Hindawi Publishing Corporation
Discrete Dynamics in Nature and Society
Volume 2008, Article ID 286836, 18 pages
doi:10.1155/2008/286836

Research Article

The Long-Run Dynamic of the Nexus between Military Strength and National Power: An Econometric Analysis

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Received 23 December 2007; Accepted 8 August 2008

Recommended by Xue-Zhong He

A number of literatures suggest that military strength has been losing centrality and importance to nonmilitary factors of national power. In this paper, logistic regressions and data from the Correlates of War (COW) project are used to investigate whether over the 1820–2000 time horizon, for the great powers and their proximate contenders, the importance of military capabilities to national power has declined vis-à-vis that of economic capabilities. Estimation was carried out using generalized estimating equations (GEEs). The overall picture that emerges from the analysis is that of a transition in progress from a systemic state in which military capabilities were the dominant determinants of national power to a state in which economic capabilities will become the dominant ones. The analysis is concerned with long-run trends, and its results are not necessarily applicable to specific countries and circumstances.

1. Introduction

A substantial literature suggests that over the past two centuries the comparative contribution of military capabilities to national power has declined. However, there are also voices supporting the view that military power has been and is the quintessential determinant of power upon which a country's standing in the international system depends. This paper presents an econometric analysis of the "decreasing comparative importance of military capabilities" thesis. Specifically, it investigates whether over the 1820–2000 time horizon, for the great powers and their proximate contenders, the importance of military capabilities to national power has declined vis-à-vis that of economic capabilities.

The results presented in this paper show that in fact early on realized military capabilities were by far the most important determinants of national power, and that their comparative importance vis-à-vis economic capabilities greatly decreased over time. The overall picture that emerges is that of a transition from a state of affairs in which military capabilities were the dominant determinants of national power to one in which economic

capabilities may become dominant. Today's international system is near the midpoint of this transition: the military capabilities are still twice as important as the economic ones, but are slowly moving toward parity.

This paper is intended as a contribution to assessing the comparative validity of contrasting views on the importance of military capabilities, and to evolving realistic world views that neither overestimate nor underestimate the role of military strength to a country's security and international influence. Realistic views about the declining importance of military capabilities constitute an important background to the guns-versus-butter type of debates. To be sure, the decisions about the military capabilities a country needs depend upon a myriad of specifics. Yet, the historical decline in the importance of military capabilities is very relevant to strategic decisions on the appropriate mix of military and nonmilitary tools and policies.

The methodology used in this paper builds upon the literature that regards the perceptions of national power by "experts" as indices of power. This literature focuses upon the specification and estimation of relations between power rankings, dependent variable, and power determinants, independent variables. Also, it shows that both observed and predicted perceptions of power are closely correlated with the conventional indices of national power obtained by combining indices of power determinants on the basis of assumptions rather than by estimation.

Here the power perceptions used are in the form of a classification of the top countries in the international system into major and minor powers. The binary variable implementing this classification and the indices of power determinants employed to "explain" it are from the Correlates of War (COW) project. The analyses consist of logistic regressions carried out on an unbalanced time series of cross-sections. Generalized estimating equations (GEEs) techniques are employed to address the temporal autocorrelation in the data.

This paper starts with a review of the literature on the importance of military capabilities to national power. The body of the paper is comprised of a methodology and an empirics sections. In the methodology section, the mathematical models used are presented and discussed, and the literatures on the indices of power are briefly reviewed. The empirics section discusses the models' estimation and its results. A conclusions section caps the paper.

2. Literature

Let us review selected literature threads concerning the historical changes in the importance of military strength to national power. The two quotes that follow typify how both scholars and the public viewed the importance of military capabilities in the pre WW2 era. In a textbook popular in the 1930s Simonds and Emeny [1, pages 27–29] wrote: "... the world of today is a lawless world ... But in a lawless world, force must be the ultimate means of pursuing policy, and resort to force must mean war. ...[H]owever states ... vary in the degree to which they can clothe their national policies with force. As a consequence, only a few [states] will posses the force necessary to support their national policies effectively, and these alone constitute the Great Powers. Thus, ours is not only a world without enforceable international law but also a Great Powers world. Such, too, it has always been during the centuries which have seen the development of the modern states system." Carr [2, page 109] outlined the linkage between this worldview and the importance of military capabilities in the following terms: "The supreme importance of the military instrument lies in the fact that the ultima ratio of power in international relations is war. Every act of the state, in its power

aspect, is directed to war, not as a desirable weapon, but as a weapon which it may require in the last resort to use."

Recently however, in explaining the changes in the comparative importance of military capabilities, Nye [3] wrote: "Traditionally, the test of a great power was "strength for war." War was the ultimate game in which the cards of international politics were played and estimates of relative power were proven. Over the centuries, as technology evolved, the sources of power have shifted. Today, the foundations of power have been moving away from the emphasis on military force."

