has a great source of arms and weapons, there are two sources of arms and weapons first one is External sources i.e. country is importing the weapons from other countries and second one is producing it by own i.e. having countries own government or private limited companies for manufacturing and advancement of the required weapons. When country is most dependent on imported weapons for its forces it would be risky as well as economically damaging for that nation, as imported weapons comes with deals and conditions with other taxes with it so it costs pretty more than its usual price and the risk factor is when the country which provides you respective weapons get through some type of national emergency stops its export of arms and weapons for its own security which would be risky for importing nation. So to be powerful also means one nation should have its own manufacturing companies and centre.

The budget and number of defense personals have always been deciding factors for strength of the nation. Defense budget of nation decides how advanced and modernized armed forces it will have and number of defense personals should always be high as much as possible because at the end it's a person who is going to use that weapons. This is a reason why we choose these four parameters to define strength of defense of country.

- **PARAMETERS OF DEFENSE STRENGTH INDEX**

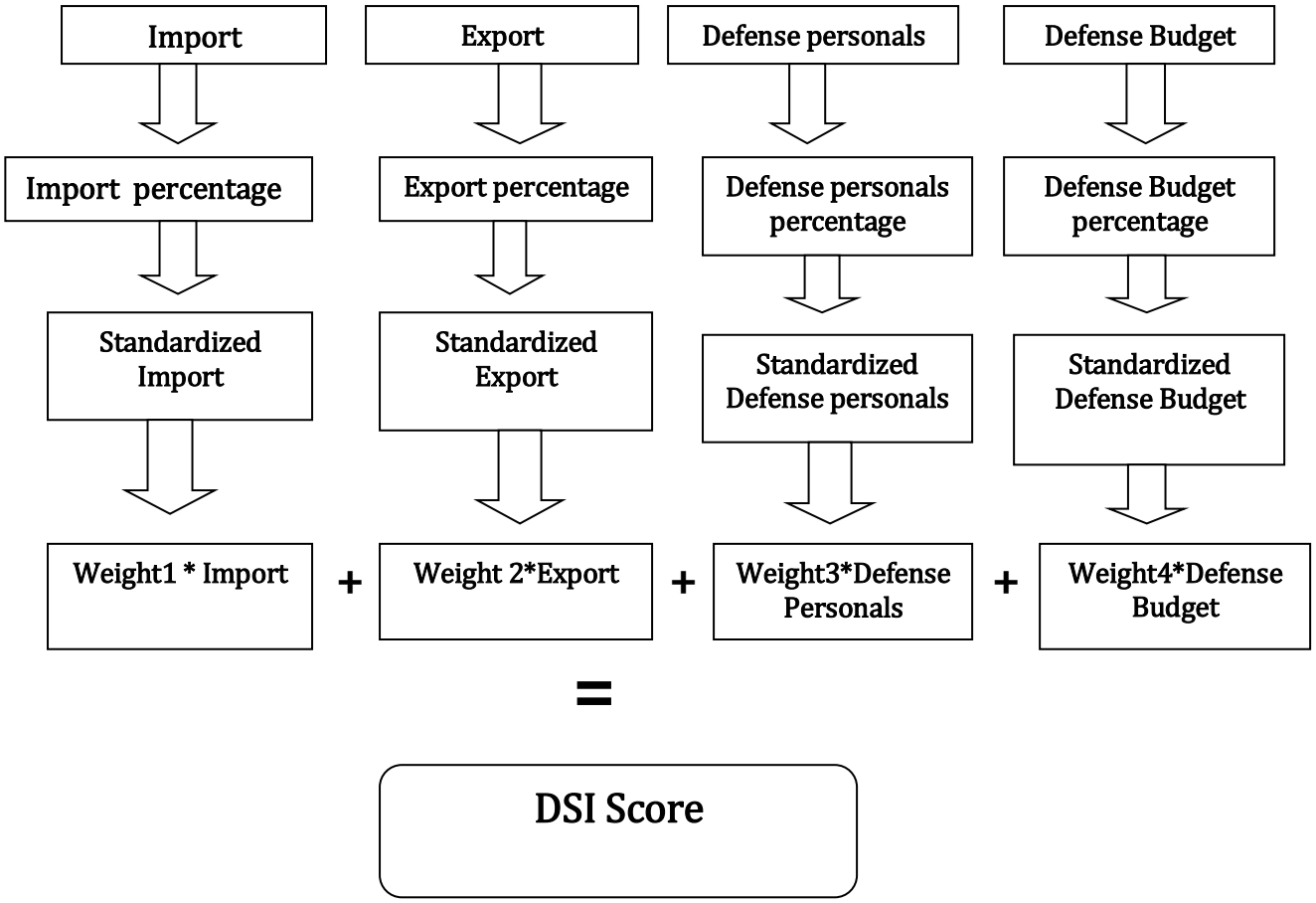
i) **IMPORT**: Import of arms and weapons from different nations, this parameter gives the value of weapons imported in MILLION US DOLLARS.

ii) **EXPORT**: Export of arms and weapons from this selected nation to other respective nations which give the value of weapons exported by the nation in MILLION US DOLLARS.

iii) **DEFENSE BUDGET**: Defense Budget of selected nation plays an important role to maintain the strength of a country which is measured in BILLION US DOLLARS.

iv) **DEFENSE PERSONALS**: Number of personals working in all the fields of armed forces of selected nation including official workers to infantry or field duty workers.

- **METHODOLOGY OF INDEX**



- **STEPS TO DEVELOP THE INDEX.**

The following Table 8 shows the data to be used to calculate defense strength index of 48 countries consist four parameters Import, Export, Defense personals and Budget.

Table 8: Countries with their parameters.

Country	Import (in millions $)	Export (in millions $)	Defense Personals	Budget (in billions $)
United States	868	10613	1358500	705
Russia	135	2744	1000000	65.9
France	41	3954	208750	56.65
Germany	192	914	183638	56
United Kingdom	878	601	148220	68.4
China	981	1085	2035000	293
Italy	210	1717	165500	32
Netherlands	652	299	41199	14.4
Israel	476	606	169500	24.3
Spain	135	612	133282	14.88
Ukraine	39	86	700000	5.94
Sweden	122	332	23600	7.8
Switzerland	10	147	140000	5.74
South Korea	798	566	555000	50.2
Canada	256	119	68000	26.4
Belarus	225	98	62000	0.76
Turkey	272	380	425000	15.48
Norway	514	58	23250	8.25
South Africa	30	83	66500	3.3
Australia	1260	173	60330	31.8
Thailand	146	3	45360	7.4
Poland	74	5	150000	13.71
Belgium	255	48	24676	6.31
Brazil	247	88	334500	18.7
Finland	53	14	23800	5.9
Viet Nam	244	1	482000	1.1
Afghanistan	65	0	85000	0.27
UAE	508	48	65000	5.7
Uzbekistan	47	1	68000	0.25
Denmark	303	27	17000	5.3
Bulgaria	1	3	28000	1.21
Morocco	235	21	200000	1.39
Japan	947	13	247150	54.1
Austria	34	16	23000	3.83
Jordan	67	15	100500	2.18
India	4167	33	1400000	76.6
Bangladesh	73	0	165000	4.4
Singapore	156	72	71000	11.12
Malaysia	133	2	115000	3.83
Indonesia	321	17	400000	8.25
Portugal	6	11	27000	4.9
Syria	11	1	169000	4.65

Country	Import (in millions $)	Export (in millions $)	Defense Personals	Budget (in billions $)
Egypt	1287	41	438500	5.14
Greece	246	7	107600	8.08
Serbia	116	7	25000	1.2
Kazakhstan	85	2	40000	1.68
Pakistan	1180	5	654000	11.3
Saudi Arabia	1739	1	480000	55.6

- **STEP 1**

Converting the value of a respective parameter into percentage of total value

1) Import percentage= ((Import value of country)/(20840))*100
2) Export percentage= ((Export value of country)/(25689))*100
3) Budget percentage= ((Budget value of country)/(1810.3))*100
4) Defense personals= ((Defense personals of country)/(13553355))*100

Converting the value of parameter gives the contribution of respective country in percentage from the total value of 48 countries.

