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Abstract

In this paper we newly design and quantitatively measure the performance index - 'amount of the military forces compared to the nation's resources,' which is equivalently interpreted as the nation's dependency on the military instruments. And, we analyze the changes in the security environments from the Cold War period to the post-Cold War period using DEA.

Keywords: Data Envelopment Analysis; Malmquist Productivity Index; Military Force; Cold War.

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Introduction

Since the dismantle of the Soviet Union in 1991, the world stretching from the east to west witnessed an enormous change in the security environments of a host of nations. It was since then increasingly felt about the greater possibility of regional conflicts among nations. Moreover, the Gulf War at the end of the Cold War, which was conspicuously perceived as the indication of post-Cold War threat to the West, exuded the presentiment of Revolution in Military Affairs (RMA) in the future.

Many nations were plunged to change their security policies due to the then ongoing turbulent changes in the security environments. Citing few examples, Pentagon reviewed its military force structure in 1993; Russia was also found to reorganize its military forces in 1993; and similarly Japan reviewed its National Defense Program Outline (NDPO), which outlined the nature of Japan's defense capability, and prescribed the required military instruments that it should possess, and consequently adopted a new NDPO in 1995.

The question is then how the change in the security environments has altered a nation's instrument system for security policy. This question can be well addressed by gripping the policy instrument system, which is tantamount to unfolding the underlying inherent features such as the changes in the feature of the security policy, security environments, relationships among nations, and so on. This paper makes an attempt to quantitatively measure these changes through a case study in which a macro analysis based on our newly designed index - 'amount of the military forces compared to the nation's resources' is presented. We have used here a new variant of Data Envelopment Analysis (DEA) models (Tone (2001a,b, 2002)), called Slacks-based Measure of Super-efficiency (Super SBM), which has recently drawn closer attention as a superior index for total factor productivity growth in the presence of slacks.

In our attempt we draw two broad inferences from Dr. Kissinger's description concerning efficiency trends as well as efficiency differential among nations from the Cold War period to the post-Cold War period. Our results indicate that two nations (U.S. and Russia) confirm to the first inference that their efficiency is increasing over time, and most of the nations confirm to our second inference that their efficiency differential is decreasing. The Malmquist results show that there was a remarkably fall in productivity in

mid-1980s when the extreme tension between the east and the west was fomenting followed by a steady rise in productivity after the end of the Cold War. Our cluster analysis shows that the nations belonging to each particular group fits in historically.

The rest of the paper unfolds as follows. In Section 1 we have explained in detail our newly constructed index, 'amount of the military forces compared to the nation's resources.' This section also describes various types of the nation's resource data used in analysis while analyzing the relation between the nation's resources and the military forces. Section 2 presents the discussion of results followed by a brief introduction to DEA. Here, the inferences drawn from the Cold War to the post-Cold War are verified with our DEA results. In Section 3 the concept of Malmquist Index is discussed, and the nations exhibiting similar characteristics are clustered based on the Malmquist Index values. Section 4 concludes with the agenda for future research.

1 Selection of nation's resources

The index - 'amount of the military forces compared to the nation's resources' is newly designed in order to quantitatively measure the changes in the security policy instruments so as to capture the essence that is enumerated in the third item (which is given below) of "Basic Policy on National Defense" by Japanese National Defense Council and Cabinet in 1957.

> "To develop incrementally the effective defense capabilities necessary for self-defense, in accordance with the nation's resources and the prevailing domestic situation" (*Defense of Japan 2001, p.282*).

It seems plausible that the nation's level of the military forces is not completely unrelated to the nation's resources. The reason is that every nation takes the volume of its resources into account as a constraint on the military force build-up or the size of defending objects while deciding upon the possession level of the military forces for national security policy. It is quite reasonable to expect that a nation with abundance resources has a large number of military forces if there is a positive correlation between the nation's resources and the military forces (This hypothesis is verified later). And it might be the inefficiency of a nation when it has too a large number of military forces as compared to its resources.

However, the size of a nation's military forces is dependent not only on the volume of its resources but also on several other factors such as geopolitical factors, its relationship with other nations, defense consciousness, posture to the crisis-management, and so on.

The ultimatum now is to shore up the following question: Can this index capture 'the prevailing domestic situation'? Putting it differently, can this index be interpreted as nation's 'dependency on the military instruments' against the background of "the prevailing domestic situation" rather than the nation's performance? It is quite possible to construct this index, using panel data of many countries over time, that is capable of essentially capturing various features of security environment and world situation.

1.1 Studies on national power

In international politics, there is a concept of 'national power.' Despite the widely claim that the concept itself is very abstract in nature, it is not inimical to think of a nation with abundant resources synonymously with the one having more power. That is, a nation's resources become some elements determining its national power (In Japanese, both national power and nation's resource are being treated in one word, "kokuryoku").

Let us now see the current studies on national power in which nation's resources are intertwined with national power. If the description of the idea of national power as well as its components are traced, it will be possible to know the relative importance of nation's resources. Fortunately, the current domestic as well as foreign studies on national power are found in 'Total national power of Japan ('Nihon no Sogo-kokuryoku' in Japanese)' edited by Japan Economic Planning Agency.

To our knowledge, there are 14 studies (eight foreign & six domestic) on 'Total national power of Japan,' in which 'basic ideas concerning the national power' and 'components of the national power' are dealt with. Looking at the 'basic ideas concerning the national power,' they are indeed many concerning whether to value military force or economic potential, to regard influence or means, and so on. A closer look at this leads us to concede that there is no unique way to define 'national power.' And, it is quite reasonable to argue that the idea of the national power is very different depending on the age, background, the world situation or the purpose of research.

Similarly, concerning the 'components of the national power' we find that

they are indeed different depending on how to define national power in each study. Here the components are broadly divided into five categories (see Appendix A). The most common category, Military force (including the descriptions such as strategic organization of politics and strategic leverage) is found in 12 out of 13 studies. Economic potential (including the descriptions such as resource and production) and Qualitative elements (covering government, leadership, people, intention, public opinion, politics, diplomacy, civilization, society, etc.) are each discussed in 11 studies. Population and territory is discussed in seven studies, and finally Geographical condition in four studies.

The military force is generally perceived to be included in the elements of national power in current studies. However, taking the position that the military force can be viewed from the perspective of nation's resource in our study, it is not included in the nation's resources. The relation between national power in current studies and nation's resources in our study is demonstrated in Figure 1.

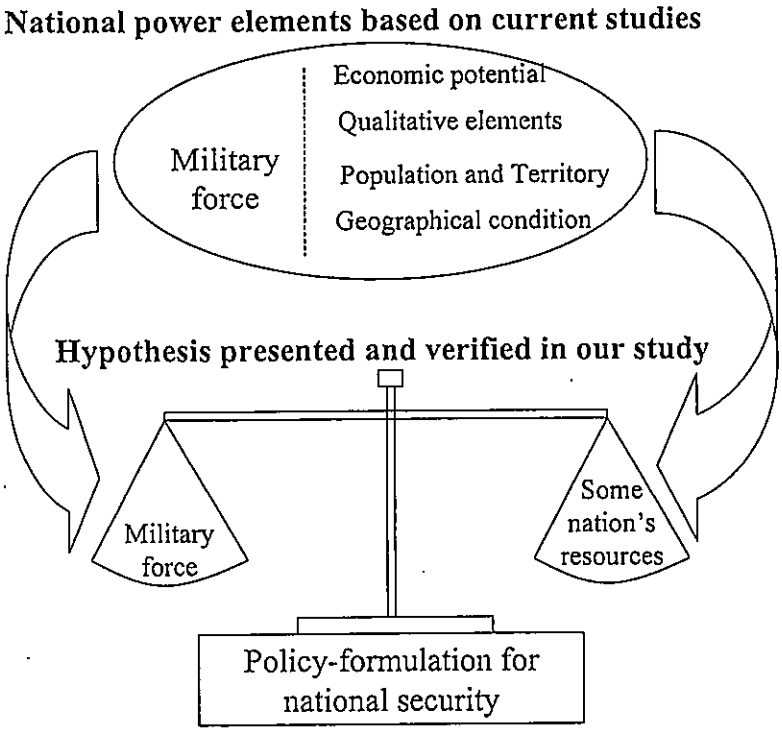

Figure 1: Relation between current studies and our study

We have made an attempt here to explicitly maintain a balance between the military forces and other elements of national power (nation's resources). All we need to do here is to examine the proposition that how the volume of the military forces *vis-á-vis* the nation's resources among nations behave over time. Here, we need to strongly position that a striking balance between the military forces and nation's resources is maintained while formulating policies on national security. So our work can be construed as verifying and testing the above stated proposition.

In the next section we verify the above-mentioned proposition by selecting some quantitative indicators representing the nation's resources, which have all positive correlations with the level of military forces.