The result of a recent international poll shows that indeed the international public opinion today believes that the foundations of national power have been moving away from an emphasis on military force. In a 2002 public opinion poll commissioned by the Chicago Council on Foreign Relations and the German Marshall Fund [4, page 23], 1000 men and women over 18 from each of six European countries were asked: "Which of the following do you think is more important in determining a country's overall power and influence in the world—a country's economic strength or its military strength?" The respondents who choose "economic strength" and "military strength" were respectively 81% and 15% in Great Britain, 89% and 9% in France, 80% and 16% in Germany, 89% and 7% in The Netherlands, 88% and 10% in Italy, 83% and 11% in Poland. The average percentages for the six countries (calculated as the mean of country averages weighted by population) indicated that 84% to 12% of the Europeans polled selected economic strength over military strength as the most important determinant of national power. The 1097 USA respondents who answered the same question [5, page 40] choose 66% to 27% economic strength over military strength as the most important determinant of power. These polls can be accessed at http://www.worldviews.org/. Clearly, today there is a remarkable popular consensus across the Atlantic that military power is less important than economic power.

The historical circumstances, collective experiences, and trends impacting the importance of the military and economic capabilities on national power have been extensively discussed, for example in Keohane and Nye [6], Nye [7, 8], Mansbach [9], Rothgeb [10, page 27 ff], and Snow [11, 12]. A few key points culled from these writings are sketched hereafter.

After WW2, military strength retained a major role in the international relations, however the limitations of, and constraints upon military actions became by far more prominent than previously. The limitations of military superiority became apparent in a number of conflicts between more powerful and less powerful countries. The decolonization pitted militarily weak movements of national liberation against militarily strong colonial powers, and the latter lost on a grand scale. Stalin's inability to squelch Tito's independence, and the loss of the US to Vietnam and of the Soviet Union to Afghanistan also demonstrated that an overwhelming military superiority does not necessarily lead to the defeat of national movements that are militarily weak. Today and in the recent past, countries that are militarily strong may greatly damage or obliterate each other, may easily defeat countries that are militarily weaker, but will still experience a great deal of difficulty to overcome national movements.

A major constraint upon the use of military force is represented by the reaction of the public opinion to the loss of blood and treasure it entails. War has probably always generated a domestic opposition that grows larger and more visible as its costs and casualties become larger and more visible. However, the ferocity of this opposition and the speed at which it can unfold are greater today than in the past, especially in the developed countries.

It has been argued that the destructiveness of the atomic weapons places a major constraint upon the use of military force. Throughout the cold war, the USA and USSR did

certainly retain a major commitment to military strength and preparedness, but their conflicts never led to a WW3 that could produce "mutual assured destruction." The destructiveness of the atomic weapons possibly was the major factor that prevented an unrestrained reliance on military force. It can be conjectured that in the absence of countervailing atomic weapons, a WW3 would have been much more likely.

On the other hand, the nonmilitary factors of national power have become increasingly important. Before WW2, the actors in the international system were almost exclusively states. After it, they included also an increasing number of international and transnational organizations such as the UN and its agencies and the multinational corporations. The interactions among nations in the context of international and transnational organizations involve cooperation and conflicts that are essentially nonmilitary. International trade, international capital flows, and the movement of people across international boundaries for work, study, or tourism have increased greatly, resulting in cooperation and conflicts that are primarily nonmilitary. Although national security is still exceedingly important, other issues international in scope have been acquiring prominence. Issues such as those involving the environment, epidemics, and the movement across boundaries of illegal drugs produce cooperation and conflicts among countries that are dealt with primarily by nonmilitary instruments. All these trends taken in the aggregate suggest that over time and especially after the end of WW2, the economic and political factors of national power increased in importance while the military factor did not.

An econometric study that indirectly supports the "declining comparative importance of military power" thesis is due to Stoll [13]. Stoll defines three world views that he calls, respectively, Classical, Bipolarist, and Interdependent. Here they are referred to by the acronyms CWV, BWV, and IWV. The CWV depicts the pre WW2 international relations, and in it military power is the paramount component of national power. In the BWV, national power depends upon a combination of military and economic capabilities. In the IWV, national power is multidimensional, and military strength is only an important but not major component of it. The BWV and IWV emerged after WW2.

Stoll carried out factor and t-test analyses on 1850, 1900, 1950, and 1980 datasets. One of his conclusions is that all the three worldviews are applicable to the current (the 1980s) international realities. Since the CWV depicts primarily the pre WW2 international relations and military strength is paramount in it, Stoll's conclusion that all three worldviews apply to the post WW2 international relations implies that WW2 separates the era in which military strength is supremely important, from the subsequent one in which is only one of multiple sources of national power.

However, there are contemporary voices arguing for the primacy of military strength. For instance, the authors of a Rand Corporation's report [14, page 41] wrote: "... military forces remain the final arbiter of disputes in the 'anarchic' realm of international politics. The country that has the most effective military instruments—understood as an amalgam of technology, doctrine, training, and organization—can shape the operations of the international system to its advantage: it can define and enforce, as it were, 'the rules of the game'."

The rationales for these views were summarized in the following three points: "First, ... countries will remain the most important units of the international system in comparison to individuals, nongovernment actors, and transnational organizations, at least where issues of 'high politics'—those issues relating to order and governance—are concerned. In this environment, countries will continue as the ultimate arbiters of their own political choices, and while these choices will be limited by the actions and capabilities of others, countries

will nonetheless continue to employ power in defense of their own interests. Second, ... the most important manifestation of power will continue to be military capability because it pertains to the domain of survival and conditions the freedom of action enjoyed by entities in an environment where there is no other overarching ideological or moral constraint on national action. Third, where military capability is concerned, the ability to conduct diverse conventional operations effectively will remain critical because, even though nuclear weapons have become the ultima ratio regum in international politics, their relative inefficacy in most situations other than those involving national survival implies that their utility will continue to be significant but highly restricted. The ability to conduct different and sophisticated forms of conventional warfare will, therefore, remain the critical index of national power ..." (ibidem pages 42–3).