Table 9 shows the converted value into percentage using the above formulae.

Table 9: Values of parameters in %

Export (in %)	Import (in %)	Defense Personals (in %)	Budget (in %)
41.3134	4.1651	10.0233	38.9438
10.6816	0.6478	7.3782	3.6403
15.3918	0.1967	1.5402	3.1293
3.5579	0.9213	1.3549	3.0934
2.3395	4.2131	1.0936	3.7784
4.2236	4.7073	15.0147	16.1852
6.6838	1.0077	1.2211	1.7677
1.1639	3.1286	0.304	0.7954
2.359	2.2841	1.2506	1.3423
2.3823	0.6478	0.9834	0.822
0.3348	0.1871	5.1648	0.3281
1.2924	0.5854	0.1741	0.4309
0.5722	0.048	1.033	0.3171
2.2033	3.8292	4.0949	2.773
0.4632	1.2284	0.5017	1.4583
0.3815	1.0797	0.4575	0.042
1.4792	1.3052	3.1358	0.8551
0.2258	2.4664	0.1715	0.4557
0.3231	0.144	0.4907	0.1823
0.6734	6.0461	0.4451	1.7566

Export (in %)	Import (in %)	Defense Personals (in %)	Budget (in %)
0.0117	0.7006	0.3347	0.4088
0.0195	0.3551	1.1067	0.7573
0.1869	1.2236	0.1821	0.3486
0.3426	1.1852	2.468	1.033
0.0545	0.2543	0.1756	0.3259
0.0039	1.1708	3.5563	0.0608
0	0.3119	0.6272	0.0149
0.1869	2.4376	0.4796	0.3149
0.0039	0.2255	0.5017	0.0138
0.1051	1.4539	0.1254	0.2928
0.0117	0.0048	0.2066	0.0668
0.0817	1.1276	1.4756	0.0768
0.0506	4.5441	1.8235	2.9885
0.0623	0.1631	0.1697	0.2116
0.0584	0.3215	0.7415	0.1204
0.1285	19.9952	10.3295	4.2313
0	0.3503	1.2174	0.2431
0.2803	0.7486	0.5239	0.6143
0.0078	0.6382	0.8485	0.2116
0.0662	1.5403	2.9513	0.4557
0.0428	0.0288	0.1992	0.2707
0.0039	0.0528	1.2469	0.2569
0.1596	6.1756	3.2354	0.2839
0.0272	1.1804	0.7939	0.4463
0.0272	0.5566	0.1845	0.0663
0.0078	0.4079	0.2951	0.0928
0.0195	5.6622	4.8254	0.6242
0.0039	8.3445	3.5416	3.0713

- ## STEP 2

The parameters we have i.e. Import, Export, Defense personals and Budget are measured in different units i.e. Import and Export are measured in millions US dollars, Budget is measured in billions US dollars and Defense personals are just measured in numbers. So to get every parameter in one unit we standardized the given parameters. There are number of ways we can standardized the parameters of different unit but taking the values of parameters under consideration standardization using the threshold frequency is the best option to standardized.

Threshold frequency: The integer value slightly greater than the highest value of respective parameters.

- Export has a threshold frequency 45 because its highest percentage value is 41.31.
- Import has a threshold frequency 20 because its highest percentage value is 19.98.
- Budget has a threshold frequency 40 because its highest percentage value is 38.94.
- Defense personals have a threshold frequency 20 because its highest percentage value is 15.01.

Then the conversion is done such that

1) Standardized Export= ((Export percentage of country)/(45))*100
2) Standardized Import= ((import percentage of country)/(20))*100
3) Standardized Budget= ((Budget percentage of country)/(40))*100
4) Standardized Defense personals= ((Import percentage of D.P.)/(20))*100

The following Table 10 shows the standardized value of respective parameters.

Table 10: Standardized values of Parameters

Standardized Export	Standardized Import	Standardized D. Personals	Standardized Budget
91.8076	20.8253	50.1167	97.3596
23.7369	3.239	36.8912	9.1007
34.204	0.9837	7.701	7.8233
7.9065	4.6065	6.7746	7.7335
5.1989	21.0653	5.468	9.4459
9.3858	23.5365	75.0737	40.4629
14.8529	5.0384	6.1055	4.4192
2.5865	15.643	1.5199	1.9886
5.2422	11.4203	6.2531	3.3558
5.2941	3.239	4.9169	2.0549
0.7439	0.9357	25.8239	0.8203
2.872	2.9271	0.8706	1.0772
1.2716	0.2399	5.1648	0.7927
4.8962	19.1459	20.4746	6.9326
1.0294	6.142	2.5086	3.6458
0.8477	5.3983	2.2873	0.105
3.2872	6.5259	15.6788	2.1378
0.5017	12.3321	0.8577	1.1393
0.718	0.7198	2.4533	0.4557
1.4965	30.2303	2.2256	4.3915
0.026	3.5029	1.6734	1.0219
0.0433	1.7754	5.5337	1.8933
0.4152	6.118	0.9103	0.8714
0.7612	5.9261	12.3401	2.5824

0.1211	1.2716	0.878	0.8148
0.0087	5.8541	17.7816	0.1519
0	1.5595	3.1358	0.0373
0.4152	12.1881	2.3979	0.7872
0.0087	1.1276	2.5086	0.0345
0.2336	7.2697	0.6272	0.7319
0.026	0.024	1.033	0.1671
0.1817	5.6382	7.3782	0.192
0.1125	22.7207	9.1177	7.4711
0.1384	0.8157	0.8485	0.5289
0.1298	1.6075	3.7076	0.3011
0.2855	99.976	51.6477	10.5784
0	1.7514	6.0871	0.6076
0.6228	3.7428	2.6193	1.5357
0.0173	3.191	4.2425	0.5289
0.1471	7.7015	14.7565	1.1393
0.0952	0.144	0.9961	0.6767
0.0087	0.2639	6.2346	0.6422
0.3547	30.8781	16.1768	0.7098
0.0606	5.9021	3.9695	1.1158
0.0606	2.7831	0.9223	0.1657
0.0173	2.0393	1.4756	0.232
0.0433	28.3109	24.1269	1.5605
0.0087	41.7226	17.7078	7.6783

- **STEP 3**

The parameters we have i.e. Import, Export, Budget and defense personals don't supposed to have equal importance and to describe the importance of the parameters we find out the weights of the parameters using the factor analysis method to find out the weights of parameters.