1.2 Quantitative indicators of nation's resources

The following two considerations are taken into account to examine the above-mentioned proposition.

1. Investigating a policy mechanism, which defines a positive relation between the economic potential and the military forces while historically tracing the Japanese security policy since the post-World War era.

2. Confirming a positive correlation by the rank correlation test using real-life panel data of 158 countries, and conducting the statistical hypothesis test.

We now explain the above two in detail as follows.

1.2.1 Relation between economic potential and military forces

When we think of quantitative indicators for the nation's resources being positively related with the military forces, economic potential generally comes to mind first. For example, a nation without requisite capital cannot maintain the military force. Putting it differently, the military force might become necessary to defend nation's economic interests. For instance, "ensuring the viability and stability of major global systems," which is enumerated in five items of U.S. vital national interests recommended by the U.S. high-ranking government official, includes trade, financial markets, and supplies of energy. About Chinese advancement to the South China Sea in the post-Cold War,

China justifies the purpose of defense for the interests concerning the ocean resources. Japan is similarly emphasizing for the defense of the sea lane, which is the lifeline of its national economy.

Assuming the relationship between the economic potential and the military force, we investigate the mechanism defined in the policy process. We have traced and investigated the speeches by Japanese Prime Minister and Foreign Minister in Japanese Diet and foreign countries since the end of the World War. Japan's economy was completely drained, and there were no military forces at the end of the World War. However, afterwards they almost showed a monotonic increase, even went up to the second place in the world in terms of gross national product, and fourth place in the national defense expense. So, Japanese process in the post-World War days becomes a typical sample in which a positive relation between the economic potential and the military force can be perceived.

We pick up the following three items from the speeches.

1. Size of economic potential

2. Purpose of defense: necessity of defense, defense object, etc.

3. Relation between size of economic potential and required military force

We have highlighted here only the main results. The relation between the economic potential and the military forces is demonstrated in Figure 2.

As is seen in Figure 2, the purpose of defense becomes wider with the increase in not only the size of economic potential but also the necessity of the military force. A positive relation between the economic potential and the military forces is established through such a mechanism. In particular, when the size of economic potential is small, the purpose of the defense is mainly meant for 'independence' and 'self-defense,' and the small size of economic potential is a restriction on the build-up of the military force. If the necessity of the military force of a nation is so high compared to its economic potential, it might happen that the defense effort might exceed some tolerable level. Therefore, we feel that some quantitative indicators of the nation's resources, which might be positively related with the necessary amount of military forces for 'independence' and 'self-defense,' should be selected in this section.

When we think of using military forces for the self-defense of a nation, the military forces have several roles and functions such as resistance to

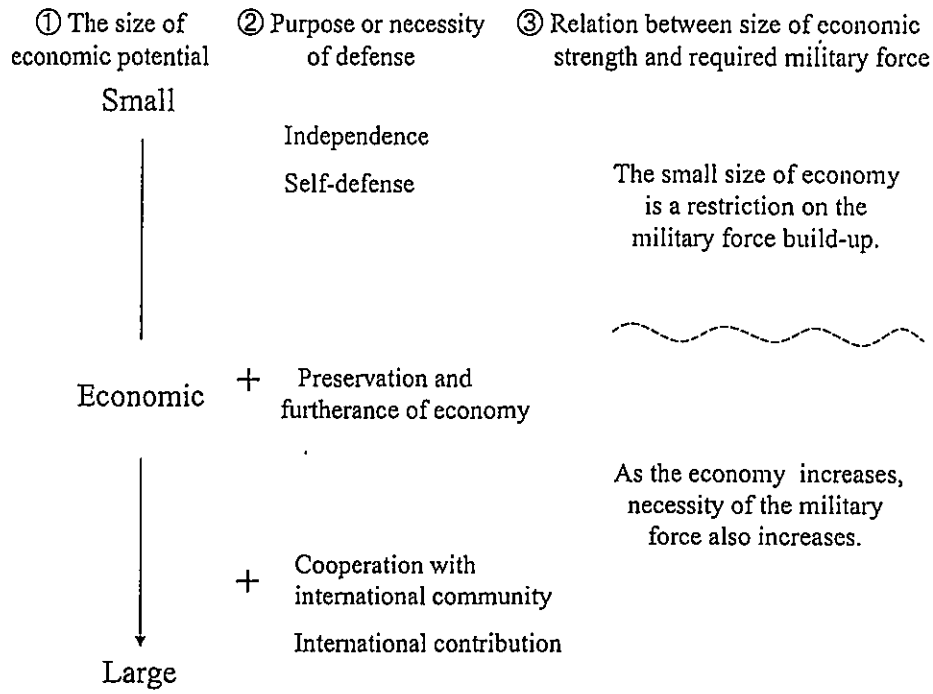

Figure 2: Relation between economic potential and military forces

an external threat, domestic public peace keeping, and so on. These led us to think of 'Territory area' and 'Population' corresponding to the size of defending objects to be selected for possible representatives of nation's resources. To sum up, with larger territory, the stationed military force for national security is more, and similarly with larger population, the military force for the stability of public is also more.

However, in addition to 'Economic potential,' 'Territory area' and 'Population' might become the constraints for the military force build-up. For example, in the process of making the former Japanese NDPO, besides 'Economic potential' the restrictions on the number of soldiers as well as on the establishment and operation of defense facilities were taken into consideration.

We consider here three indicators *viz.* 'Economic potential,' 'Territory area' and 'Population' to be the possible candidates for representing the nation's resources. Using now the index - 'amount of the military forces compared to the nation's resources,' it is reasonable to argue that a nation

with these three indicators of higher magnitudes has a large number of military forces. And, when a nation has too a large number of military forces compared to these elements, its 'dependency on the military instrument' is considered to be high.

1.2.2 Test of statistical hypothesis

We verify here the positive correlation between the quantitative index of the military force and each of these nation's resources using real-life data. Before proceedng the analysis, due considerations were given to the problem that what numeric data should be used for 'Economic potential.' Considering all factors which might possibly influence the military force build-up, we find that there are a wide range of factors such as economic vulnerability, shipment, industrial engineering capability, energy resource, and so on. However, in this research gross national product (GNP) is taken as a proxy, which can capture many such factors, and can be considered a good representative for 'Economic potential.'

Using the data of 158 countries in the world, we calculated the Spearman's rank correlation coefficients for each of nation's resource elements with defense expense and their corresponding t-statistics. The null hypothesis considered here is: There is no correlation for the national defense expense with GNP, territory area, population respectively. The results are reported in Table 1.

Table 1: Rank correlation coefficients and their corresponding t-statistics

	Defense expense - GNP	Defense expense - Territory area	Defense expense - Population
Rank correlation coefficient	0.921	0.337	0.629
t	29.427	4.472	10.109

As is seen from Table 1, all the three null hypotheses are rejected at 0.1% level of significance. In other words, all the three elements of the nation's resources (GNP, Territory area and Population) have significant positive relationship with Defense expense. On comparison, GNP is found to have high

rank correlation. And in case of Territory area, the correlation coefficient, though found to be comparatively low, seems to be unquestionable because it is significant even at 0.1% level.

2 Analysis using DEA

Using panel data we make a comparative analysis among nations based on the performance index. In the spirit of Kim and Hendry (1998) we compute this performance index using the Slacks-based Measure of Super-efficiency (Super SBM) (Tone (2002)).

2.1 Merits of using DEA

2.1.1 Basic DEA models: CCR and BCC

Data Envelopment Analysis (DEA) is a linear programming based technique to measure the relative performance of decision making units (DMUs) where the presence of multiple inputs and outputs makes the comparison difficult. In the past single-factor (*e.g.*, labor productivity or capital productivity) ratios were used to produce a set of *ad hoc* productivity/efficiency measures. Yet there is no reason *a priori* that these single-factor ratios should yield a consistent summary view of performance. A summary total-factor measure of performance avoids the ambiguity of single-factor ratios, but requires the aggregation of inputs and outputs. DEA embodies the principle of total-factor view of efficiency, and in addition, provides a system of weights allowing the reduction of multiple ratios into a scalar overall view of performance. To put it differently, DEA expresses the efficiency of a DMU as the ratio of virtual outputs (weighted combination of outputs) to virtual inputs (weighted combination of inputs). The virtual inputs and outputs convey the information on the relative importance that a DMU attaches to particular inputs and outputs in order to attain maximum efficiency rating.

In our study we take various nation's resources as outputs and military forces as inputs. DEA provides weight for each individual input and output and expresses each nation's efficiency as the ratio of virtual output to virtual input. In DEA setting, the concept of efficiency is based on the idea that a nation (we treat here each nation as a distinct DMU) is efficient if it has less military forces compared to its resources. For example, a nation's

efficiency score being less than one indicates that it has more military forces compared to its resources, thus yielding the interpretation that the nation's 'dependency on the military instrument' is high.