The thesis that over the past two centuries the comparative importance of military capabilities to national power decreased vis-à-vis that of economic capabilities is investigated in the next two sections that are, respectively, concerned with methodology and empirics.

3. Methodology

The research reported in this paper aims at testing whether over the 1820–2000 time horizon and for the great powers and their proximate contenders, the comparative importance to national power of military capabilities declined vis-à-vis that of the economic capabilities. The economic capabilities are viewed as proxies for most determinants of national power except realized military strength.

The approach used involves the following: (a) an Initial model relating a binary variable with values 1 and 0, respectively, for major and minor powers, to indices of military and economic capabilities is specified and estimated; (b) an Expanded model generated by redefining the parameters of the Initial model into functions of time is specified and estimated; (c) a parsimonious Final model is extracted from the Expanded model and estimated; (d) the results of the analyses are used to test the "decline" hypotheses.

Two subsections follow. In the first one, the Initial and Expanded models are specified and discussed. The second subsection briefly discusses strands of the literatures on the indices of national power that constitute the foundation on which the investigation presented in this paper is built.

3.1. Models

Let MP be a binary variable with values one and zero, respectively, for major and minor powers. Denote the probability that a given country at a given point in time is regarded as a major power by $pr = pr(MP = 1)$, and its logit by P, where

$$P = \ln\left(\frac{pr(MP = 1)}{1 - pr(MP = 1)}\right), \tag{3.1}$$

P and pr are rank-equivalent indices of national power. To clarify, consider the following: (a) two indices of national power are rank-equivalent when they produce identical power rankings of the same countries; (b) two indices yield same rankings when one is a monotonically increasing function of the other; (c) the pr variable is an index of national power since countries that "are" more powerful will tend to have a greater probability to "be regarded" as major powers; (d) since P is a monotonically increasing function of pr; P and

pr are both rank-equivalent perceptual indices of national power. A discussion of indices of national power, perceptual, or otherwise can be found in the next subsection.

Define the Initial model

$$P = \alpha_0 + \alpha_M M + \alpha_E E, \tag{3.2}$$

that relates the index of national power P to the indices of military and economic capabilities M and E.

The empirical variables MP, M, and E are described in the data subsection. However, let us note here that M and E index distinct determinants of national power, that the military capabilities, M, are "realized," not "potential" capabilities, and that the economic capabilities, E, are a proxy for most other factors of national power unrelated to realized military strength.

The parameters α_M and α_E of (3.2) indicate how much P changes in response to unit changes in M and E. Consequently, they also indicate to what extent M or E influences P and thus define the "importance" or "effect" of the military and of the economic capabilities to national power. Since positive increments in M or E cannot affect negatively the national power, these "importance parameters" α_M and α_E are restricted to be non-negative.

The parameter α_0 represents the net effect of factors of national power that are not represented or proxied by M and E. This follows directly from the fact that $P = \alpha_0$, if $M = E = 0$ and/or if $\alpha_M = \alpha_E = 0$. In other words, if the military and economic capabilities equal zero, and/or the effects of military and economic capabilities on national power are nil, the index of national power P equals α_0. Consequently, $P - \alpha_0$ represents the portion of national power that results from the capabilities M and E. The ratio

$$RI = \frac{\alpha_M}{\alpha_E} \tag{3.3}$$

denotes the comparative importance of the military/economic capabilities to national power.

A model suited to test for the temporal decline in the comparative importance of military capabilities can be arrived at by "expanding" the parameters of (3.2) into functions of time t [15]. Here this was accomplished by redefining the parameters α_0, α_M, and α_E into quadratic polynomials in time

$$\alpha_0 = \alpha_{00} + \alpha_{01} t + \alpha_{02} t^2, \tag{3.4}$$

$$\alpha_M = \alpha_{M0} + \alpha_{M1} t + \alpha_{M2} t^2, \tag{3.5}$$

$$\alpha_E = \alpha_{E0} + \alpha_{E1} t + \alpha_{E2} t^2. \tag{3.6}$$

These polynomials allow α_0, α_M, and α_E to increase or decrease over time at accelerating or decelerating rates, and are adequate to investigate the potential occurrence and modalities of the parameters' long-run temporal change.

Upon replacing the right-hand sides of (3.4), (3.5), and (3.6) for the parameters α_0, α_M, and α_E in (3.2), the following "expanded" model is produced:

$$P = \alpha_{00} + \alpha_{01} t + \alpha_{02} t^2 + \alpha_{M0} M + \alpha_{M1} M t + \alpha_{M2} M t^2 + \alpha_{E0} E + \alpha_{E1} E t + \alpha_{E2} E t^2. \tag{3.7}$$

It should be noted that α_M and α_E defined by (3.5) and (3.6) are also restricted to be greater than or equal to zero throughout any time horizon to which the Expanded model is applied.

The comparative "importance" of the military/economic capabilities, RI, that correspond to the expanded model (3.7) is

$$RI = \frac{\alpha_{M0} + \alpha_{M1}t + \alpha_{M2}t^2}{\alpha_{E0} + \alpha_{E1}t + \alpha_{E2}t^2}. \tag{3.8}$$

The notions that the comparative importance of the military/economic capabilities to national power declined over a given time horizon is validated if, over this time horizon, the estimated RI is a decreasing function of time, and the two polynomials in RI are greater than zero.

