Investigation of Armed Forces from the Atlantic Ocean to the Ural Mountains*

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ABSTRACT

The Conventional Armed Forces in Europe (CFE) Treaty covers 30 countries across the Atlantic Ocean to the Ural Mountains (ATTU). This paper analyzes the armed forces in CFE and makes a comparison and relative ranking of CFE countries' armaments using factor analysis. The results suggest that there are three different factors that explain the whole data set, and the military based comparison of countries is obtained by these factors. A general military power factor is also calculated for a general comparison.

Keywords: Conventional Armed Forces in Europe (CFE), Atlantic Ocean to the Ural Mountains (ATTU), factor analysis, ranking, military power.

1. INTRODUCTION

Conventional Armed Forces in Europe (CFE) Treaty is an agreement among 30 countries, providing a basis for lasting European security and stability. The key conventional armaments of countries from Atlantic Ocean to the Ural Mountains (ATTU) are limited by CFE Treaty. Some of the countries in CFE fully use their armament limits while the others do not. On the other hand, the countries also have differences in their Gross Domestic Products (GDP) and military expenditures. As a result of the above mentioned points, countries have different military capabilities. Some countries have greater military capabilities than the others so a ranking on military capabilities of CFE countries arise. This ranking gives information on one country's defense ability relative to another, and is quite useful for policy makers to decide on whether to increase or decrease military expenditure. If the relative defense ability of a country is poor, then the policy makers would increase military expenditure. On the other hand, if the ability is great, then it would be a good decision to decrease defense expenditures and to increase education or health expenditures. Thus, providing the ranking of the military capabilities is important.

The defense literature is generally aimed to compare two countries for a selected military indicator (Looney and Frederiksen, 1986; Looney, 1997; Looney, 1998; Dunne et al., 1999; Khalifa, 2002;

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Brauer, 2002; Brauer, 2003; Yıldırım and Öcal, 2006, Yıldırım and Erinç, 2007). To the best of the authors' knowledge, this is the first multi-country study that ranks the CFE countries in a multivariate framework.

Since there are many indicators of armament (i.e. military expenditures; number of helicopters, troops, battle tanks etc.), it would be quite difficult to rank countries by each one of these individual indicators. Even if these countries were ranked by these indicators, it would still have been possible to have different rankings for each indicator. This problem could be solved by using dimension reduction techniques. In this paper, the whole data set is reduced to a smaller dimension and the rankings are obtained using the new space. The dimension reduction is obtained by using factor analysis.

The organization of the paper is as follows; the CFE Treaty is explained briefly in the second section. The third section explains the data and methodology used in the paper, and the empirical evidence is given in the fourth section. Finally, section five concludes the paper.

2. THE CFE TREATY

In 1990, 22 members of the North Atlantic Treaty Organization (NATO) and the former Warsaw Pact, signed the CFE Treaty. The original CFE Treaty entered into force in 1992. The original treaty has unlimited duration and it is a landmark arms control agreement that established parity in major conventional forces and armaments in ATTU. Following the demise of the Warsaw Pact and the enlargement of NATO in 1990s, 30 CFE States Parties signed the Adaptation Agreement at the Istanbul Organization for Security and Co-operation in Europe (OSCE) Summit on 19 November 1999. This adaptation agreement let CFE countries' to take account of the evolving European geo-strategic environment (Almanac of Policy Issues).

The CFE Treaty covers the entire land territory of the States Parties in Europe in ATTU. It thus excludes much of the territory of Russia and all the territory of the U.S. and Canada – all signatories of the original and Adapted Treaty. However, the conventional forces of all three countries that are stationed in Europe are also subject to CFE limits (Almanac of Policy Issues).

The CFE States Parties are alphabetically given in Table 1. There are 30 countries signed the Treaty.

Table 1. The list of CFE countries.