Factor Analysis: stand exp, stand imp, stand def per, stand budget

Principal Component Factor Analysis of the Correlation Matrix

Unrotated Factor Loadings and Communalities

Variable	Factor1	Factor2	Factor3	Factor4	Communality
stand exp	0.825	-0.504	-0.192	0.170	1.000
stand imp	0.483	0.819	-0.310	0.010	1.000
stand def per	0.839	0.335	0.426	0.059	1.000
stand budget	0.936	-0.278	-0.052	-0.208	1.000
Variance	2.4931	1.1141	0.3171	0.0758	4.0000
% Var	0.623	0.279	0.079	0.019	1.000

Factor Score Coefficients

Variable	Factor1	Factor2	Factor3	Factor4
stand exp	0.331	-0.452	-0.606	2.247
stand imp	0.194	0.735	-0.978	0.134
stand def per	0.336	0.300	1.343	0.776
stand budget	0.376	-0.250	-0.165	-2.743

Then from these factor score coefficient we calculate weight as,

Weight (parameter) =factor1 (variable)/Total (factor1)

The weights are,

1) PCA(stand exp)=factor1(stand exp)/sum(factor 1)=0.331/1.237=0.27
2) PCA(stand imp)=factor1(stand imp)/sum(factor 1)=0.194/1.237=0.16
3) PCA(stand def per)=factor1(stand def per)/sum(factor 1)=0.336/1.237=0.27
4) PCA(stand budget)=factor1(stand budget)/sum(factor 1)=0.376/1.237=0.30

The weights are,
Export = 0.27
Import = 0.16
Budget = 0.30
Defense personals = 0.27
In the following Table 11 we display the parameters multiplied with their respective weights

Table 11: Weights multiplied with their parameters

PCA Export	PCA Import	PCA Def Per	PCA Budget
24.788	3.3321	13.5315	29.2079
2.5342	3.7658	20.2699	12.1389
0.0771	15.9962	13.9449	3.1735
6.409	0.5182	9.9606	2.7302
9.2351	0.1574	2.0793	2.347
0.0023	6.6756	4.7811	2.3035
1.322	3.0633	5.5282	2.0798
0.0117	4.5298	6.5143	0.4682

PCA Export	PCA Import	PCA Def Per	PCA Budget
0.0958	4.9405	4.3677	0.2129
1.4037	3.3704	1.4764	2.8338
0.0304	3.6353	2.4618	2.2413
4.0103	0.8061	1.6485	1.3257
0.2009	0.1497	6.9724	0.2461
0.4041	4.8369	0.6009	1.3175
2.1348	0.737	1.8292	2.3201
0.8875	1.0441	4.2333	0.6413
1.4154	1.8273	1.6883	1.0067
0.0023	0.9367	4.801	0.0456
0.0397	1.2322	3.9843	0.3418
0.2055	0.9482	3.3318	0.7747
0.6984	2.5029	0.4104	0.5966
1.4294	0.5182	1.3276	0.6165
0.2779	0.9827	0.6773	1.0937
0.049	0.9021	1.9921	0.0576
0.1121	1.9501	0.6474	0.2361
0.1355	1.9731	0.2316	0.3418
0.0163	0.9443	1.0718	0.3348
0.0117	0.2841	1.4941	0.568
0	0.2802	1.6435	0.1823
0.3433	0.0384	1.3945	0.2378
0.1682	0.5988	0.7072	0.4607
0.0023	0.0422	1.6833	0.1926
0.0047	0.5106	1.1455	0.1587
0.7754	0.4683	0.2351	0.3232
0.2289	0.8637	0.6176	0.0315
0.0631	1.1631	0.1693	0.2196
0.1121	0.9789	0.2458	0.2614
0.035	0.2572	1.001	0.0903
0.007	0.5605	0.4518	0.3066
0.1939	0.1152	0.6624	0.1367
0	0.2495	0.8467	0.0112
0.0023	0.1804	0.6773	0.0104
0.0047	0.3263	0.3984	0.0696
0.0163	0.4453	0.249	0.0497
0.0327	0.2035	0.2371	0.2444
0.0374	0.1305	0.2291	0.1587
0.0257	0.023	0.2689	0.203
0.007	0.0038	0.2789	0.0501

- **STEP 4**

Here the final score which we called as defense strength index score is calculated by adding the weight multiplied parameters for each country.

DSI Score = PCA Export + PCA Import + PCA Defense personals + PCA Budget.

The following Table 11 shows the ranking which is given on the basic of constructed DSI score, higher the score, higher the rank. This is rank wise representation of strength of 48 countries.

Table 11: Country wise constructed DSI

Rank	Country	DSI Score	Rank	Country	DSI Score
1	United States	70.8595	25	UAE	2.9458
2	China	38.7088	26	Norway	2.682
3	India	33.1916	127	Greece	2.3672
4	Russia	19.618	28	Poland	2.3578
5	France	13.8187	29	Bangladesh	2.106
6	Saudi Arabia	13.7625	30	Switzerland	2.014
7	South Korea	11.9932	31	Singapore	1.9349
8	Pakistan	11.5238	32	Syria	1.9206
9	Egypt	9.6169	33	Malaysia	1.8194
10	UK	9.0843	34	Sweden	1.802
11	Japan	8.3688	35	Belarus	1.7417
12	Italy	7.7907	36	Denmark	1.6151
13	Ukraine	7.5691	37	Belgium	1.5982
14	Australia	7.1593	38	Jordan	1.3836
15	Germany	7.021	39	Thailand	1.3259
16	Turkey	6.8063	40	South Africa	1.1081
17	Israel	5.9377	41	Afghanistan	1.1074
18	Viet Nam	5.7856	42	Uzbekistan	0.8704
19	Indonesia	5.598	43	Kazakhstan	0.799
20	Brazil	5.2603	44	Serbia	0.7604
21	Netherlands	4.2082	45	Finland	0.7177
22	Spain	3.8917	46	Austria	0.5557
23	Canada	3.0317	47	Portugal	0.5207
24	Morocco	3.0009	48	Bulgaria	0.3399

CONCLUSION:

This index of 48 countries gives ranking to the countries from 1 to 48, Country having strongest defense strength has rank 1 and country with weakest defense strength has rank 48. So, as we can observe USA, China, India, Russia, France and the bottom five countries are Serbia, Finland, Austria, Portugal and Bulgaria. As this index is made up on

four parameters Import, Export, Defense personals and Budget of the countries, So this index says that the country which topped the index have comparatively good in three fields that are Export, defense personals and Budget . Russia, the United States, China, and India are considered to have strong defense capabilities for several reasons

- Technological Advancements: These countries have made substantial investments in research and development, leading to technological advancements in defense systems. They have developed sophisticated weapon systems, cutting-edge aircraft, advanced naval vessels, missile defense systems, and other advanced technologies.
- Large Defense Budgets: Russia, the United States, China, and India are known for their substantial defense budgets. These budgets allow for the acquisition of modern military equipment, the development of advanced defense technologies, and the maintenance of a strong defense infrastructure.
- Military Personnel and Training: These countries have large and well-trained military forces. Their defense personnel undergo rigorous training and are equipped with the necessary skills to operate advanced weapon systems, carry out complex military operations, and adapt to changing threats.
- Geopolitical Influence: Russia, the United States, China, and India are major global powers with significant geopolitical influence. Their defense capabilities contribute to their ability to project power and protect their national interests both regionally and globally.