3.2. Power indices

The analyses in this paper are built upon the literature on the "perceptual indices" of national power, and on the "estimated perceptual indices" of national power obtained by regressing a perceptual measure of power versus indices of power determinants. Let us place this literature in perspective.

Most indices of national power are either perceptual measures of power, or are generated by regressing perceptual measures of power versus indices of power determinants, or are obtained by combining indices of power determinants on the basis of assumed weights.

The indices of national power obtained by combining indices of power determinants on the basis of assumed weights are the most common. A prominent example of them is the *CINC* index [16–18]. *CINC* is arrived at by averaging six indicators of factors of power, namely, by assigning a weight of 1/6 to each indicator. Thus, *CINC* is based on assumed weights that define the comparative "importance" or "effect" of each determinant of national power. In addition to *CINC*, the best known indices of this type are the GDP ([19, page 346], [20, page 436], [21]), and the indices by Cline [22, 23] and German [24].

A second literature strand is concerned with obtaining measures of national power and then regressing them versus indices of power determinants. Doran et al. [25], Alcock and Newcombe [26], and Shinn [27] produced perceptual measures of power in the form of rankings of countries in terms of their power as perceived by "experts." These measures were then regressed versus indices of economic development, economic strength, and military strength to produce estimated perceptual indices of national power.

The case for perceptual measures of national power was effectively made by Doran et al. [25] who wrote: "Instead of beginning with a formal definition of power as previous theorists advocate, we have followed Alcock and Newcombe [26] and Shinn Jr. [27] in simply asking individual respondents to use their own concept of power to rank nations. We have not forced a definition of power upon our sample of respondents; rather, we have naively assumed that most people have experienced power in their lives and that, based on that experience, they would be able to rank states in terms of their own intuitive appreciation of the power concept." (page 432). On the advantages of ranking countries by perceived power they commented: "It is the actual perceptions rather than idealized or so-called objective measures of ... [determinants of power] ... that we hope will enable us to escape the jungle of competing definitions and formulations ... Our solution is neither to delineate the power concept more finely nor to banish it altogether. Rather, a high level of agreement about hierarchy within the international system can exist, we argue, despite high disagreement regarding an operational definition of the concept." (page 433).

There is empirical support to the notion that the perceptual measures of power, the estimated perceptual indices of power, and the *CINC* types of power indices are all indices

of national power. Merritt and Zinnes [28], Taber [29], and Sullivan [30] found that the perceptual measures of power, the indices of power obtained by combining indices of power determinants on the basis of assumed weights, and the estimated perceptual indices agree significantly. Sullivan (1990 page 110) referred to this agreement as "convergent validation," and commented that "If different studies using different indicators or manipulating them in different ways, produce fairly similar rankings of nations' power, then there is probably some merit to those measures. And they are more likely reflecting power levels that actually exist in the real world."

This paper builds upon the literature on the indices obtained by regressing a perceptual ranking of countries in terms of their power versus indices of national power's determinants. Let us articulate why so.

Ranking a group of countries in terms of power is tantamount to classifying the countries into mutually exclusive classes ordered in terms of power. However, rankings may differ in the number of classes (two or more) and in the number of countries in each class (one or more). Thus, the classification of many countries in two classes qualifies as a ranking. Hence, the classification of countries into major and minor powers by a binary variable taking the values of one/zero constitutes an empirical perceptual measure of power in the tradition of the Alcock and Newcombe, Shinn, and Doran. A logistic regression with such a binary dependent variable yields the estimated logit of the probability that a country is a major power. Hence, within this tradition also this estimated logit is a perceptual estimated index of power.

4. Empirics

The analyses discussed in this section are based on a dataset consisting of 291 observations and six variables. Each observation refers to a country year duplet. The observations' identifiers are the variables "name" and "year." The years are 1820, 1830, . . . , 2000. The other variables in the dataset are: a binary variable, "*MP*," with values one for the major powers and zero for the minor powers; a military capability shares variable, "*M*"; an economic capability shares variable, "*E*"; and a time variable, "*t*," obtained by the transformation $t = year - 1800$. The dataset consists of an unbalanced time series of cross-sections. The source data, the salient characteristics of the variables, their suitability, and the rationale for the selection of the observations included in the study are discussed in the next subsection.

The analyses are concerned with the estimation of the Initial, Expanded, and Final models, and with the investigation of the *RI* ratio calculated using the estimated Final model. This ratio allows testing the hypothesis that the comparative importance to national power of military/economic capabilities declined over time.

The Initial, Expanded, and Final models were estimated by logistic regressions [31–35] using generalized estimating equations (GEEs) techniques [36–40]. The use of GEEs techniques is necessitated by the data's unbalanced panel structure and by the temporal autocorrelation of the dependent variable *MP*. This autocorrelation should be assumed since a country's status as a major or minor power changes slowly over time, and since here the data generating process consists in an iterated reevaluation of each country's current status as a major or minor power. The GEE technique is well suited to estimate a logistic regression from unbalanced panel data characterized by within-group temporal autocorrelation.

4.1. Data

This subsection describes the "dataset" used in the analyses and the research choices made to assemble it. The source data were downloaded from http://www.cow2.la.psu.edu/.