Armenia	Kazakhstan
Azerbaijan	Luxembourg
Belarus	Moldova
Belgium	Netherlands
Bulgaria	Norway
Canada	Poland
Czech Republic	Portugal
Denmark	Romania
France	Russia
Georgia	Slovak Republic
Germany	Spain
Greece	Turkey
Hungary	Ukraine
Iceland	UK
Italy	USA

The original CFE Treaty set equal limits for the East and West in the ATTU on key conventional armaments essential for conducting surprise attacks or initiating large-scale offensive operations. Those armaments/equipments include battle tanks; armored combat vehicles; artillery pieces; combat aircraft (except for naval air) and attack helicopters. In addition to limitations on the number of armaments in each category, the Treaty also provides for central zonal limits to prevent

destabilizing force concentrations in Europe and for regional ("flank") limits, which were modified by the Flank Agreement of May 1996 (Almanac of Policy Issues).

Whereas the original CFE Treaty established an East-West group structure for limiting NATO and Warsaw Pact conventional armaments, the Adapted Treaty provides for a system of national and territorial ceilings (the former limits the number of armaments each state may possess, while the latter limits the total number of Treaty-limited equipment present within a State Party's borders); an accession mechanism for new States Parties; enhanced verification and transparency regimes; and honors the current Treaty commitments pending entry into force of the Adapted Treaty. The Adapted Treaty will facilitate NATO enlargement and reinforce the territorial sovereignty of individual States Parties (Almanac of Policy Issues).

National and territorial ceilings are different in regards to where the limits are applied. As mentioned in Boese (2003), a national ceiling is described as each country having a specific limit on tanks, armored combat vehicles (ACVs), heavy artillery, combat aircraft, and attack helicopters—collectively referred to as treaty-limited equipment (TLE)—that it can deploy “in the treaty’s area of application”, which covers the area between the Atlantic Ocean and the Ural Mountains. On the other hand, a territorial ceiling is described as each country with territory in the treaty’s area of application having a cap on the total number of tanks, ACVs, and heavy artillery that can be deployed “within its borders”. This restricts national and foreign-stationed TLE.

3. DATA AND METHODOLOGY

In order to compare the CFE countries in Table 1, it is necessary to measure their military power. However, in a defense context, it is quite difficult for a researcher to find the appropriate data for the study. So the data sets in this field are usually limited. There are different indicators that determine a country’s military power. These are weapon holdings; armed forces personnel; military expenditure; GDP *et cetera*. However, the countries in our study have limits on their TLE, and therefore we include ceilings (national) in the data set. The variables used in the analysis are given in Table 2.

Table 2. The variables used in the analysis.

Variable	Description
X_1	Armed forces personnel (in 1000s)
X_2	Weapon holdings (aggregate number of heavy weapons)
X_3	Battle tanks (Ceilings)
X_4	Battle tanks (Holdings/Ceilings)
X_5	ACVs (Ceilings)
X_6	ACVs (Holdings/Ceilings)
X_7	Artillery (Ceilings)
X_8	Artillery (Holdings/Ceilings)
X_9	Aircraft (Ceilings)
X_{10}	Aircraft (Holdings/Ceilings)
X_{11}	Helicopters (Ceilings)
X_{12}	Helicopters (Holdings/Ceilings)

X_{13}	CFE 1A Manpower (Ceilings)
X_{14}	CFE 1A Manpower (Holdings/Ceilings)
X_{15}	Military expenditure in constant US dollars
X_{16}	Military expenditure/GDP

All the variables listed in Table 2 are taken from the Facts on International Relations and Security Trends (FIRST) database. To obtain data consistency, we used 2003 values for the variables. The ceilings and holdings/ceilings ratios for each military source are included in the data set. Since countries' willingness to use the ceilings is considered important, we used holdings/ceilings ratios to measure this effect.

Factor analysis can be a highly useful and powerful multivariate statistical technique for effectively extracting information from large databases and making sense of large bodies of interrelated data (Özgür et al., 2004). The essential purpose of factor analysis is to describe, if possible, the covariance relationships among many variables in terms of a few underlying, but unobservable, random quantities called factors. Basically, the factor model is motivated by the following argument: Suppose variables can be grouped by their correlations. That is, suppose all variables within a particular group are highly correlated among themselves, but have relatively small correlations with variables in a different group. Then it is conceivable that each group of variables represents a single underlying construct, or factor, that is responsible for the observed correlation (Johnson and Wichern, p.477, 2002).