Finland, Austria, Portugal, and Austria are generally considered to have smaller defense capabilities and the reasons are

- Limited Defense Budgets: These countries may have smaller defense budgets compared to major global powers. Limited financial resources can restrict their ability to invest in advanced military equipment, modernization, research and development, and defense infrastructure.
- Technological Dependencies: These countries may rely on defense imports and cooperation with other countries for access to advanced military technology. This dependency on external suppliers can limit their ability to develop indigenous defense industries and may restrict their defense capabilities.

India can enhance its defense capabilities through various measures. Firstly, increasing defense spending can provide the necessary resources to modernize the armed forces, acquire advanced military technology, and improve infrastructure and also by producing weapons by own that importing it. This would enable India to maintain a technologically advanced and combat-ready military.

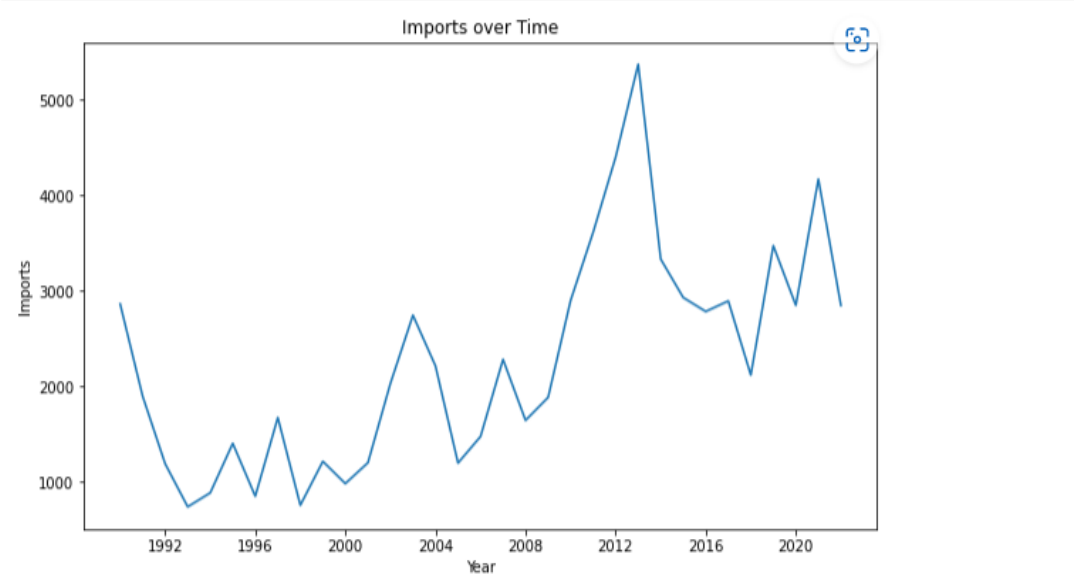
CHAPTER 6: TIME SERIES ANALYSIS AND FORECASTING

Data of given parameters is given yearly that is from 1990 to 2021. So for forecasting, Time Series is the best option for the given data. In this chapter time series analysis of four parameters Import, Export, Budget and Defense personals is performed and forecasting is based on this four parameters is done using the ARIMA model and Exponential smoothing and the test used to check the stationarity of the data or parameters using the "Dickey Fuller Test" and from the given result the next step is taken i.e. which model to apply on the given data to make it stationary and also to forecast the values for next 3 years.

1. TIME SERIES ANALYSIS OF IMPORT OF ARMS AND WEAPONS

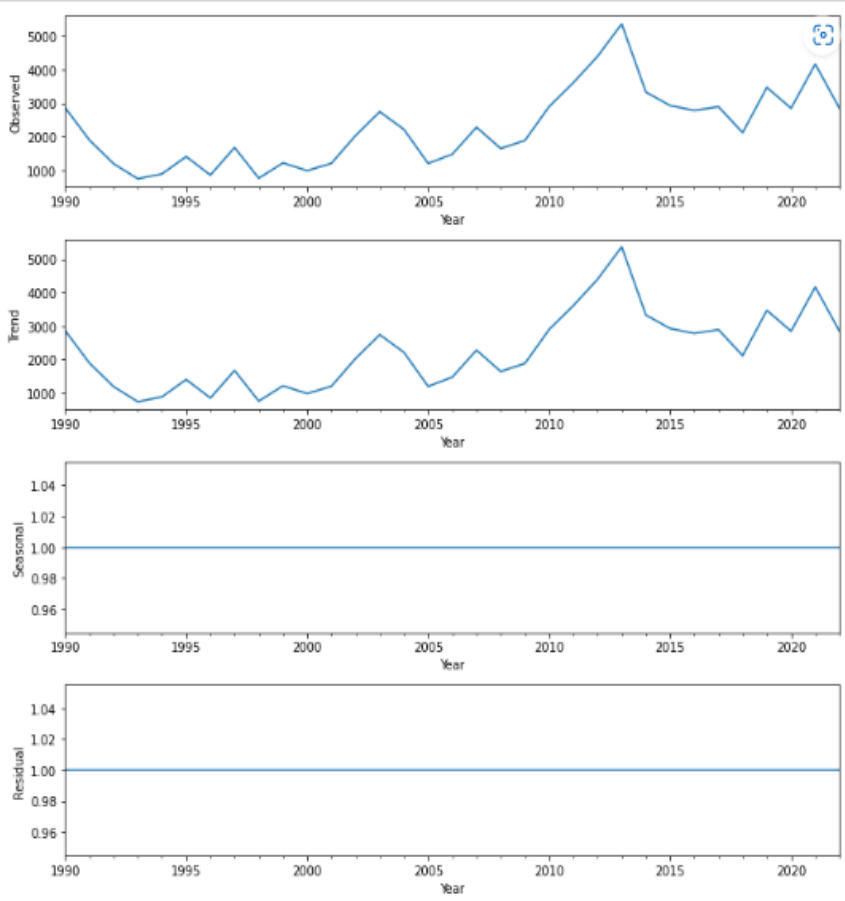
We use the data from Table 3 which is about import of weapons of India from 1990 to 2021. For this data we do time series analysis.

- ### Time Series Plot



From above time series plot we can conclude that India shows overall growth in the import of arms and weapons till 2013, After that due to projects like AGNI, PRITHVI, TRISHUL, TEJAS, Project 15A and B, Project 17A, India started producing aircraft engines by its own, This results in decrease of import of arms and weapons.

- **Auto covariance, Autocorrelation and Residual Plot.**



This plots interprets that there is a presence of Trend but seasonality component is not present in the given data of import .

- **Dickey-fuller test to check stationarity.**

```
Dickey-Fuller Test Results:
Test Statistic                  -2.107714
p-value                          0.241424
Lags Used                        0.000000
Number of Observations Used     32.000000
Critical Value (1%)             -3.653520
Critical Value (5%)             -2.957219
Critical Value (10%)            -2.617588
dtype: float64
```

Dickey-fuller test is used to check the stationarity of the data i.e. if the p-value of Dickey-fuller test is less than that of 0.05 then the data is said to be stationary otherwise it is called as non-stationary. So, for this data of import, the p-value is greater than 0.05 therefore data of import is non-stationary.