They can be also extracted from the EUGene database [41] downloadable from http://eugenesoftware .org/. The "dataset" consists of 291 observations and six variables. Each observation refers to a country year duplet. The observations' identifiers are the variables "*name*" and "*year*." The years are 1820, 1830,. . . , 2000. The other variables in the dataset are: a binary variable, "*MP*," with values one for the major powers and zero for the other countries in the sample; a military capability shares variable, "*M*," an economic capability shares variable, "*E*"; and a time variable, "*t*," obtained by the transformation $t = year - 1800$. Let us remark again for emphasis that "*M*" and "*E*" are "shares" variables since they denote, respectively, the ratios of military or economic capabilities of each country at a point in time divided by the military or economic capabilities of all the countries in the international system at that point in time. The dataset has a panel structure and consists of an unbalanced time series of cross-sections.

The source data for *MP* were extracted from the COW2 "State System Membership file" (major2002.csv). The major 2002.cvs file defines the dummy variable (here, *MP*) with value one for the countries classified as "major powers." The coding of *MP* produced by the COW project reflects the best judgment of generations of scholars as to which countries play a major systemic role and project their influence worldwide [13].

The source data for *M* and *E* were extracted from the COW2 file "National Material Capabilities" (NMC_3.0.csv). The articles of record for the NMC dataset are Singer [16, 42]. The NMC file contains, for all the states in the "International System" and for the 1816–2001 time interval, the annual values of total population, urban population, iron and steel production, energy consumption, military personnel, military expenditures, and the year and country to which each observation refers.

In order to obtain the indices *M*, *E*, and *CINC*, (a) the raw indicators of material capabilities were converted in yearly capability "shares" by dividing each indicator's value for a country and year by its aggregate value for the international system for the year; (b) these shares were then aggregated into a military capability shares index, *M*, an economic capability shares index, *E*, and a demographic capability shares index, *D*, by averaging, respectively, the military personnel and the military expenditures shares, the iron and steel production and the energy consumption shares, and the total population and the urban population shares; and (c) the Combined Index of National Capabilities (*CINC)* was obtained by averaging *M*, *E*, and *D*.

The *M* and *E* variables index conceptually distinct dimensions of national power. Specifically, *E* is an index of economic strength, and a proxy for most nonmilitary determinants of national power. *M* is an index of "realized military strength," that is virtually identical to what Knorr in "The War Potential of Nations" calls the ready military strength of a nation. He writes: "Mobilized manpower, munitions supplies, and such establishments as army camps, airfields, and naval bases make up the ready military strength of a nation." Knorr [43, page 19].

The dataset used in this paper was obtained from the source data in four steps. First, the observations for the years 1820, 1830,. . . , 2000 were extracted from the source data. Second, for each of these years, the observations with a rank higher than 20 on the *CINC* index were dropped. Third, the observations with missing or zero values on *M* or *E* were dropped. Fourth, for each of the extant countries, the sequences of temporally contiguous observations made of two or fewer observations were dropped.

The rationale for selecting observations with a 10 years spacing is that the dependent variable *MP* changes over time very slowly since countries tend to persist in the major or minor power status for very long periods. This implies that *MP* tends to possess a high

temporal autocorrelation. Since, everything else being equal, temporal autocorrelation tends to be smaller for measurements taken at points in time more distant from each other, it can be presumed that measurements at 10-year intervals are less autocorrelated than measurements taken at one year intervals. This research decision follows the lead of Kugler and Arbetman [44, page 49 ff] who in a study of national capabilities used data at 10 year intervals since "national capabilities change at a relatively slow pace" (page 55).

The decision to select observations for the great powers and their proximate contenders is based on the stated objective of this study, which is to investigate whether the comparative importance of the military versus the economic components of national power tended to decline over the 1800–2000 interval and for the countries at the top of the power hierarchy. The rationale for this choice rests on the hierarchical nature of the international system, in which most power as well as most of the ability to project power at great distances are concentrated at the top. Therefore, the decreasing comparative importance of military capabilities is of special consequence if it occurs at the top of the power hierarchy, where the "rules of the game" in the international system are set. Selecting for each cross-section the top 20 countries on the *CINC* index is an arbitrary but plausible operational rule to select the top of the power hierarchy.

The decision to use the *CINC* index to select the top 20 countries was inspired by the finding that all the major indices of national power in the literature tend to produce very similar power rankings, especially so as regards to the countries at the top ranks [28–30]. If this is the case, an index as commonly used as *CINC* can be expected to be well suited to implement this selection.

4.2. Analyses

The Initial model defined by (3.2) is estimated under the assumption that its parameters did not change over the 1820–2000 time horizon. The estimation results in column 1 of Table 1 suggest that the military and economic capabilities contributed to national power to a very different extent. In fact, their ratio $RI = a_M/a_E = 9.994$ means that, in the average, during the 1820–2000 horizon, military capability was ten times more important to national power than economic capability.

The estimate of the Expanded model defined by (3.7) is shown in Table 1, column 2. A Wald test was carried out in order to determine whether the block of the six expansion parameters in (3.7) adds significantly to the explanatory power of the Initial model. The test was significant at better than the 1% level, indicating that the expansion of α_0, α_M, and α_E with respect to time was warranted. However, none of the coefficients of the six expansion variables is significant and the collinearity diagnostics CN and Max(VIF) reported in Table 4, column 2, indicate a strong degrading collinearity.