DEA has a distinct advantage over statistical regression in the evaluation of such efficiency. The conceptual difference between the two is explained below with the help of Figure 3. Let us first consider the Charnes, Cooper and Rhodes (CCR) model (Charnes *et al.*(1978)).

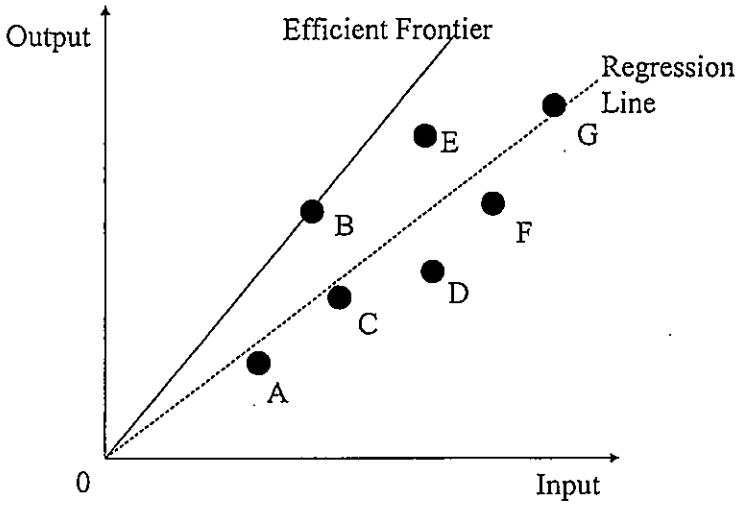

Figure 3: Example of CCR model

Figure 3 exhibits 7 DMUs (A, B, C, D, E, F and G); each uses a single input to produce a single output. The regression line is drawn in such a manner that it should pass through as many points as possible, *i.e.* the error sum of squares will be least. This regression line does not reveal the best performance of the DMUs operating on the boundary of the production possibility set, because there are some DMUs (which are operating above the regression line) producing more output compared to DMUs operating on the regression line.

On the other hand, considering the slopes (productivity) of line emanating from the origin and passing through the each of these points, we find that the line from the origin through B attains the highest slope. This line is called the "efficient frontier" because this line corresponds to the highest productivity. The frontier line designates the performance of the best DMU B, which is assigned an efficiency score of 1. And the remaining DMUs attain a score of

less than 1 as measured by deviations of their individual observations from the frontier.

Thus, there exists a fundamental difference between statistical approach (*via* regression analysis) and DEA. The former reflects 'average' or 'central tendency' behavior of DMUs while the latter deals with the estimation of frontier of those DMUs revealing best performance, and then evaluates the DMUs operating below the frontier by the deviation from the frontier. Thus, these two methods suggest differently for performance improvement. DEA identifies a point like B for future examination or to serve as a "benchmark" for seeking improvements. The statistical approach, on the other hand, averages B along with the other observations, including D as the basis for suggesting the performance.

The CCR model exhibited in Figure 3 assumes constant returns to scale (CRS). However, this assumption is relaxed in the Banker, Charnes and Cooper (BCC) model (Banker *et al.*(1984)), which assumes variable returns to scale (VRS). This model is demonstrated in Figure 4 below. The efficient

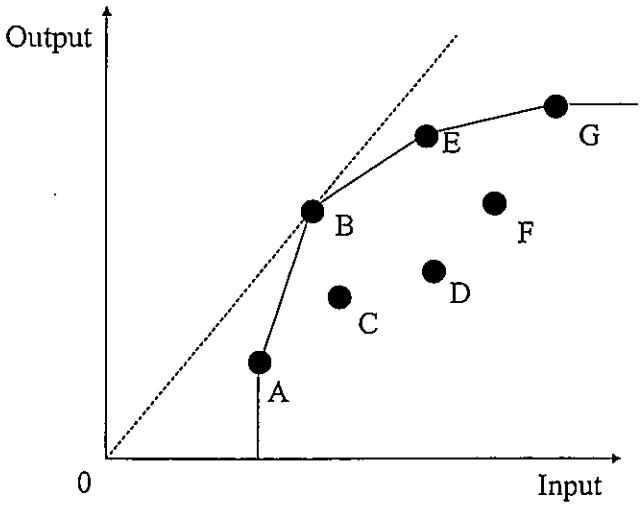

Figure 4: Example of BCC model

frontier of CCR model is the dotted line passing through the point B from the origin. The frontier of the BCC model consists of the solid lines connecting the points A, B, E and G. In BCC model frontier lines are constructed in the manner that for each and every successive increase in the input, the corresponding maximum possible output levels are identified. The BCC model

thus takes scale characteristics into account while evaluating efficiency of DMUs. It is to be noted here that CCR-efficiency score does not exceed the BCC-efficiency score.

2.1.2 Super SBM model

We have used in our work a new variant of DEA model, *i.e.*, Super SBM model of Tone (2002), which is considered superior on two counts: 1) in the presence of slacks (input surplus or output shortage) and 2) in discriminating among efficient units.

Concerning the problem of slacks, one important property that an efficiency measure should ideally satisfy is that when a DMU's input increases or output decreases, its efficiency value should decrease. The efficiency scores in basic DEA models do not exhibit such desirable property. However, SBM efficiency measure (Tone (2001a)) does satisfy this property. Coming back to the second, the basic DEA models suffer from the problem that how to rank efficient units as they all receive unity efficiency scores. However, the upper bound of efficiency score of '1' is removed in the Super SBM model, assigning the highest score to the most efficient unit and slightly a lower score to the next best efficient unit, and so on. The efficiency score computed in this model is called 'super-efficiency.'

There are four types of Super SBM models, shown in Table 2, by the following two divisions: 1 - whether the efficiency is measured from input/output oriented model, and 2 - whether the assumption of CRS or VRS is maintained in each orientation.

Table 2: Four types of Super SBM models

2 \ 1	Input-oriented	Output-oriented
CRS	Super SBM-I-C	Super SBM-O-C
VRS	Super SBM-I-V	Super SBM-O-V

We have used in our study the input-oriented model by considering the military forces adjustable parameters. Also, the assumption of VRS is maintained from the viewpoint of Japanese security policy concerning the relation between economic potential and military forces. When we used the Super

SBM VRS model, some of the DMUs such as U.S., Russia, India and China constantly get unity efficiency score. The reason is that these countries are found to have very high values in some of the output parameters (*e.g.*, Russia in territory area, India and China in population, the U.S. in GNP) compared to other countries. For such DMUs, the Super SBM VRS model always assigns unity efficiency scores. We therefore used the CRS model (Super SBM-I-C model) to analyze the efficiency trends of the U.S. and Russia.

2.2 Frame of analysis

2.2.1 Object of study

We have considered 19 countries in our study. They are listed below.

The United States, Russia, The United Kingdom, Germany, France, Italy, Egypt, Iran, India, Thailand, Australia, Indonesia, Vietnam, The Philippines, Japan, South Korea, North Korea, Iraq and China (which includes Taiwan).

2.2.2 Input and output (I-O) items

The three outputs considered in our study are GNP, Territory area and Population. We first thought of the defense expenses and the amount of the military forces as the input items. Since the reliability of the data on the defense expense of the Communist countries is low, we decided to drop it and consider only the latter in that we selected three items *viz.* 'Ground forces,' 'Naval tonnage' and 'Number of combat aircraft,' which represent respectively the ground, naval and air force.

The military capability should ideally be viewed not only from the quantitative indexes but also from the organized and integrated capability adding the morale, quality of equipment, information, logistics, and so on. However, we exclude these variables because we find it difficult in measuring such capabilities. Moreover, the nuclear weapon is also excluded from the consideration.

2.2.3 Sources of data

The panel I-O data of 19 countries over 14 years (from 1984 to 1997) are considered.

Real GNP (base price in 1990 fiscal year) The United Nations, *Statistical Yearbook*, 40th issue (1993) and 44th issue (1997).

Population The United Nations, *Demographic Yearbook*, 45th issue (1993) and 49th issue (1997).

Territory area The Yano Tsunetaro Memorial foundation, *The data and chart of nations in the world* ('Sekaikokuseizue' in Japanese), 1988-89 and 2000-01.

Amount of the forces Asagumo Press, *Defense Handbook* ('Bouei Handbook' in Japanese), from 1985 to 1998. Japan Defense Agency, *Defense of Japan*, from 1985 to 1998.

2.2.4 Using data

We consider both the former Soviet Union and Russia as one DMU (Soviet Union until 1992 and Russia after 1993). Similarly, we consider both West Germany and Germany as one DMU (West Germany until 1990 and Germany after 1991). We make a reference DMU (Japan B), which includes the U.S. Forces stationed in Japan.