- **Dickey-Fuller Test after applying the differencing to the model**

```
Dickey-Fuller Test Results:
Test Statistic                -6.563709e+00
p-value                        8.258994e-09
Lags Used                      0.000000e+00
Number of Observations Used    3.100000e+01
Critical Value (1%)           -3.661429e+00
Critical Value (5%)           -2.960525e+00
Critical Value (10%)          -2.619319e+00
dtype: float64
```

After differencing the data, we observe that p-value for Dickey-fuller test is less than 0.05. Hence the given data is stationary now.

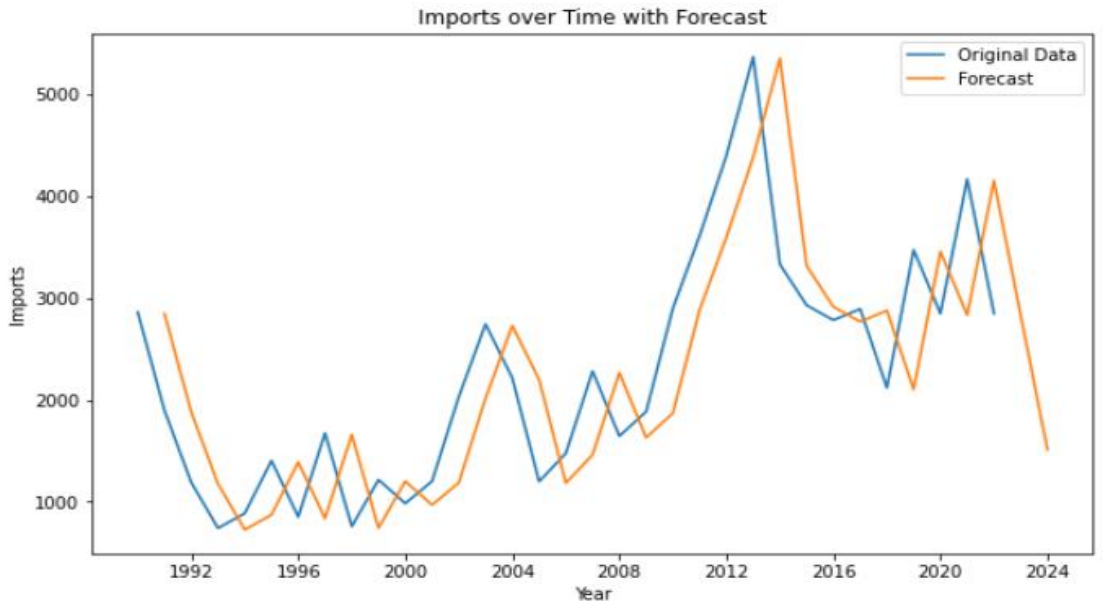
- **ARIMA and Most Suitable Model for Data**

```
Performing stepwise search to minimize aic
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=inf, Time=1.50 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=524.170, Time=0.02 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=524.097, Time=0.03 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=523.986, Time=0.11 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=522.170, Time=0.03 sec
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=524.886, Time=0.31 sec

Best model:  ARIMA(0,1,0)(0,0,0)[0]
Total fit time: 2.101 seconds
```

As the data is stationary, we observe that ARIMA (0, 1, 0) is the best fit model which can be used to forecast the import for next few years and the model equation for ARIMA(0,1,0) is $Xt - Xt{-}1 = Zt$

- **Actual and predicted plot.**



This is the plot of import over time with forecast generated from the past observations of import and the predicted values of import for year 2023 and 2024 are **2831.0** and **1510.0**.

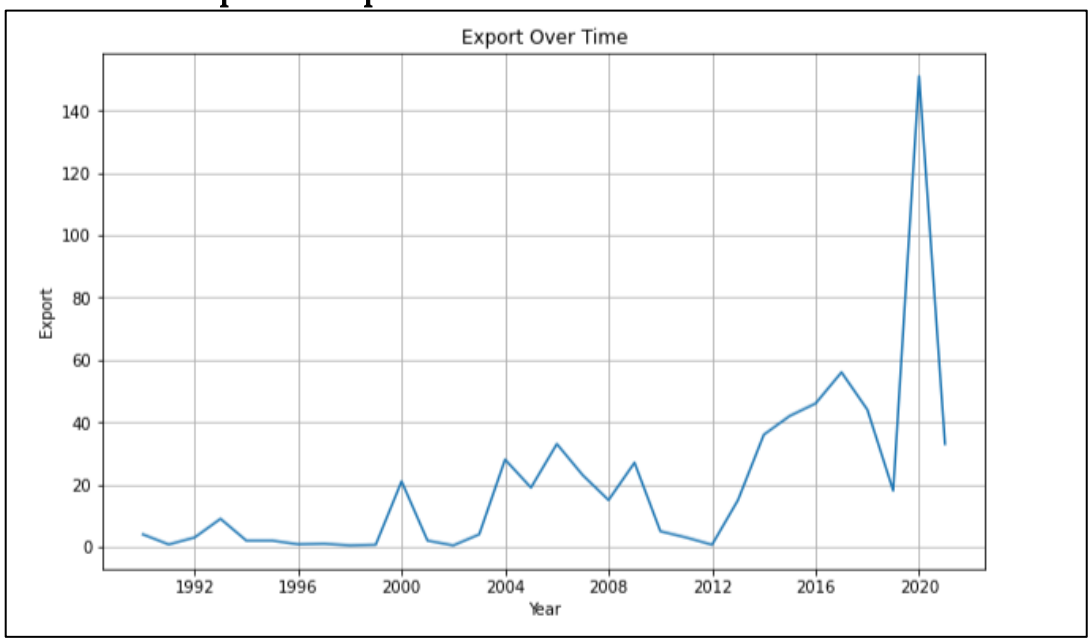
- **Time series analysis and forecasting of export**

The following Table 13 shows the year wise data of export for years 1990 to 2021.