Let us discuss next the approach used to extract from the overparametrized Expanded model a parsimonious Final model. The approach does not presuppose that either the Expanded or the Final models are "true" models. Today many scholars are in sympathy with this line of thinking. To exemplify, consider a couple of quotes: Kennedy [45, page 73] wrote "It is now generally acknowledged that econometric models are 'false' and that there is no hope, or pretense, that through them 'truth' will be found. "Feldstein [46, page 829] remarked" ... in practice all econometric specifications are necessarily 'false' models ... The applied econometrician, like the theorist, soon discovers from experience that a useful model is not one that is 'true' or 'realistic,' but one that is parsimonious, plausible and informative."

Table 1: GEEs estimates.

	(1) Initial model	(2) Expanded model	(3) Final model
M	$6.74e+01$	$2.10e+02$	$7.12e+01$
	(2.17)*	(0.89)	(2.18)*
E	$6.74e+00$	$1.25e+01$	—
	(1.03)	(0.18)	
t	—	$1.26e-01$	—
		(1.27)	
t^2	—	$-5.12e-04$	—
		(1.29)	
Mt	—	$-2.71e+00$	—
		(0.60)	
Et	—	$-2.88e-01$	—
		(0.23)	
Mt^2	—	$1.21e-02$	—
		(0.66)	
Et^2	—	$2.09e-03$	$8.11e-04$
		(0.40)	(2.31)*
Const	$-3.37e+00$	$-1.08e+01$	$-3.72e+00$
	(4.47)**	(2.05)*	(4.36)**
#obs	291	291	291

z statistics in parentheses;
*Significant at 5%; **Significant at 1%.

The Final model is arrived at by removing some of the variables that appear in the Expanded model. The rationale for retaining in a model only a parsimonious number of variables has been articulated as follows by Hosmer Jr. and Lemeshow [34, pages 82-83]: "The traditional approach to statistical model building involves seeking the most parsimonious model that still explains the data. The rationale for minimizing the variables in the model is that the resultant model is more likely to be numerically stable ... The more variables included in a model, the greater the estimated standard errors become, and the more dependent the model becomes on the observed data. Recently there has been a move ... to include all scientifically relevant variables in the model, irrespective of their contribution to the model. ... The major problem with this approach is that the model may be overfitted and produce numerically unstable estimates. Overfitting is typically characterized by unrealistically large estimated coefficients and/or estimated standard errors."

The model selection approach used here is inspired by Hendry's "General to Specific" methodology ([47, 48], [49, Chapter 20], [50], [51, pages 58–83], [52]). Specifically, the approach used starts with a heuristic iterated estimation of the Initial model over a sequence of overlapping intervals spanning the 1820–2000 time horizon. The parameter sequences thus obtained show which parameters of the Initial model changed over time how much, and therefore suggest which blocks of parameters should be tested for significance. These suggestions lead to iterated Wald tests followed by the sequential elimination of blocks of nonsignificant variables. The Final model arrived at by this process is then analyzed for congruence with the hypothesized long-term change in the comparative importance of the military and economic capabilities.

The moving windows analyses were carried out by estimating the initial model by logistic GEE regressions over the nine overlapping intervals 1820–1920, 1830–1930,...,

Table 2: Temporal change in the importance of the military and economic capabilities to national power.

Year	$a_M(t)$	$a_E(t)$	$R(t)$
1820	71.2	.325	219
1840	71.2	1.3	54.8
1860	71.2	2.92	24.4
1880	71.2	5.19	13.7
1900	71.2	8.11	8.77
1920	71.2	11.7	6.09
1940	71.2	15.9	4.48
1960	71.2	20.8	3.43
1980	71.2	26.3	2.71
2000	71.2	32.5	2.19
2920	71.2	39.3	1.81
2940	71.2	46.7	1.52
2960	71.2	54.8	1.30
2980	71.2	63.6	1.12
2100	71.2	73.0	0.97

$a_M(t)$ and $a_E(t)$ = importance of M and E, $a_M(t)/a_E(t)$ = comparative importance of M and E.

Table 3: Parameter indices from window regressions.

Time window		Indices		
t_0	t_1	ia_M	ia_E	ia_0
1820	1920	1.00	1.00	1.00
1830	1930	1.15	1.05	1.05
1840	1940	0.81	3.82	0.85
1850	1950	0.81	3.99	0.83
1860	1960	0.85	4.22	0.86
1870	1970	0.81	4.34	0.83
1880	1980	0.81	4.91	0.82
1890	1990	0.79	6.70	0.82
1900	2000	0.68	20.50	0.86

1900–2000. Wide overlapping intervals ("windows") were selected in order to obtain parameter traces reflecting primarily long-run trends. The three time sequences of estimated α_M, α_E, and α_0 obtained were subsequently converted into the dimensionless indices ia_M, ia_E, and ia_0 by dividing each parameter sequence by its first value. These dimensionless and comparable indices can suggest whether and in which manner the parameters of the Initial model tend to change in the long run. The indices are given in Table 3. Each line in the table corresponds to a logistic GEE regression over a time interval with end points $year_0$ and $year_1$, and shows the ia_M, ia_E, and ia_0 indices computed from estimated regression parameters. The table suggests that over time, α_E increased substantially and at an accelerating rate, while α_M and α_0 remained quasiconstant.