We have now in total 20 DMUs out of 19 nations, and sort out four exceptional DMUs - Australia, Iraq, China and Japan B from the other 16 basic DMUs. Because Australia's efficiency is outstanding and Iraq's is extremely influenced by the Gulf War, we regard them as exceptional DMUs. And regarding China we generally consider it separately (by excluding Taiwan) keeping in mind the security problems.

Regarding 16 basic DMUs, we evaluate them only in a basic group. Regarding Japan B, we replace Japan with Japan B, and evaluate it with 16 basic DMUs. As regards the three exceptional DMUs, we evaluate each one of them with 17 DMUs (an objective DMU and 16 basic DMUs). The reason for going through such an above-mentioned procedure is that it is necessary to avoid the efficiency evaluation based on the efficient frontier spanned by exceptional DMUs because DEA efficiency estimate is very sensitive to frontier.

2.3 Comparative analysis among nations

We evaluate here the efficiency of all nations for each of these 14 years separately using Super SBM-I-V model. The results are plotted in Figure 5.

Barring Australia and Japan, we cannot examine the performance of other nations in details in this figure. We explain them separately in the subsequent graphs. However, the U.S., Russia, India and China are excluded in the subsequent graphs because their efficiency values are all '1' as has been explained in Section 2.1.2. It is to be noted here that the low/high DEA-efficiency scores reveal high/low dependency on the military instruments.

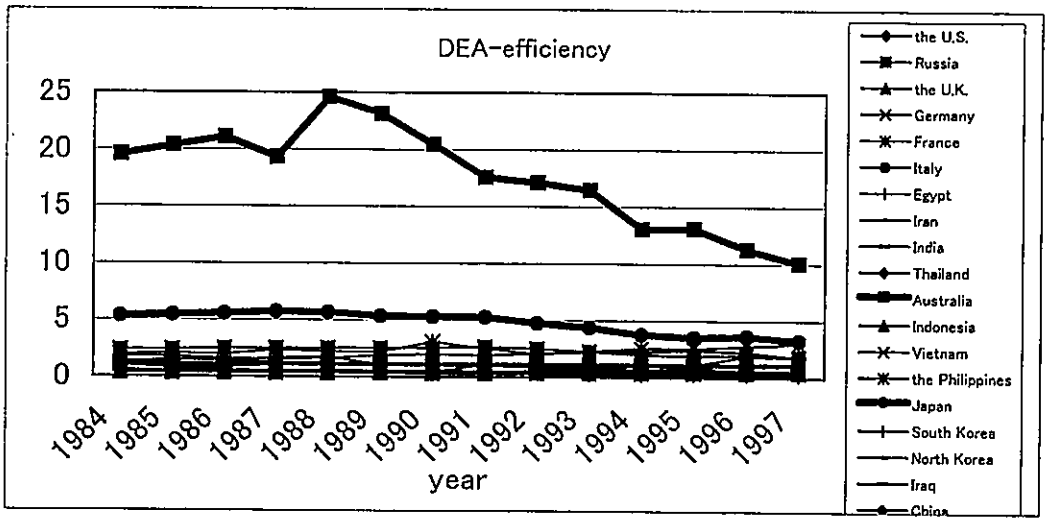

Figure 5: All DMUs' efficiencies

2.3.1 Australia

The performance of Australia is outstanding, and is at least two to four times that of Japan, which ranks second in our sample. This result might be due to less remarkable threat to the surroundings in Australia reflecting peaceful environment in the country. Looking at the input output data in 1997 (see in Appendix B) we know that Australia's ground force and air force are very low, and naval force is below the average.

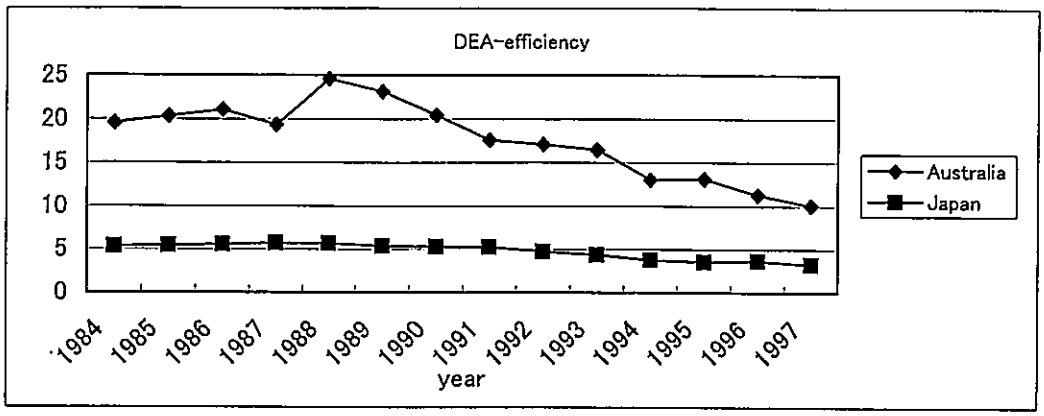

Figure 6: A comparison between Australia and Japan

Table 3: Order of the Australia's forces

Ground forces	Naval tonnage	Number of combat aircraft
19th / 19 nations	13th / 19 nations	18th / 19 nations

2.3.2 The Middle East

The efficiency changes of Iran and Iraq in 1980s can be viewed from the perspective of the Iran-Iraq War. The war condition was worse for Iran leading to its extreme political isolation, and most of the Iran's forces were destroyed. This has led to increase in Iran's efficiency until the end of the war in 1988. On the contrary, Iraq's efficiency has been decreasing until 1988 because Iraq was able to reinforce its forces with the support from the other nations despite its worse economic conditions. Iran's efficiency, which has started decreasing after 1988, is mainly due to the increase of the number of combat aircraft. Looking at the I-O data we find that Iran increased its combat aircraft by more than six times during the time period: 1988-1997. The remarkable increase in Iraq's efficiency after 1990 is largely due to the destruction of many of its forces in the Gulf War.

Egypt's efficiency plot gives us a mix picture until around 1987. Egypt was expelled from the Arab League by making a peace treaty with Israel in 1979, but however joined back in the Casablanca conference in 1989. The efficiency change might reflect the instability of diplomatic situation. However,

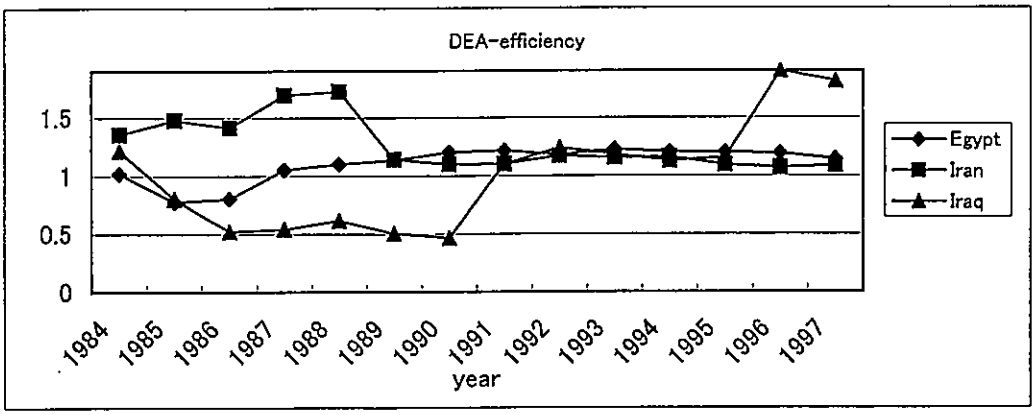

Figure 7: A comparison among the Middle East nations

after 1989 Egypt improved its diplomatic relations remarkably, and came to play an important political role in the region.

2.3.3 Main NATO nations

It is seen here that Germany has shown remarkable increase in efficiency after 1991 before which there is not seen to be much efficiency differentials among these nations. However, after the former West Germany was changed to Unified Germany in 1990-91, it has shown such a dramatic increase in efficiency. A close look at the I-O data reveals that Germany has reduced its ground forces and the number of combat aircraft by about 30% from 1991 to 1997, which has resulted an increase in its efficiency.

2.3.4 Asia

As far as Asia is concerned, two separate graphs are prepared depending on the magnitude of its nations' efficiency scores, and are shown in Figure 9 and Figure 10.

Japan's efficiency has been very high (more than 5) during the Cold War period, but has started declining after 1987, and this decline is however more prominent from 1991 onwards. The I-O data indicate that Japan increased its naval tonnage and combat aircraft by about 1.4 times between 1987 through 1997.

