## NISKA SKUTECZNOŚĆ MODELI POTĘGI PAŃSTW

# THE DEPLORABLE PERFORMANCE OF REPLICABLE NATIONAL POWER INDEXES

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**Słowa kluczowe:** indeks potęgi narodowej, percepcja potęgi, wskaźniki potęgi

War performance and power perception are introduced as two possible ways to test performance, then choosing and proceeding with power perception. The background and content of the power surveys used is followed by an explication of the performance measures used. A brief discussion of each of the replicable power indexes used is given along with results. The conclusion shows that calibrated indexes outperform non-calibrated indexes and single-indicator approaches by three to one, while non-calibrated indexes and single-indicator approaches perform equally.

Skuteczność prowadzenia wojny oraz percepcja potęgi są przedstawione jako dwie potencjalne metody testowania skuteczności, następnie omawiana i kontynuowana jest percepcja potęgi. Po zaprezentowaniu tła i zawartości przeprowadzonych badań potęgi, przedstawione jest wyjaśnienie skuteczności zastosowanych wskaźników. Zaprezentowano krótkie omówienie na temat każdego z powtarzalnych indeksów potęgi wraz z wynikami badań. Wnioski wskazują, że skalibrowane indeksy przewyższają nieskalibrowane indeksy i jedno-wskaźnikowe podejścia w skali trzy do jednego, podczas gdy nieskalibrowane indeksy i jedno-wskaźnikowe podejścia charakteryzują się równą skutecznością.

## 1. Introduction: Two ways to test the performance of national power indexes

The problem with power measurement to date has been that many an author of a power index believes implicitly or explicitly, in accordance with their expertise, that their power index is, if not the best, then at least as close to the best as can be created; this is also an entirely logical perception, for if they thought there might still be a better way, then they would have implemented it, assuming the possibility of convenient implementation. Without any method to compare any two indexes to determine which is objectively the better, we are left with the choice between many power indexes, having only a faint idea of how they perform and no idea which one ought to be preferred in assessing national power resources.

For comparison we would need observation values for power, and then we could see which index produces prediction values closest to the observation values. However, we do not have observation values, at least not readily available ones.

There are two ways that this problem can be overcome. One can get observation values for national power by looking at war performance, or one gets them through perception surveys.

Karl Haushofer stated that the ultimate test of national strength is war (Haushofer 1913: 8). Nicholas Spykman stated likewise (Spykman 1942: 22). AJP Taylor stated that traditionally "the test of a Great Power is then the test of strength for war" (Taylor 1954: xxix). George Perkovich stated in a more recent lecture on India that war provides the empirical test of military power (Perkovich 2003: 14, 2004: 136). Chang Chin-Lung referred to "one-on-one all-out conflicts, as the acid test for power equations" (Chang 2004: 21). Lenin also stated that "war is a test of every nation's complete economic and organizational power" (Lenin, quoted in Pillsbury 2000: 212).

Thus a cross-national and cross-ideological consensus exists that war is important. In many instances wars have decided whether the state or regime was to be or not to be. This is not to underappreciate the role of national power in gaining a favorable trade deal in bilateral or multilateral negotiations as well as the many other examples of expressions of national power in times of peace. The argument says merely that war is the most serious and critical situation where power makes a difference – nothing more. War performance does not measure national power in times of peace.

Perception surveys are more comprehensive in this regard. They measure the power of nations in either peace or war or both, reflecting the historical and political expertise of those surveyed. Alcock and Newcombe concluded that people tend to perceive the power of nations more in terms of GDP unless these nations were at war recently or are at war, in which case national power is perceived more in terms of military expenditure (Alcock & Newcombe 1970: 340).

Thomas Hobbes can be quoted to the effect that "reputation of power is power" (Hobbes, *Leviathan* X). Theoretically it can be argued that the human brain is not just the most comprehensive estimator of national power but that it is perception itself that defines power. It is different from power as resources as in war, where the outcome can contradict expectations.

The operational issue with war performance is that it has to date been measured crudely according to who won and who lost (with a few cases being draws); the surveyed assessment has come from the scholarly consensus among historians (Wayman et alia 1983: 500). The idea is that normally in war the stronger country defeats the weaker country, but that contention is not confirmed in all instances.

To give a classic example: "few would deny that the United States was a vastly more powerful state than North Vietnam, yet the weaker state was able to defeat the stronger in the Vietnam War (1965−1972)" (Mearsheimer 2001: 60). Thus by using outcomes to judge the performance of power indexes, any produced power index should show North Vietnam to be more powerful than the United States in those years, yet such a possible power index would be nonsensical.