In order to quantify the extent of these indices' variation over time, their coefficients of variation $CV(ia_M)$, $CV(ia_E)$, and $CV(ia_0)$ were calculated by dividing their standard deviations by their means. These CVs are dimensionless measures of variation and allow to compare the temporal variation of ia_M, ia_E, and ia_0. Their values are, respectively, 0.161, 1.049, and 0.095.

Table 4: Collinearity diagnostics and Wald tests. The columns in the table correspond to the Initial, Expanded, and Final models plus the two intermediate models referred to as Temp1 and Temp2. In the body of the table we can distinguish three segments separated by rows of blanks. In the first segment we find vertical sequences of the symbols "×" and "—" that indicate whether a given variable in the left stub is included in a given model. A second "x" in the columns corresponding to the Expanded, Temp1 and Temp2 models identifies the variables tested for significance as a block by Wald tests. The collinearity diagnostic CN, that stands for Condition Number, and Max(VIF), that stands for Maximum Variance Inflation Factor are located in the second segment of Table 4 the results of the Wald tests are shown in the third segment.

	(1) Initial model	(2) Expanded model	(3) Temp1 model	(4) Temp2 model	(5) Final model
M	×	×	×	×	×
E	×	×	×	××	—
t	—	××	—	—	—
t^2	—	××	—	—	—
Mt	—	×	××	—	—
Et	—	×	×	××	—
Mt^2	—	×	××	—	—
Et^2	—	×	×	×	×
Const	×	×	×	×	×
CN	2.45	63.30	46.79	21.77	2.46
Max(VIF)	1.22	159.59	117.16	62.02	1.22
d.o.f	—	2	2	2	—
chi2	—	1.69	0.13	0.40	—
$p >$ chi2	—	.4294	.9390	.8185	—

Clearly, the variation of ia_M is only slightly greater than that of ia_0, and the variations of both ia_M and ia_0 are much smaller than that of ia_E. This implies that the expansion terms associated with α_0 (namely, t and t^2) are less likely to be significant than those associated with α_M (namely, Mt and Mt^2) which in turn are less likely to be significant than those associated with α_E (namely, Et and Et^2). These results suggest to test for significance as a group, and if appropriate, to remove first the expansion terms associated with the parameter with the smallest CV, α_0, and subsequently the ones associated with α_M, that have the next smallest CV.

The sequence of steps that produce the Final model is documented in Table 4. The table summarizes the collinearity diagnostics and Wald tests that justify these steps. The columns in the table correspond to the Initial, Expanded, and Final models plus the two intermediate models referred to as Temp1 and Temp2. In the body of the table, we can distinguish three segments separated by rows of blanks. In the first segment, we find vertical sequences of the symbols "×" and "—" indicating, respectively, whether a given variable in the left stub is included in a given model. A second "×" in the columns corresponding to the Expanded, Temp1, and Temp2 models identifies the variables tested for significance as a block by Wald tests. The collinearity diagnostics CN, that stands for condition number, and Max(VIF), that stands for maximum variance inflation factor are located in the second segment of Table 4. The results of the Wald tests are shown in the third segment.

The CN and VIF entries document the possible occurrence of "harmful collinearity." Following the guidelines in Kennedy [53, page 213], in Belsley et al. [54], and in Belsley et al. [55, Chapter 3], harmful collinearity is signaled by a CN > 30 and/or by a VIF > 10. Clearly the collinearity in the Expanded model is intolerably high.

In keeping with the first suggestion emanating from the moving window regressions, a Wald test of the null hypothesis that the parameters of the terms t and t^2 in the Expanded model are equal to zero was carried out. The test yielded a chi2 = 1.69 and a $p > chi2 = 0.43$, meaning that the null hypothesis $\alpha_{01} = \alpha_{02} = 0$ cannot be rejected. This result justifies dropping the t and t^2 variables to produce the Temp1 model.

Upon estimation, Temp1 showed a collinearity lower than that in the Expanded model but still very high. To implement the second suggestion from the moving window regressions, a Wald test of the null hypothesis that the parameters of Mt and Mt^2 in Temp1 are equal to zero was carried out. The test yielded a chi2 = 0.13 and a $p > chi2 = 0.93$ indicating that the null hypothesis $\alpha_{M1} = \alpha_{M2} = 0$ cannot be rejected. This result justifies dropping Mt and Mt^2 from Temp1, thus producing the Temp2 model.

Moving from the Expanded, to Temp1, to Temp2 models the collinearity declines, as shown by the decrease of the CNs from 63.3 to 46.8 to 22.8, and by the decrease of Max(VIF) from 159.6 to 117.2 to 62.0. Yet, the collinearity in the Temp2 model is still too high since its Max(VIF) of 62 is still much larger than the VIF = 10 threshold. Some relevant clues from the literature provide an avenue for improving upon the Temp2 model.