When it comes to be occurred of factors, various extraction methods can be used (Seber, 1984). We consider the most popular method of parameter estimation which is called the Principal Component. Principal component analysis (PCA) consists of an orthogonal transformation from the original variables to a new set of variables, called principal components. The main stage in the analysis is calculating the correlation matrix to observe any natural groupings of variables with high correlations and calculating the eigenvalues and eigenvectors of the correlation matrix. It is followed by an examination of the eigenvalues and trying to decide how many are "large". This should indicate the effective dimensionality of the data. Finally, the groupings of variables suggested by the components should be looked at, and it should be considered whether the components have some meaningful interpretation (Chatfield and Collins, p.79, 1980).

Since the original loadings may not be readily interpretable, a common practice is to rotate them until a "simpler structure" is achieved. Rotated factor loading matrix gives a final result for the factor analysis. From this point on, variables are ranked according to the power of their weights, instead of the former ranking. After examination of the unrotated component matrix and consideration of some of the factors which could not be interpreted, we prefer the Varimax rotation which is one of the orthogonal factor rotation methods (Johnson and Wichern, p.502, 2002).

4. EMPIRICAL EVIDENCE

In order to define the indicators that will be included in the analysis, a correlation matrix value based on indicators has been considered, since it enables eliminating those indicators that have small correlations with the others. An anti-image matrix containing the negative partial correlations has been used to confirm this assumption. Finally, 16 indicators, which are described in Table 2, were included in the analysis.

When investigating the correlation coefficients, there should be relatively few correlations near zero. If it is seen that there a many very small correlations, we should reconsider using factor analysis with the data. When the correlation matrix is examined, it is seen that all the variables are highly correlated with each other. Furthermore we checked a table of significance values. These are p-values for testing whether the corresponding correlations are different from zero. All variables introduced in the analysis have small p-values.

After investigating the correlation matrix, the criterion Kaiser-Meyer-Olkin (KMO) and MSA, which measure sampling adequacy are examined. First of all the value of KMO is calculated as 72.3%.

Then the scores of MSA, which take place on the main diagonal of the anti-image correlation matrix, are checked. As these values are big enough, it was decided that our data is suitable for the factor analysis.

Finally the "Barttlett Sphericity Test" is examined. Bartlett's test of sphericity shows whether the correlation matrix is an identity matrix, which would indicate that the variables are unrelated. The significance level gives the result of the test. The χ^2 statistic for the Bartlett's test is 625.68 and it's p value is 0.000, so the null hypothesis stating the correlation matrix is equal to the identity matrix is rejected, and the decided data is appropriate to the factor analysis again.

While extracting factors, the frequently used principal component analysis method is preferred. The next step is to determine the number of eigenvalues which are to be included in the analysis. There are some criteria developed for this purpose. The most common one, that is called a Kaiser Test, is to select those for which the variance share is grater than one. Table 3 shows the three eigenvalues that are to be included in the analysis. As expected, the first principal component has a large variance accounting for 50.31%. In other words, the first component explains a substantial amount of variation in the variables while the remaining two components explain a considerably less amount. The cumulative variance explained by the three components is 82.70%.

Table 3. Total variance explained.

Factor	Eigenvalues	% of Explained Variance	% of Cumulative Explained Variance
1	8.05	50.31	50.31
2	3.97	24.81	75.12
3	1.21	7.58	82.70

Thus, at the end of this step, the original data set of 16 variables was converted into 3 components, capturing most of the information in the original data set.

The component matrix reports the factor loading for each variable on the rotated components or factors. Each number represents the correlation between the item and the unrotated factor. The algebraic sign and magnitude of the factor weight indicate the direction and the importance of the contribution of each indicator to all components. These correlations help us interpret the factors.

After all, the rotated component matrix has been applied as shown in Table 4 below.

Table 4. Rotated component matrix.