Table 13: Year wise of export of Arms and Weapons

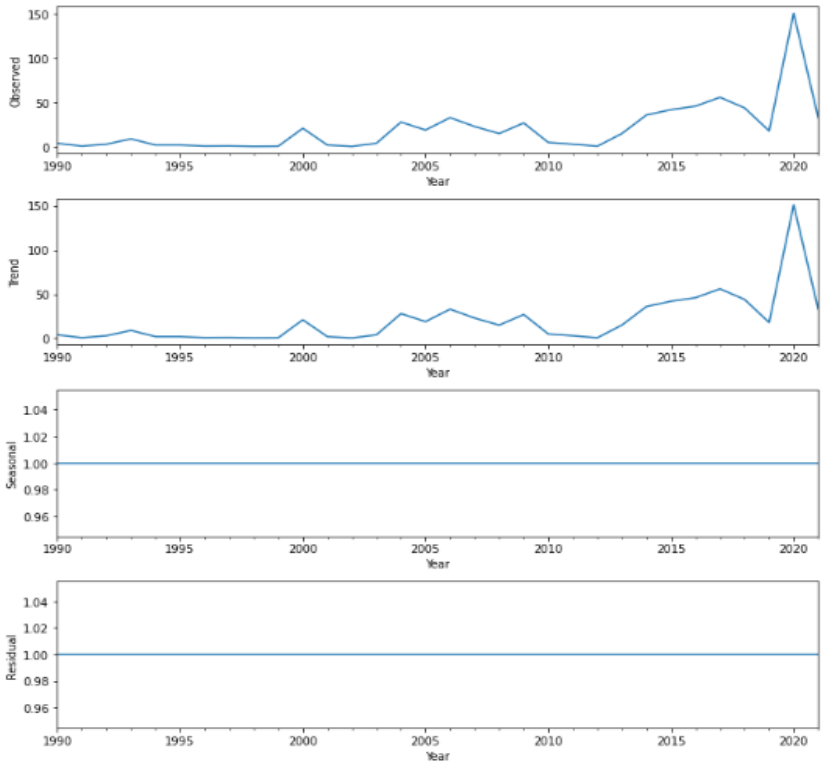
Year	Export (in million $)	Year	Export (in million $)
1990	4	2006	33
1991	0.78	2007	23
1992	3	2008	15
1993	9	2009	27
1994	2	2010	5
1995	2	2011	3
1996	0.84	2012	0.68
1997	1	2013	15
1998	0.5	2014	36
1999	0.68	2015	42
2000	21	2016	46
2001	2	2017	56
2002	0.48	2018	44
2003	4	2019	18
2004	28	2020	151
2005	19	2021	33

- **Time Series plot of export of India.**



Export of India had been low throughout the years but shows tremendous growth in year 2020 due to some deals explained earlier and shows downfall in year 2021.

- **Auto covariance, Autocorrelation and Residual Plot.**



This plots interprets that there is presence of Trend but Seasonality is not present in the given data of export

- **Dickey-fuller test to check the Stationarity**

```
Dickey-Fuller Test Results:
Test Statistic                  0.007856
p-value                         0.959177
Lags Used                       1.000000
Number of Observations Used    30.000000
Critical Value (1%)            -3.669920
Critical Value (5%)            -2.964071
Critical Value (10%)           -2.621171
dtype: float64
```

Dickey-fuller test is used to check the stationarity of the data i.e. if the p-value of Dickey-fuller test is less than that of 0.05 then the data is said to be stationary otherwise it is called as non-stationary. So, for this data of import p-value is greater than 0.05 therefore from the Dickey-fuller test the given data of export is non-stationary.

- **Dickey-fuller test after applying the first order differencing .**

```
Dickey-Fuller Test Results:
Test Statistic                 -1.126501e+01
p-value                         1.587490e-20
Lags Used                       0.000000e+00
Number of Observations Used     3.000000e+01
Critical Value (1%)            -3.669920e+00
Critical Value (5%)            -2.964071e+00
Critical Value (10%)           -2.621171e+00
dtype: float64
```

After differencing the data, we observe that p-value for Dickey-fuller test is less than 0.05. Hence the given data is stationary now.

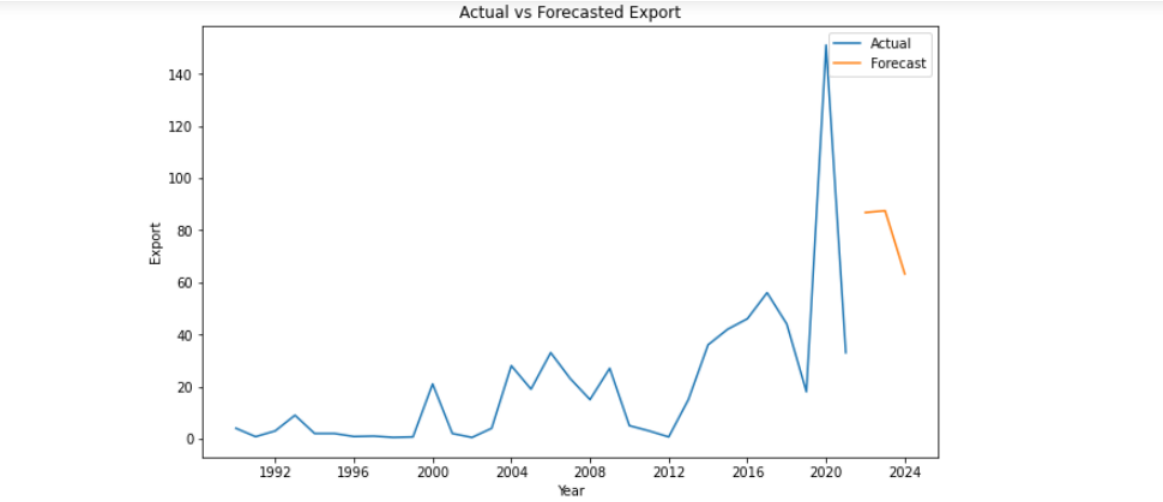
- **ARIMA model to analyze and forecast the Export.**

```
Performing stepwise search to minimize aic
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=294.887, Time=1.12 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=310.533, Time=0.04 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=291.750, Time=0.07 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.17 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=308.557, Time=0.03 sec
 ARIMA(2,1,0)(0,0,0)[0] intercept   : AIC=290.962, Time=0.12 sec
 ARIMA(3,1,0)(0,0,0)[0] intercept   : AIC=292.946, Time=0.33 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=292.938, Time=0.23 sec
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=291.157, Time=0.19 sec
 ARIMA(3,1,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.60 sec
 ARIMA(2,1,0)(0,0,0)[0]             : AIC=291.069, Time=0.07 sec

Best model:  ARIMA(2,1,0)(0,0,0)[0] intercept
Total fit time: 3.061 seconds
```

As the data is stationary now ARIMA (2, 1, 0) is the best fit model for the given data in this model differencing is applied once to make the series stationary, and it includes autoregressive components of order 1 and 2. The model equation for ARIMA(2, 1, 0) is $\boldsymbol{X_t - (1 + \phi_1)X_{t-1} - (\phi_2 - \phi_1)X_{t-2} + \phi_2 X_{t-3} = Z_t}$.

- **Actual vs Predicted plot and predicted values for Export of India.**




```
Forecasted Values:
2022-01-01    86.760157
2023-01-01    87.450490
2024-01-01    63.210821
Freq: AS-JAN, Name: predicted_mean, dtype: float64
```

In this plot blue line shows the actual value data have whereas orange line shows the predicted value using ARIMA (2, 1, 0) model.

The predicted values for year 2022, 2023 and 2024 are 86.76, 87.45 and 63.21.