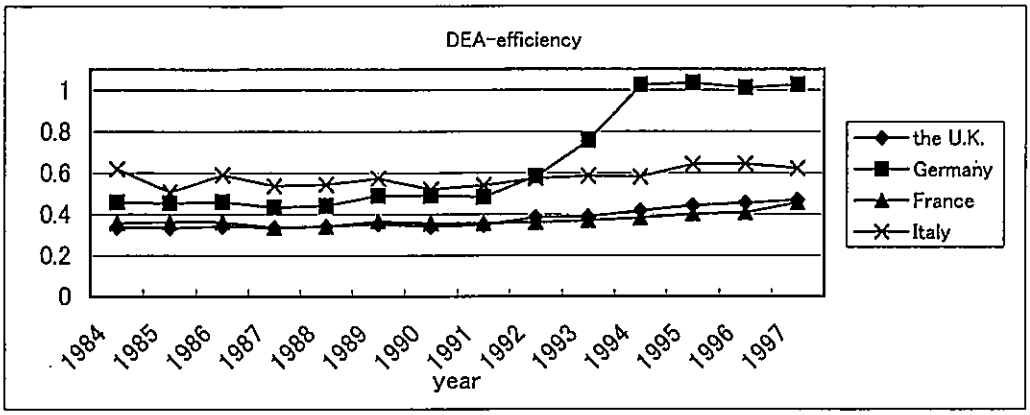

Figure 8: A comparison among the main NATO nations

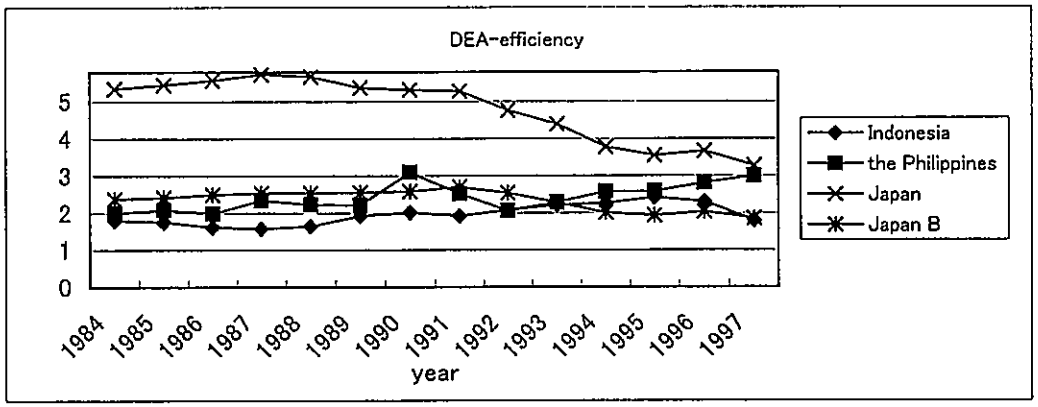

Figure 9: A comparison among the Asian nations showing higher efficiency

Comparing the efficiency trends of Japan and Japan B (in which the stationed U.S. Forces are included), we find that the efficiency differential was very high during the Cold War period after which it started declining. In particular, between 1987 and 1991, Japan's efficiency is decreasing whereas it is increasing in case of Japan B. The I-O data indicate that the number of combat aircraft used in the U.S. Forces stationed in Japan is reduced by about 30% during this time period: 1987 through 1991 in response to the decrease in the threat level of the former Soviet Union. So the inference that the U.S. Forces stationed in Japan played a vital role in security of Japan in response to the threat of the former Soviet Union during the Cold War

period can be easily fathomed from the above finding. Thailand's efficiency

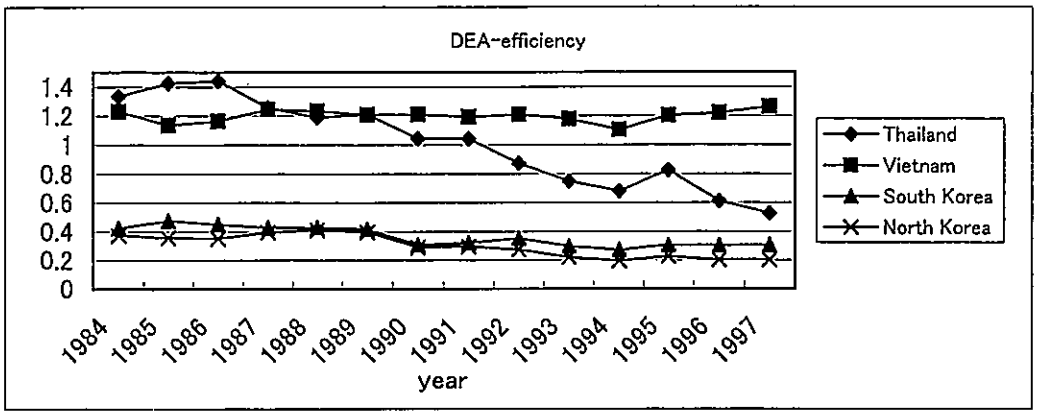

Figure 10: A comparison among the Asian nations showing lower efficiency

decreases remarkably after 1986 due to its increased naval tonnage by 2.6 times from 1986 to 1997. Both North and South Korea's efficiencies are consistently in the ballpark of bottom five of 19 nations (in the bottom 4 after 1988, and in the bottom 2 after the end of the Cold War in 1990). This finding exudes that the military tension in this region became more ominous especially after the end of the Cold War.

2.4 Verification of the inferences

We now attempt to verify the inferences drawn from Dr. Kissinger's description (given below) from the efficiency trends of various nations from the Cold War period to the post-Cold War period.

2.4.1 Setting the problem

Dr. Kissinger was a member of the faculty of Harvard University, served as Assistant to the President for National Security Affairs in Nixon Administration, and as the Secretary of State concurrently in Ford Administration. He is known to the public in many ways *viz.*, as a scholar, a politician, a strategist, and so on. To quote Dr. Kissinger who wrote in his book 'Diplomacy' the following:

"In the Cold War world, the traditional concepts of power had substantially broken down. Most of history has displayed a synthesis of military, political, and economic potential, which in general has proved to be symmetrical. In the Cold War period, the various elements of power became quite distinct. The former Soviet Union was a military superpower and at the same time, an economic dwarf. It was also possible for a country to be an economic giant but to be militarily irrelevant, as was the case with Japan.

In the post-Cold War world, the various elements are likely to grow more congruent and more symmetrical. The relative military power of the United States will gradually decline. The absence of a clear-cut adversary will produce domestic pressure to shift resources from defense to other priorities - a process which has already started. When there is no longer a single threat and each country perceives its perils from its own national perspective, those societies which had nestled under American protection will feel compelled to assume greater responsibility for their own security. Thus, the operation of the new international system will move toward equilibrium even in the military field, though it may take some decades to reach that point. These tendencies will be even more pronounced in economics, where American predominance is already declining, and where it has become safer to challenge the United States." (Kissinger (1994, p.23))

The two inferences drawn from the above description are

Inference 1 The U.S. and Russia show an increasing efficiency trend whereas the trend is oppsite in case of Japan during the time period from the Cold War period to the post-Cold War period.

Inference 2 The efficiency differential among the nations is becoming smaller and smaller during the above stated time period.

2.4.2 Verification

In the foregoing section, we evaluated separately the efficiencies of nations for each year. We however evaluate here the efficiencies of the nations for the whole time period by treating each DMU over time as distinct. We now have a total of 324 DMUs (16 nations $\times$ 14 years). We evaluate here only 16 basic DMUs over 14 years using the Super SBM-I-C model. This efficiency

evaluation is made using only one efficient frontier constructed from our panel data. The efficiency trends are shown in Figure 11.

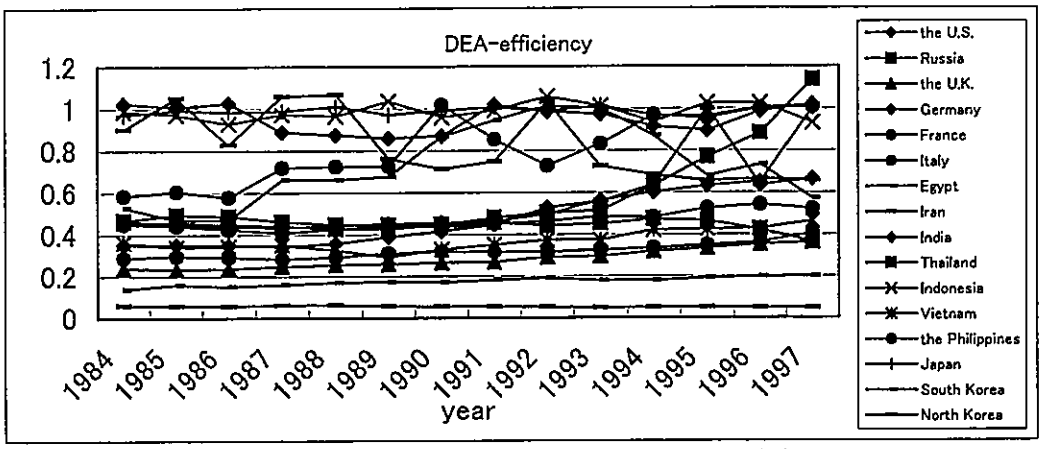

Figure 11: Efficiency changes of 16 basic DMUs

Inference 1

The efficiency changes of the U.S., Russia and Japan are separately shown in Figure 12. As expected, the U.S. and Russia show an increasing efficiency trend. But, there is no trend visible in case of Japan. The I-O data indicate that though Japan's military force has increased, this increase is just offset by the equivalent percentage increase in GNP growth, leading to de-trend in efficiency pattern.