The ia_E trace in column 4 of Table 3 shows that the importance of the economic capabilities to national growth, α_E, grew at accelerating rates over the 1800–2000 time horizon. The term in Temp2 that reflects this accelerated growth is $\alpha_{E2}Et^2$. The parameters α_{E0} in the $\alpha_{E0}E$ term and α_{E1} in the $\alpha_{E1}Et$ term denote, respectively, the importance of economic capabilities and the rate of growth of such importance at time zero. The literature reflects a consensus to the effect that military capabilities were by far the most important determinant of power for centuries until sometime after 1800. Consequently, during this time the direct contribution of the economic capabilities to national power was small. And since this state of affairs lasted centuries it follows that at the beginning of the nineteenth century the rate of growth of the economic capabilities' importance was also small. This line of reasoning suggests that both the parameters α_{E0} and α_{E1} are approximately zero. A Wald test of the null hypothesis that in Temp2 these parameters are not significantly different from zero yielded a chi2 = 0.40 and a $p >$ chi2 = 0.82. This means that the null hypothesis $\alpha_{E0} = \alpha_{E1} = 0$ cannot be rejected, so that it is warranted to drop E and Et thus producing the Final model.

The estimate of the Final model (see Table 1 column 3) shows that all its coefficients are significant. Also, the CN and Max(VIF) of the Final model are, respectively, 2.5 and 1.22 (see Table 4) that is well below the harmful collinearity thresholds. These results tell us that the Final model provides a parsimonious depiction of the long-run trends investigated in this study.

In a capsule, the approach used to extract a parsimonious Final model from the overparametrized Expanded model involved the following: (a) the Initial model was estimated over a sequence of overlapping intervals spanning the 1820–2000 time horizon; (b) the temporal sequence of parameters thus obtained produced "suggestions" as to which parameters of the Initial model changed over time how much; (c) these suggestions plus others were translated into the sequential testing and elimination of blocks of the Expanded model's variables that produced the Final model.

The estimated Final model (see Table 1 column 3) shows that all the coefficients in it are significant and the collinearity diagnostics in Table 4 are well below the harmful collinearity thresholds. Since all the estimated parameters of the Final model are statistically significant, and since the estimated $\alpha_M(t)$ and $\alpha_E(t)$ are greater than zero over the 1820–2000 time

horizon, it is safe to conclude that the ratio *RI* based on them portrays the estimated temporal change in the comparative importance of the military and economic capabilities over the 1820–2000 time horizon.

Equation (4.1) shows the estimated ratio *RI* based on the Final model's estimated parameters,

$$RI = \frac{71.18519}{.0008114t^2}. \tag{4.1}$$

Clearly *RI* is a decreasing function of time, and this supports the thesis that, for the countries at the top of the power hierarchy, and over the 1820–2000 time interval, the comparative importance of the military/economic capabilities to national power did decline.

Table 2 shows the estimated change of *RI* over 1820–2000, and its projected change over 2000–2100. The table shows that *RI* declined much more quickly in the earlier than in the later portion of the estimation horizon. Specifically, it declined from 219 to 8.8 between 1820 and 1900, and from 8.8 to 2.2 between 1900 and 2000. Over the 2000–2100 forecast horizon, *RI* is projected to decline from 2.2 to about 1.0. Also, (4.1) shows that *RI* approaches zero as *t* grows large.

5. Conclusions

The picture emerging from the results of the analyses reported in this paper is that the major powers and their proximate contenders are in the midst of a transition from a past in which military strength was the dominant determinant of national power, to a future in which economic strength will replace it in this capacity. Two caveats, though, need to be seriously considered. First, this picture of a transition in the importance of military power involves an extrapolation beyond the time horizon spanned by the analyses, and any extrapolation has to be considered cautiously and questioned. The second caveat is that since the analyses in the study are concerned with long-run trends, their results are not necessarily applicable to specific countries and circumstances. However, they can still provide a useful background to the ongoing debates about the importance and role of military capabilities in today's world.

The comparative importance of military strength figures prominently in the worldviews that attempt to explain and shape the international relations. This is especially true with respect to the realist and the liberal worldviews. Let us briefly relate this study to the debates about the realist and liberal perspectives.

Realism and liberalism reflect traditions of political and philosophical thought that span centuries and encompass a number of variants [56–63]. However, the central tenets present in all these variants reflect contrasting views on the role and importance of military strength.

The realism postulates that states only are major actors in the international system, and that the structure of the international system is "anarchic" since above the states there is not a "world government" with laws, courts, and police that can adjudicate and enforce solutions to international conflicts. In an anarchic world, the states depend on military strength to pursue their objectives and for the defense of their national interests. Even when nonmilitary policy tools prove successful, it is the implicit threat represented by military strength that makes them effective. Thus, in terms of a realist frame of reference, military strength is of paramount importance, and the major powers are such because of their greater military strength.

The liberal perspective postulates that the actors in the international system include international and transnational organizations as well as states; that countries are bound to each other by treaties, common interests, and common problems; that war is evitable even in an anarchic system because of the interdependencies, interactions, common interests among countries; and that the supranational organizations provide opportunities and avenues for mediating conflicts and crises. Within a liberal frame of reference, both the military and nonmilitary components of national power are important.

Realism and liberalism can be regarded as perspectives that emphasize distinct facets of the international realities. However, there are historical situations that are best characterized in terms of a realist perspective, and others that are best understood and explained in terms of a liberal perspective. The results of this study support the notion that during the 1820–2000 time horizon, the comparative validity of the two perspectives has shifted, and that the happenings in, and structure of, the international system are best described and explained by the realist perspective at the beginning of the horizon, while the liberal perspective is to a greater extent applicable at the end of it.

Acknowledgments

Comments and suggestions by Professor R. J. Stoll, Rice University, and by anonymous referees are gratefully acknowledged. The errors are the author's.

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