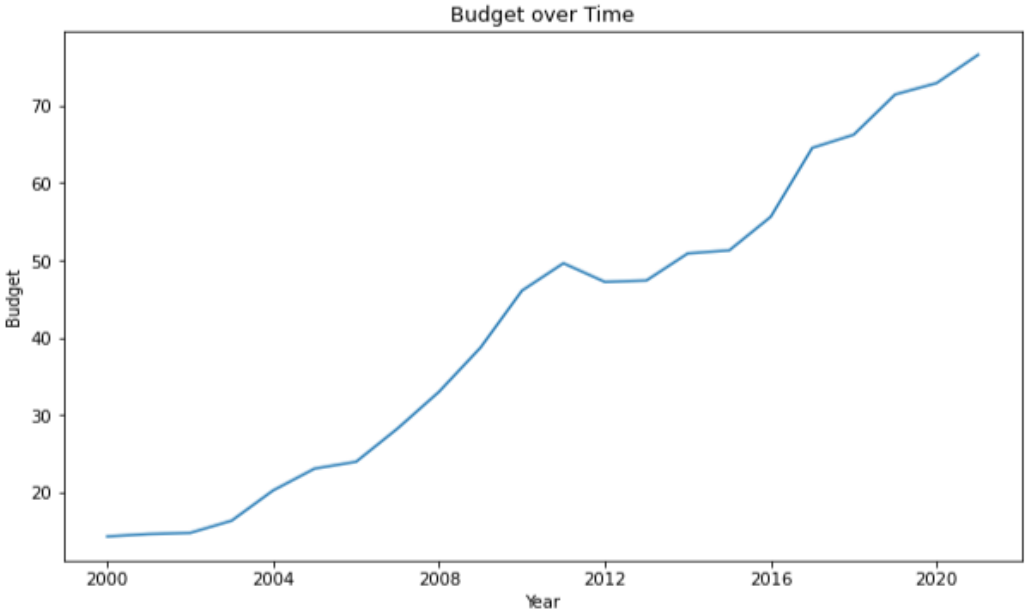
- **Time series analysis and forecasting Defense Budget.**

Table 14: Defense Budget

Year	Budget		Year	Budget
2000	14.29		2011	49.63
2001	14.6		2012	47.22
2002	14.75		2013	47.4
2003	16.33		2014	50.91
2004	20.24		2015	51.3
2005	23.07		2016	55.64
2006	23.95		2017	64.56
2007	28.25		2018	66.26
2008	33		2019	71.47
2009	38.72		2020	72.94
2010	46.09		2021	76.6

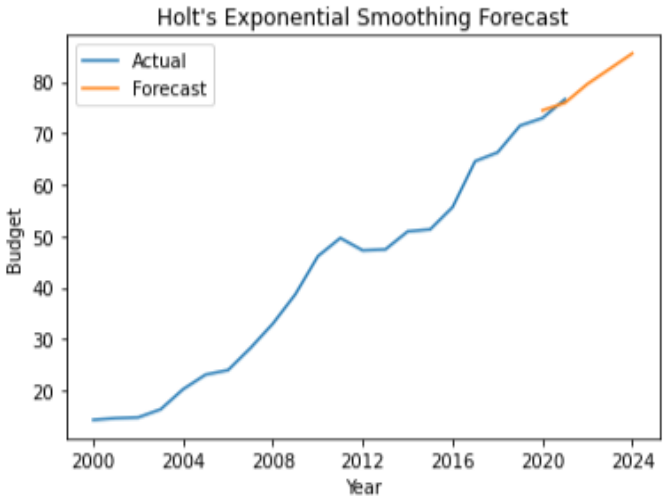
This is year wise values of defense budget (in billion) of India from year 2000 to 2021.

- **Time Series plot for budget.**



This is a time series plot show budget from year 2000 to 2021, overall shows overall increasing trends in the budget from year 2000 to 2021.

- **Forecasting of Budget using Exponential Smoothing.**




```
Forecasted Values:
2020-01-01    74.437064
2021-01-01    75.907064
2022-01-01    79.567064
2023-01-01    82.534127
2024-01-01    85.501191
Freq: AS-JAN, dtype: float64
```

Defense budget data exhibits simpler pattern and also follows trend. So, in this case exponential smoothing method is used to predict and forecast the values of defense budget. The predicted values for year 2022, 2023 and 2024 are 79.56, 82.53 and 85.50.

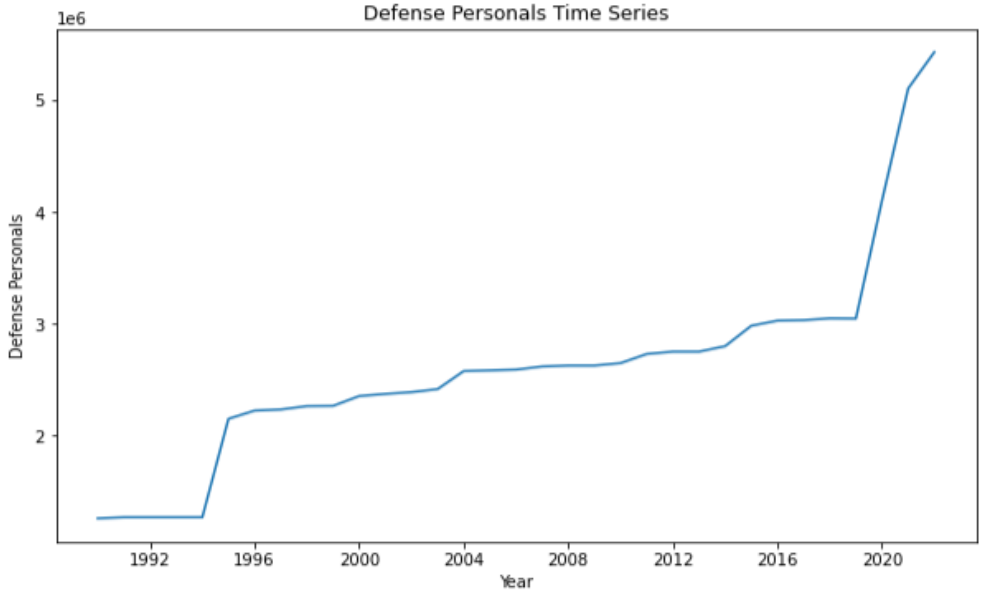
- **Time series analysis and forecasting of number of Defense Personals.**

The following Table 15 shows year wise data of number of defense personals from year 1990 to 2022.

Table 14: year wise Defense personals

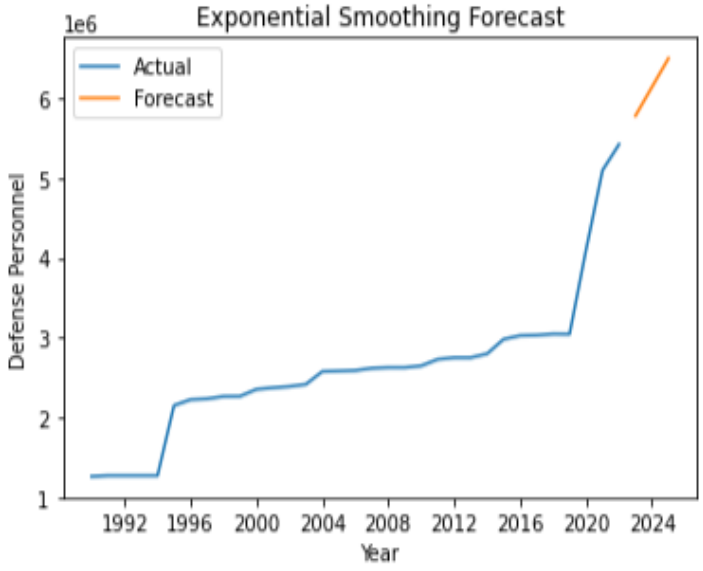
Year	Defense Personals		Year	Defense Personals
1990	1260000		2006	2589000
1991	1270000		2007	2617000
1992	1270000		2008	2625586
1993	1270000		2009	2625586
1994	1270000		2010	2647150
1995	2149500		2011	2728700
1996	2223000		2012	2749700
1997	2233000		2013	2749700
1998	2263000		2014	2798800
1999	2265000		2015	2981050
2000	2352700		2016	3026500
2001	2372000		2017	3031000
2002	2387700		2018	3047000
2003	2414700		2019	3045000
2004	2576000		2020	4100000
2005	2582000		2021	5100700

- **Time series plot of number of defense personals.**



Time series plot of number of defense personals shows continues growth throughout the years but shows high growth specifically from 2019 onwards considering the increasing threat from china, Pakistan and terrorism.