Inference 2

The efficiency variation as shown in Figure 13 confirms to the validity of our second inference. The variation is highest (0.59) in the year 1985 when there was extreme tension between the east and the west. And it is least (0.47) in 1994 after which the trend is seen to be slightly upward.

2.4.3 Consideration

We have made an attempt here to verify the inferences drawn from Dr. Kissinger's description concerning the symmetry/asymmetry of the synthesis of military,

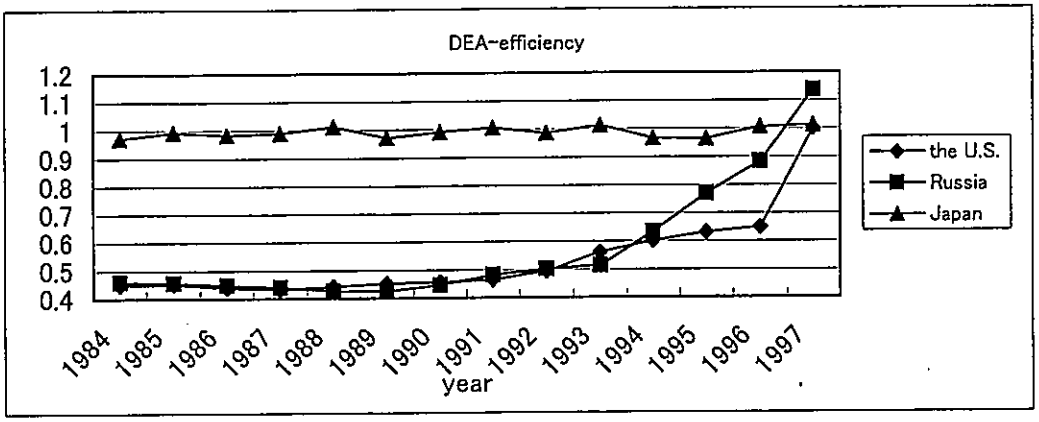

Figure 12: Efficiency changes of the U.S., Russia and Japan

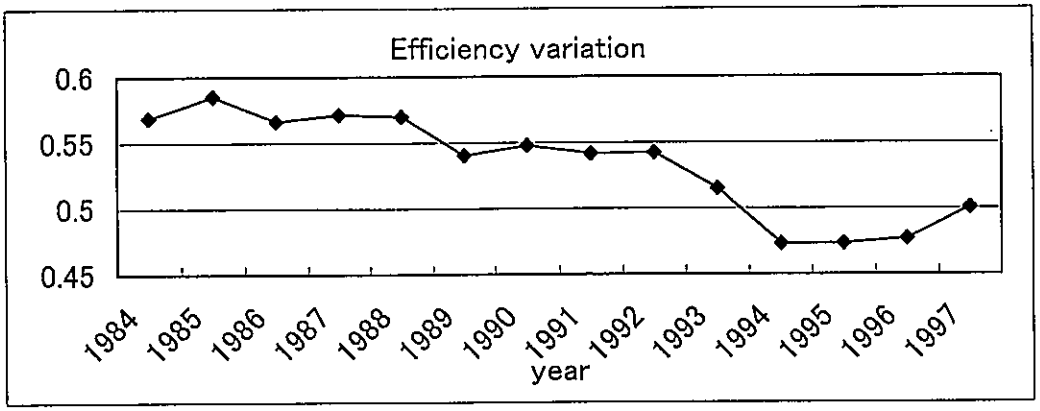

Figure 13: Efficiency variation among the nations

political and economic potential during the period from the Cold War period to the post-Cold War period. Concerning the first inference, two nations out of three confirm to the validity of our inference that efficiency is increasing over time. And our second inference that efficiency variation is decreasing over time is also confirmed. However, Japan's efficiency trend, though did not confirm to our first inference, has not negated it too.

We have evaluated the DEA-efficiency scores based on the one efficient frontier from the panel data of 16 nations over 14 years in order to avoid the frontier shift. However, it would be difficult to measure super-efficiency in this method. For example, the high efficient nations such as Japan and India

take unity efficiency scores in Figure 11. The reason is that the comparison is made here against the same nations, which is not so while measuring super-efficiency. Therefore, Japan's efficiency hardly shows any change in its efficiency behavior over time. The Malmquist Index, which is a composite measure of efficiency change (catch-up) and frontier shift, is however quite useful to accurately know the resultant changes in performance over time.

We can however confirm to the validity of the second inference if we evaluate efficiencies of nations separately for each year irrespective of the nature of returns to scale environment.

3 Analysis using Malmquist Index

We analyze here, using Malmquist Index, the productivity changes of nations over time. Before proceeding it is however necessary to know what is Malmquist Index.

3.1 Malmquist Index

Let us consider, for the sake of simplicity, a production technology for a given time period, which uses a single input to produce a single output. The efficient frontier derived from this technology is shown in Figure 14. Now let us evaluate the efficiency of DMU A, which operates below the frontier. So in the input-oriented DEA model, DMU A's efficiency is the ratio of 'minimal input required' to 'actual input used' for the continued production of given output of DMU A, i.e. Efficiency of DMU A $= \frac{QP}{QA}$.

We now consider the case when DMU's efficiency changes over time. We illustrate it in Figure 15. Now we have two efficiency frontiers corresponding to time periods 1 and 2. Suppose that DMU A operates at point A1 in time period 1 and at point A2 in time period 2. DMU A's efficiency based on each time period's frontier are $\frac{Q_1P_{11}}{Q_1A_1}$ and $\frac{Q_2P_{22}}{Q_2A_2}$. The efficiency change from t=1 to t=2 of DMU A is $\frac{Q_2P_{22}/Q_2A_2}{Q_1P_{11}/Q_1A_1}$, which is generally called as *catch-up* (signifying to what extent the DMU is catching up to the frontier) in the DEA literature. On the other hand, the efficiency change can also be evaluated based on the same frontier. For example, A1's efficiency based on the t=2's frontier is $\frac{Q_1P_{12}}{Q_1A_1}$, and the efficiency change is $\frac{Q_2P_{22}/Q_2A_2}{Q_1P_{12}/Q_1A_1}$. Similarly, the efficiency change

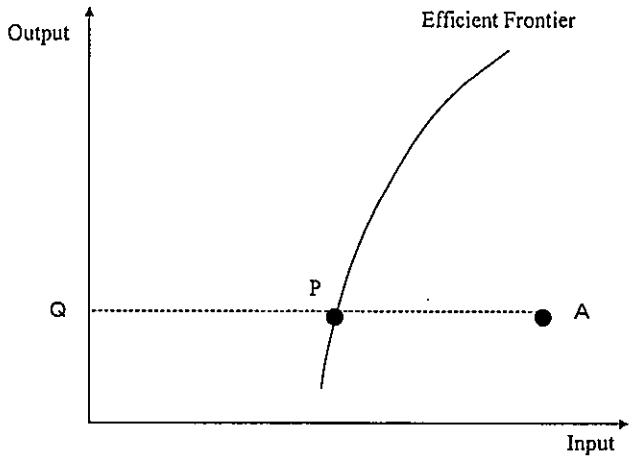

Figure 14: Efficient frontier and DEA efficiency

based on the t=1's frontier can be expressed as $\frac{Q_2P_{21}/Q_2A_2}{Q_1P_{11}/Q_1A_1}$. Malmquist Index (MI), widely known as total factor productivity growth, is nothing but the geometric mean of these two efficiency changes, which is shown below:

$$Malmquist\ Index = \left(\frac{Q_2P_{21}/Q_2A_2}{Q_1P_{11}/Q_1A_1} \times \frac{Q_2P_{22}/Q_2A_2}{Q_1P_{12}/Q_1A_1} \right)^{1/2}$$

MI can further be decomposed into the following:

$$\begin{aligned} Malmquist\ Index &= \frac{Q_2P_{22}/Q_2A_2}{Q_1P_{11}/Q_1A_1} \times \left(\frac{Q_1P_{11}}{Q_1P_{12}} \times \frac{Q_2P_{21}}{Q_2P_{22}} \right)^{1/2} \\ &= Catch-up \times Frontier\ Shift \end{aligned}$$

'Frontier Shift' term is calculated as a geometric mean of the frontier changing ratios at points A1 and A2. Malmquist Index is calculated as the product of the *catch-up* and *frontier shift*, and this decomposition gives us deeper insights concerning whether productivity change is due to *catch-up* or *frontier shift*. We compute this index using Super SBM model of Tone (2001b).