	Component		
Variables	**F_1**	**F_2**	**F_3**
X_9	0.970		
X_{13}	0.967		
X_5	0.957		
X_{11}	0.918		
X_7	0.913		
X_3	0.890		
X_2	0.864		
X_{16}	0.621		
X_8		0.883	
X_4		0.867	
X_6		0.858	
X_{10}		0.827	
X_{14}		0.763	
X_{12}		0.502	
X_{15}			0.907
X_1			0.737

When investigating the rotated factor loading matrix, it is seen that the first factor, which has the maximum power of explanation, contains X_9, X_{13}, X_5, X_{11}, X_7, X_3, X_2 and X_{16} with superior correlation. Taking into consideration of characteristics of these variables, we called this factor (F_1) as "Military equipment ceiling".

When it comes to the second factor (F_2), we see that X_8, X_4, X_6, X_{10}, X_{14} and X_{12} have fairly high correlation values. So we give a name as "Proportion of quota usage" for F_2.

Finally the last factor (F_3) has 2 variables; X_{15} and X_1. In this manner we called F_3 as "Military spending". After the interpreting and naming of three factors, we calculated factor scores for each country. These scores are listed in Table 5.

Table 5. Factor scores for CFE countries.

Countries	**F_1**	**F_2**	**F_3**	**Countries**	**F_1**	**F_2**	**F_3**
Armenia	-0.684	-0.192	0.174	Kazakhstan	-0.249	-2.676	-0.705
Azerbaijan	-0.900	1.141	0.341	Moldova	-0.528	-1.148	-0.901
Belarus	-0.209	0.934	-0.294	Netherlands	-0.396	-0.269	-0.255
Belgium	-0.556	-0.020	-0.182	Norway	-0.708	0.063	0.027
Bulgaria	-0.184	1.072	-0.103	Poland	0.061	0.041	-0.235
Canada	-0.256	-2.673	-0.647	Portugal	-0.559	0.060	-0.277
Czech Republic	-0.423	0.357	-0.058	Romania	0.032	0.341	-0.484
Denmark	-0.650	0.444	-0.269	Russia	4.409	-0.137	-0.947
France	0.372	0.433	0.277	Slovak Rep.	-0.848	0.858	0.252
Georgia	-0.595	-1.038	-0.315	Spain	0.028	-0.392	-0.639
Germany	0.643	0.063	-0.102	Turkey	0.517	0.760	0.879
Greece	-0.184	1.225	0.343	Ukraine	-0.033	0.551	0.600
Hungary	-0.210	0.179	-0.597	UK	1.184	0.817	-0.438
Italy	0.222	0.582	-0.043	USA	0.704	-1.377	4.597

In order to obtain a ranking for a country on the basis of three factors, we arranged each factor in scores according to the magnitude of factor scores. The ranking for F_1, F_2 and F_3 is presented in Table 6a, 6b and 6c respectively.

Table 6a. Ranking for F_1

Rank	Countries	Rank	Countries
1	Russia	15	Hungary
2	Ukraine	16	Kazakhstan
3	USA	17	Canada
4	Germany	18	Netherlands
5	Turkey	19	Czech Rep.
6	France	20	Moldova
7	Italy	21	Belgium
8	Poland	22	Portugal
9	Romania	23	Georgia
10	Spain	24	Denmark
11	UK	25	Armenia
12	Bulgaria	26	Norway
13	Greece	27	Slovak Rep.
14	Belarus	28	Azerbaijan

Table 6b. Ranking for F_2

Rank	Countries	Rank	Countries
1	Greece	15	Germany
2	Azerbaijan	16	Norway
3	Bulgaria	17	Portugal
4	Belarus	18	Poland
5	Slovak Rep.	19	Belgium
6	Ukraine	20	Russia
7	Turkey	21	Armenia
8	Italy	22	Netherlands
9	UK	23	Spain
10	Denmark	24	Georgia
11	France	25	Moldova
12	Czech Rep.	26	USA
13	Romania	27	Canada
14	Hungary	28	Kazakhstan