- **Forecasting of defense personals using exponential smoothing.**




```
Forecasted Values:
2023-01-01    5.785436e+06
2024-01-01    6.145142e+06
2025-01-01    6.504849e+06
Freq: AS-JAN, dtype: float64
```

Exponential smoothing is used to predict and forecast the number of defense personals for the next three years i.e. for years 2023, 2024 and 2025 so the predicted values are 5785436, 6145142 and 6504849.

- **CONCLUSION**

In this chapter two methods of time series analysis are used to analyze and forecast the values for parameters for import, export, defense budget and number of defense personals. The methods used are ARIMA and exponential smoothing / holt's exponential smoothing.

The following table 15 shows forecasted values for 2023 and 2024.

Table 15: forecasted values for 2023-24

Year	Import	Export	Defense Budget	Number of Defense Personals
2023	2831	87.45	82.53	5785436
2024	1510	63.21	85.5	6145142

- ## Formulating the methodology of Defense Index Score

To make a formula for final score of defense strength index we have used multiple linear regression where import, export, defense budget and number of defense personals are the independent variable and the response variable is final score of defense strength index.

The following Table 16 shows the final score of defense strength index.

Table 16:Final score of defense strength index

Import (in million)	Export (in million)	Defense Personal	Budget (in billion)	SCORE
868	10613	1358500	705	70.85948
981	1085	2035000	293	38.70875
4167	33	1400000	76.6	33.19163
135	2744	1000000	65.9	19.61805
41	3954	208750	56.65	13.81874
1739	1	480000	55.6	13.76255
798	566	555000	50.2	11.99322
1180	5	654000	11.3	11.52384
1287	41	438500	5.14	9.616946
878	601	148220	68.4	9.084305
947	13	247150	54.1	8.368792
210	1717	165500	32	7.790651
39	86	700000	5.94	7.569111
1260	173	60330	31.8	7.159302
192	914	183638	56	7.021018
272	380	425000	15.48	6.806285
476	606	169500	24.3	5.937714
244	1	482000	1.1	5.785594
321	17	400000	8.25	5.597999
247	88	334500	18.7	5.260277
652	299	41199	14.4	4.208187
135	612	133282	14.88	3.891685
256	119	68000	26.4	3.03173
235	21	200000	1.39	3.000873
508	48	65000	5.7	2.945796
514	58	23250	8.25	2.681974
246	7	107600	8.08	2.367203
74	5	150000	13.71	2.357842
73	0	165000	4.4	2.106025
10	147	140000	5.74	2.01402
156	72	71000	11.12	1.934916
11	1	169000	4.65	1.920557
133	2	115000	3.83	1.819376
122	332	23600	7.8	1.801981
225	98	62000	0.76	1.741661
303	27	17000	5.3	1.615117
255	48	24676	6.31	1.598206
67	15	100500	2.18	1.383592
146	3	45360	7.4	1.325861
30	83	66500	3.3	1.10812
65	0	85000	0.27	1.10736

Import (in million)	Export (in million)	Defense Personal	Budget (in billion)	SCORE
47	1	68000	0.25	0.870438
85	2	40000	1.68	0.798994
116	7	25000	1.2	0.760378
53	14	23800	5.9	0.717651
34	16	23000	3.83	0.555658
6	11	27000	4.9	0.520667
1	3	28000	1.21	0.339873

Here

- Y = DSI score
- X_1 = Import
- X_2 = Export
- X_3 = Number of defense personals
- X_4 = defense budget

Using multiple linear regression we get,
From above we get coefficient for import, export, defense budget and number of defense personals and make regression equation as

$$\boldsymbol{Y = -2.324e-13 + 0.0038x_1 + 0.0023x_2 + 9.961e-06x_3 + 0.0414x_4}$$

Now forecasted values for import, export, defense budget and number of defense personals are

Year	Import	Export	Defense Budget	Number of Defense Personals
2023	2831	87.45	82.53	5785436
2024	1510	63.21	85.5	6145142

Putting these values in regression equation we get final defense index score of India for 2023 and 2024.

Y(2023) = -2.324e-13 + 0.0038*2831 + 0.0023*87.45 + 9.961e-06*5785436 + 0.0414*82.53

Y(2024) = -2.324e-13 + 0.0038*1510 + 0.0023*63.21 + 9.961e-06*615142 + 0.0414*85.5

Then from the above regression equations for 2023 and 2024 we get India's final DSI scores are

- **DSI (2023) = 70.6349**
- **DSI(2024) = 72.0045**

These are the India's DSI score for year 2023 and 2024.

CHAPTER 7: OVERALL CONCLUSION

- From the analysis of dataset of import of arms and weapons we concluded that India is the largest importer of arms and weapons till a date and taking steps to cut down its import and also improve manufacturing of weapons as much as possible to ensure "ATMANIRBHARTA".
- Russia, France, USA and Israel are the largest importer to India and imports 80% of total import to India.
- India is reducing its dependency year by year and as Russia was biggest importer to India but in last 10 years India's import from Russia fall by 38%. India is trying to distribute its dependency on countries like France increased by 40% and USA for weapons import .
- India spending more of its weapon import budget on aircraft, armored vehicles and missiles and if India has to reduce its import in upcoming future then it should start production and manufacturing of aircraft, armored vehicles and missiles in India in this direction India focused more on LCA TEJAS, LCH PRACHAND, DHRUV project, BHRAMHOS missiles and many other missiles also started manufacturing armored vehicles like ARJUN MAIN BATTLE TANK, T-90 BHISHMA, KESTREL, BMP-2 SARATH and many more.
- From the defense strength index we concluded that USA, China, India and Russia are the most powerful countries in defense and specially their budget, export and number of defense personals makes them so, for the weak countries it is advisable to increase the budget, number of defense personals and should step towards technological advancement.
- Using time series on export of arms and weapons by India we can conclude that India showing growth in export of arms and weapons mainly due to export of project India have started recently which will also leads in good international relationship with countries we export.
- From time series analysis we conclude that India shows continuous growth in number of defense personals and defense budget of country which may show high increment in upcoming years.
- India has witnessed significant growth in its defense sector, with a focus on indigenous development and modernization of its armed forces, observing the analysis we conclude that India is one of the defense superpower of world and will maintain and will also increase its strength in upcoming years.

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- Software: MS Excel, Minitab 17, Python

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- TIV-export-Top-50-1990-2021

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- Types of arms imported to India (1990-2021)

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- Defense personals of India (1990-2021)

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