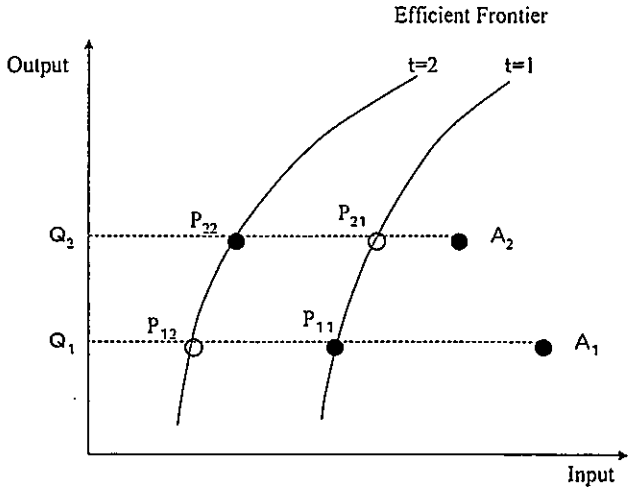

Figure 15: Frontier shift and efficiency change

3.2 Remarkable periods

Malmquist Index shows the change in productivity over time. We can judge whether the productivity rises, remains constant or falls from various values, which are shown in Table 4.

Table 4: Malmquist Index and productivity change

MI > 1	Productivity rises (productivity growth)
MI = 1	Productivity remains constant.
MI < 1	Productivity falls (productivity decay)

We computed MI of 16 basic DMUs over 14 years for the maximum of 91 (=1+2+ $\cdots$ +13) time periods and report for those time periods where most of the DMUs show productivity growth/decay. The results are reported in Table 5.

We notice here that the productivity fell remarkably in mid-1980s when the extreme tension between the east and the west was fomenting. The end of Cold War however saw the perpetual rise in productivity. This led us to understand that the military dependency of most of the nations was no more of paramount importance during this time. Let us now see in detail the results, which are reported in Table 6.

Table 5: Remarkable periods when characteristic changes are shown

Time periods when most of the DMUs show productivity decay		Time periods when most of the DMUs show productivity growth	
Periods	Number of DMUs	Periods	Number of DMUs
1984-85	9/16	1990-91	14/16
1985-86		1988-91	13/16
1985-87		1989-91	
		1989-92	
		1989-93	

Table 6: Calculated samples in the remarkable periods

DMU	1985-87			1988-91		
	Catch-up	Frontier	Malmquist	Catch-up	Frontier	Malmquist
The U.S.	1.014	0.983	0.997	0.959	1.086	1.042
Russia	0.984	0.959	0.944	1.069	1.172	1.253
The U.K.	1.039	1.007	1.047	1.044	1.015	1.060
Germany	0.968	1.016	0.983	1.234	1.013	1.250
France	0.953	1.012	0.965	1.060	1.027	1.089
Italy	0.915	1.015	0.928	1.052	1.009	1.062
Egypt	1.576	1.124	1.772	1.082	1.083	1.172
Iran	1.261	0.983	1.239	0.644	0.845	0.544
India	0.807	1.104	0.891	1.002	1.135	1.138
Thailand	0.749	1.146	0.859	0.953	1.070	1.021
Indonesia	0.888	1.070	0.950	1.177	0.928	1.092
Vietnam	1.076	0.954	1.026	0.991	1.068	1.058
The Philippines	1.047	1.229	1.286	0.996	1.159	1.155
Japan	1.086	0.971	1.054	0.957	1.041	0.996
South Korea	0.983	1.006	0.989	1.005	1.048	1.053
North Korea	1.010	1.041	1.051	0.876	1.023	0.896
Average	1.022	1.039	1.062	1.006	1.045	1.055

As is seen from the left side of Table 6, nine nations out of 16 show productivity decay (MI < 1). On the contrary, as we see in the right side of this table, 13 nations exhibit productivity growth, leaving Iran, Japan and North Korea, who have all experienced productivity decay.

3.3 Clustering nations based on Malmquist Index

We here classify the nations based on the Malmquist Index values, and examine the differences in productivity changes. We study all the 20 DMUs (both basic and exceptional), and evaluate their efficiencies under the similar procedure as described in Section 2.2.4.

3.3.1 Cluster analysis

The computed 91 Malmquist Index values show the change in the nation's productivity over 14 years. If we make cluster analysis with 1820 indexes (20 DMUs $\times$ 91 periods), we can then classify the nations based on the productivity change scores. The results are shown in Figure 16 and Table 7.

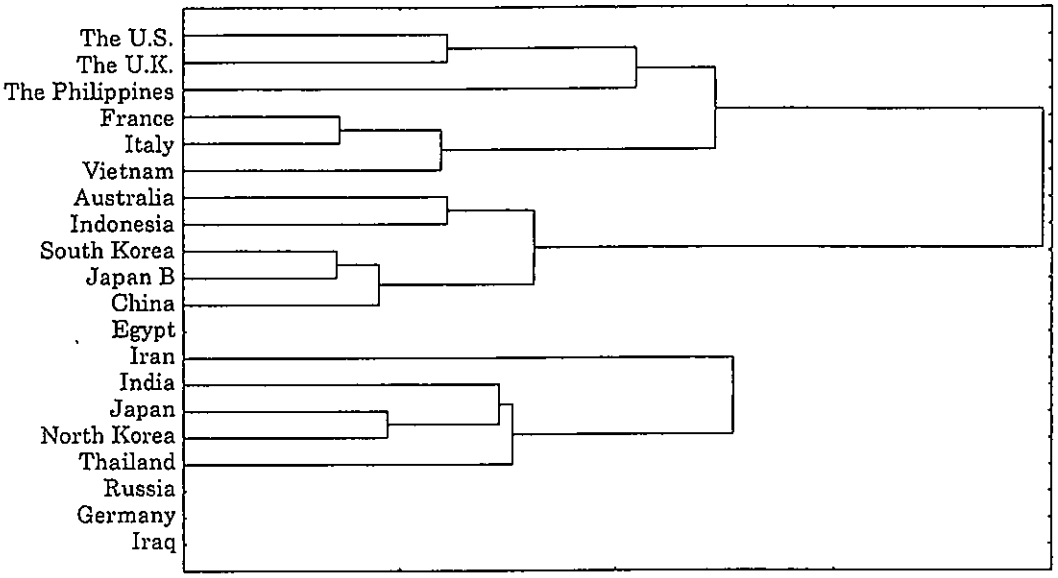

Figure 16: Results of cluster analysis

Table 7: Cluster analysis - classified group

Group1	Group2	Group3	Others
The U.S.	Australia	Iran	Egypt
The U.K.	Indonesia	India	Russia
The Philippines	South Korea	Japan	Germany
France	Japan B	North Korea	Iraq
Italy	China	Thailand	
Vietnam			

We would like to point out here that nations facing similar environments are all fit into the same cluster/group. Barring Germany the main NATO

nations came under one cluster. Germany was passing through a sudden change in its national system concerning the unification of the east and west Germany. Russia was also similarly passing through a change, *i.e.*, dismantlement of the Soviet Union. We therefore saw some consistency that these nations, which were passing through such catastrophic changes, are separated from the other European nations.

Iran and North Korea, which are specified in the list of states-sponsoring terrorism by the U.S., are classified under one group. It is also quite interesting to see that both Japan and Thailand are clustered into one group. Thailand, which was confronting the Communist Vietnam during the Cold War, seems to operate under similar environment as compared to Japan confronting the USSR concerning its dependency on the U.S. military forces.

3.3.2 Characteristics of each group

In order to know the characteristic features of each group, we plot here each group's average Malmquist Index values over all time intervals. We prepared in total 13 graphs for every time interval over 14 years separately. We pick up a sample for an interval of three years, which is shown in Figure 17.