Table 6c. Ranking for F_3

Rank	Countries	Rank	Countries
1	USA	15	Poland
2	Turkey	16	Netherlands
3	UK	17	Denmark
4	Greece	18	Portugal
5	Azerbaijan	19	Belarus
6	France	20	Georgia
7	Slovak Rep.	21	Ukraine
8	Armenia	22	Romania
9	Norway	23	Hungary
10	Italy	24	Spain
11	Czech Rep.	25	Canada
12	Germany	26	Kazakhstan
13	Bulgaria	27	Moldova
14	Belgium	28	Russia

It's seen in Table 6a that 10 countries have positive scores and the leading countries for military equipment ceilings are Russia, Ukraine, and the USA. It is not surprising to see these countries at the top of the list since they are big in surface area and they attach importance to their defense. When the other positive scores are investigated, it is observed that the only non European Union country is Turkey.

When we consider the second factor scores in Table 6b, we observe that 18 countries have positive scores for proportion of quota usage factor. The leading country for this factor is Greece and it is followed by Azerbaijan, Bulgaria and Belarus. Since these countries have lower rankings for military equipment ceilings, it can be argued that they are using the big amount of their limited ceilings. It is also seen that Ukraine, Turkey, and Italy are good in both for military equipment ceilings and proportion of quota usage factor. This can be interpreted as their ceilings and ceiling usage are relatively high, when it is compared with other countries. It is also interesting to note that Russia and the USA have lower scores for proportion of quota usage and this means that they are not using their ceilings at the limits. The relatively low ceiling usage for the USA can be explained that the holdings and ceilings are measured in the ATTU zone. Since the area does not cover the USA region, their military equipment and quota usage looks low.

The rankings for the last factor in Table 6c show that the USA, Turkey and UK have relatively high military spending score. These countries are followed by Greece, Azerbaijan, France and Slovak Republic. It is seen in Table 6b that Greece, Azerbaijan and Slovak Republic also have high quota usage, which means their military spending is concentrated on military equipment, while the military spending of France is generally for the military personnel. It is also observed that Armenia and Norway has relatively low ranking for quota usage, while their military spending scores are positive.

Table 7. General factor scores for CFE countries.

Countries	Scores	Countries	Scores
Russia	0.409	Czech Republic	-0.025
Ukraine	0.148	Spain	-0.025
Turkey	0.100	Azerbaijan	-0.028
USA	0.070	Slovak Republic	-0.038
Germany	0.064	Denmark	-0.046
France	0.061	Netherlands	-0.055
Italy	0.049	Portugal	-0.056
Greece	0.046	Belgium	-0.058
Bulgaria	0.032	Norway	-0.065
UK	0.032	Armenia	-0.073
Belarus	0.020	Georgia	-0.112
Romania	0.012	Moldova	-0.120
Poland	0.005	Canada	-0.163
Hungary	-0.021	Kazakhstan	-0.163

To obtain a general ranking for the military power a weighted average of factor scores can be calculated. This average is called as the general factor and the eigenvalues given in Table 3 are used as the weights for this average. This general factor can be named as the military power and it gives a general ranking for the military equipment, expenditures and military personnel. Military power scores are calculated for each country and the countries are ranked by their military power in Table 7. It is observed in Table 7 that Russia, Ukraine, Turkey and the USA are the leading countries for the military power in the ATTU Zone. On the other hand, Georgia, Moldova, Canada and Kazakhstan has the smallest military power scores.

5. CONCLUSION

This paper analyzes the armed forces in CFE, as well as making a comparison and relative ranking of CFE countries' armaments using factor analysis. This ranking gives information on one country's defence ability relative to another and is quite useful for policy makers to decide on whether to increase or decrease military expenditure.

The results suggest that there are three different factors that explain the whole data set and the military based comparison of the countries are obtained by these factors. For the military equipment ceiling factor Russia, Ukraine and the USA are the leading countries, while Greece, Azerbaijan and Bulgaria are the first three countries for the proportion of quota usage. When the military spending factor is considered, the USA, Turkey and UK are at the top of the list.

The general military power factor, which is calculated as a weighted average of military equipment ceiling, proportion of quota usage and the military spending, shows that Russia, Ukraine, Turkey and the USA have relatively better military power scores than the other countries have.

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