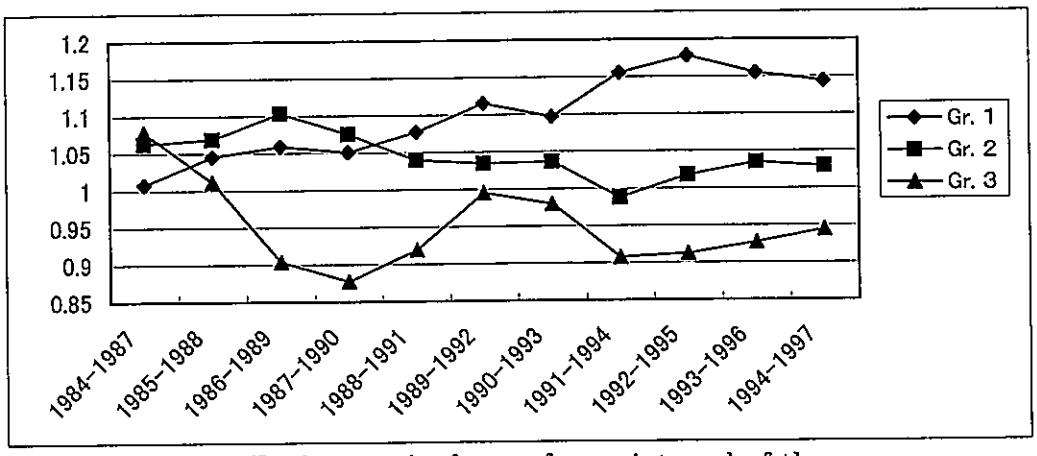

Figure 17: Each group's change for an interval of three years

We notice here that the nations in Group 1 show improvement in productivity, indicating remarkable decrease in their dependency on the military instruments in the post-Cold War. On the other hand, the nations in Group

3 have increased their dependency on the military instruments. However, little change is visible in Group 2.

3.3.3 Interpretation of the findings

The nations in Group 1 remarkably decreased their dependency on the military instruments in the post-Cold War era. These nations required to reinforce their military forces in 1980s, and this requirement was however less in the post-Cold War era. The threat of the former Soviet Union seems to have been a major concern for the main NATO nations. When Soviet's military ambition of conquering foreign nations came into prominence by its invasion of Afghanistan in 1979, the NATO alliance aimed to build up the military forces in 1980s. And, it was thought redundant of keeping military forces against the former Soviet Union in the post-Cold War era.

Vietnam not only intervened militarily in Cambodian Conflict in 1978 but also had a tense military relationship with its border country China in 1979 (which is called China-Vietnam Conflict). In the post-Cold War period the security environment of Vietnam has remarkably improved because Cambodia became under the international rule, and the relationship with China improved as well. On the other hand, Vietnam dramatically increased its GNP due to its economic reforms and open policy (called 'Doi Moi').

The nations in Group 3 increased their dependency on the military instruments despite the end of the Cold War. The end of the Cold War did not bring an end to the threat on these nations. The loss of the former Soviet Union's support at the end of the Cold War spurred North Korea to build up its military forces to maintain the authoritarian system in the international isolation. Moreover, the military force was thought of becoming a leverage on diplomacy to draw out economic aids for North Korea.

The strategic instability and lack of military forces made Iran (which is in Group 3) hugely vulnerable. It was the shortage of arms and ammunition, which had forced Iranian government to accept a cease-fire of Iran-Iraq War in 1988. Most of the littoral Arab states signed the bilateral defense agreement with the U.S. in 1992, and Saudi Arabia and UAE purchased a lot of armaments from the U.K. and France. On the other hand, Iran became more isolated from U.S., and Iran did take the advantage of the former Soviet Union's need for hard currency to acquire Soviet armaments (*Strategic Survey, 1992-1993*).

Now we need to explain why Japan remained in Group 3. Japan neither faced the lack of the military forces nor did face international isolation like North Korea and Iran. Then why is it in Group 3?

3.3.4 Interpretation of why Japan is in Group 3

Japan gradually increased its military forces despite the dismantle of the former Soviet Union. We attempt here to find out from our past results the reasons for such gradual increase in the Japan's military forces in the post-Cold War period.

We observed in Section 2.3.4 that Japan's dependency on the military instruments was very low during the Cold War era. This could be one of the possibilities for such gradual increase in military forces. However, the explanation that it is unquestionable for Japan to lower its efficiency because it was perceived too high, is not entirely convincing. It is now necessary to explain not only why Japan could raise its efficiency during the Cold War period but also why it had to lower its efficiency in the post-Cold War era.

Recalling back to Dr. Kissinger's description, it was mentioned that Japan could be an economic giant but militarily irrelevant in the Cold War period; the relative military power of the United States would gradually decline in the post-Cold War; and the nations' societies which had nestled under American protection would feel compelled to assume greater responsibility for their own security. Referring to these, we could possibly think of the following: Because Japan has a close connection with the U.S. concerning its dependency on the military forces to counter against the former Soviet Union, it could raise its efficiency during the Cold War period. And, because the need for Japan's own security would rise in case U.S. changed its policy for its own interest in the far Eastern region from military to politico-economic, Japan lowered its efficiency in the post-Cold War.

We could now confirm the validity of this using our previous results. In Table 6 in mid 1980s the main NATO nations such as the U.S., Germany, France and Italy all experienced a productivity decay whereas productivity growth was seen for Japan. This productivity differential between Japan and the main NATO nations can also be explained through an another group in Table 7. We could possibly infer from these results that Japan depended considerably on the defense supply of the West bloc for its own security.

Moreover, in Section 2.3.4 we examined the efficiency differences between

Japan and Japan B in response to the decrease in the threat level of the former Soviet Union. The efficiency differential between Japan and Japan B is also explained through another group in Table 7. We deduce here that the U.S. Forces stationed in Japan played a vital role in the security policy of Japan in response to the rising threat of the former Soviet Union during the Cold War era, and reduced in the post-Cold War era.

The reasoning offered here might be one of the many for such gradual increase in the Japan's military forces in the post-Cold War era. Though it goes without saying that a more thorough microanalysis is necessary, in our study we precisely interpreted the events based on the real-life data. Because our findings are robust in terms of greater precision, these could be extremely valuable materials for future research.

4 Concluding remarks

This study made an attempt to newly design and quantitatively measure the performance index - 'amount of the military forces compared to the nation's resources,' which is construed as the nation's dependency on the military instruments. We made here, using DEA, three types of analyses based on this performance index.

First, we made a comparative evaluation among nations. We observed here a significant heterogeneity in the efficiency pattern among nations arising from their different economic and political backgrounds. Second, we evaluated and compared the productivity trends of various nations from the Cold War period to the post-Cold War period. We verified here the inferences drawn from Dr. Kissinger's description. Third, we computed the Malmquist Index in order to know the productivity changes of the nations over time. Based on these index values we clustered 19 nations into three groups and critically examine to see whether a particular nation's association in each group fits historically. Based on our analyses we developed an understanding concerning the security environmental changes of Japan in response to such changes made in the world scenario.

Concerning the limitations of our study, first the military capability cannot be properly judged from our quantitative index. The quality of military equipments and operational capabilities relating to information and logistics are considered very important while viewing military capability. So future

research can be directed to incorporate the differences in the quality of equipments in performance index by assigning different weights on the number of equipments in a manufacturing year. Second, our study does not consider the nuclear weapons into account. The exclusion of nuclear weapons is considered unsatisfactory in international politics. Future research points to investigating the role of the nuclear weapons from a strategic perspective. Third, the evaluation of efficiency of a nation whose inputs and outputs are of high magnitudes produces large difference in weights for I/O items. In our study the efficiency of Australia whose naval force is too large compared to the ground and air force seemed to be evaluated exaggeratedly. We suggest for future research to use the assurance region model, which imposes constraints on the relative magnitude of the weights for I/Os. While applying this approach, one needs to set the bounds on weights based on auxiliary information such as unit costs.

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Appendix A

Components of the national power defined on the current research studies (excluding Japanese studies)

Study	Military force	Economic potential	Qualitative elements	Population and territory	Geographical condition
Mahan(1890)	○		○	○	○
Carr(1939)	○	○	○		
Morgenthau(1948)	○	○	○	○	○
Gorshkov(1979)	○	○			
Frankel(1979)	○	○	○	○	○
Cline(1983)	○	○	○	○	
Modelski(1983)	○	○	○		○

Mahan, A.T. (1890), *The Influence of Sea Power upon History 1660-1783.*
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Appendix B

Nations' military forces in 1997

Nation	Ground forces[a]	Naval tonnage[b]	Number of combat aircraft[c]
The U.S.	49.2	496.9	3810
Russia	42.0	338.7	2710
The U.K.	11.2	82.8	530
Germany	24.0	19.9	530
France	22.0	44.3	590
Italy	18.8	19.7	380
Egypt	32.0	6.4	590
Iran	35.0	15.6	310
India	98.0	25.9	870
Thailand	15.0	10.2	280
Indonesia	22.0	17.7	140
Vietnam	42.0	2.7	200
The Philippines	7.0	4.7	60
Japan	14.9	36.4	510
South Korea	54.8	14.7	490
North Korea	100	10.6	610
Iraq	35.0	1.0	320
China	244.0	136.2	5580
Australia	2.5	13.3	130

Note: [a] 1 unit = 10,000 soldiers, [b] 1 unit = 10,000 tons and [c] 1 unit = 1 aircraft