Unless a different measure for deducing power from war performance can be suggested, the use of only victory and defeat (and some draws) remains an overly simplistic and inaccurate measure.

Whereas the major limitation of using perception surveys to test the performance of power indexes has been a lack of known power-perception surveys.

## 2. Methodology: Power-perceptions surveys used for testing

For the purpose of this article, 36 surveys were used for the time 1998, 2003−2015 (Sułek 2015). The 1998 survey was conducted in France, 33 of the other 35 surveys were conducted in Poland, one was conducted in Turkey, and one in Slovenia.

The 1998 survey was conducted by Jean-Yves Caro at the Institute of Higher Studies for National Defense [Institut des hautes études de défense nationale – IHEDN] in France. The IHEDN is a public institution for the purpose of training military and civilian public servants in defense matters. 214 students agreed to participate in the survey. The surveyees were asked to assign scores ranging from 1−15 for the power of 40 selected countries. These scores were averaged into an interval scale and published in a series of articles (Caro 1999, 2000a, 2000b, 2000c).

The 2003−2015 surveys were conducted by Mirosław Sułek, professor of international relations at the University of Warsaw, and also featured 39−40 selected countries each, but instead of assigning a score, students were asked to rank the countries. Though the surveyees came from different classes, most of them were students of international relations or a related subject. The surveyees included anyone from first-year students to master's degree students as well as military attachés taking specific courses. The classes also varied in size from 11−125.

The issue remains regarding how representative these surveys are. In their 1970 article, Norman Alcock and Alan Newcombe had presented the survey results of 38 Canadian citizens ranking 122 nations (Alcock & Newcombe 1970). In 1974 Charles Doran, Kim Hill, Kenneth Mladenka, and Wakata Kyoji replicated the study by Alcock and Newcombe (Doran et alia 1974). Contemplating the issue of whether power perceptions may differ across cultures and political systems, they surveyed Finnish, Japanese, and American university students. The Spearman correlation coefficients between the three national groups plus the Canadians surveyed by Alcock and Newcombe are all 0.90 or above. This demonstrates that perceptions are consistent and reliable.

## 3. Methodology: Performance measures

Two performance measures are used. One performance measure concerns itself with *per capita* national power. The other measure takes the adjusted $R^2$ for the 1998 scores of the various power indexes and the results of the 1998 survey.

For the first measure all rank measures from all the surveys 1998/2003−2015 are converted into dyadic comparisons. Thus if Israel ranks 13 in one survey and Spain 19 in the same survey, the dyadic comparison assigns for the Israel-Spain dyad 1-0, meaning Israel is perceived as more powerful than Spain in that survey.

Dyadic comparisons where a more populous country is ranked as more powerful than a less populous country are removed from the set of dyadic comparisons. The rationale is simple: It is no challenge to create a size index that shows that United States is more powerful than Canada, that France is more powerful than Belgium, and so on.

Similarly, as for war performance, there remains the challenging issue "why big nations lose small wars" as Andrew Mack titled his 1975 article (Mack 1975). To write an article about why big nations win wars against smaller opponents would obviously be superfluous. It is when power and size are embodied by different actors that the differentiation and clarification of the concepts (size and power) can be appreciated.

The selected country pairs of the perception surveys are then contrasted to the same country pairs and their values from the power indexes. If both surveys and index agree that the same country was more powerful than the same other country, the result counts as positive, if not, the result counts as negative. In cases where the index values of country pairs are equal, this is counted as a tie. The positive results are added and then divided by the number of available cases, then minus 0.5 and multiplied by two, hence an index may perform anywhere from +100% to −100%.

As the 1998 survey is the only one that offers scores on an interval scale, it is the only one that can be used for taking the adjusted $R^2$ (in relation to the logged values of each power index). As for the final ranking of power indexes and single indicators, the smaller number from the two performance measures (per capita performance and $R^2$) is taken to signify robustness.

## 4. Results: Replicable Power Indexes

The replicable power indexes were selected for most part from my PhD thesis (Höhn 2011), in which a "comprehensive and systematic study of the literature in geopolitics, political geography, and international relations found no fewer than 69 different multivariate formulas and indexes designed specifically to measure national power and to rank countries in terms of their power relative to each other" (Painter 2015: 143).

Replicability refers to being able to find the necessary input data in available databases as well as being able to directly calculate results from that. It excludes all approaches that have some subjective evaluation element as one of the variables (e.g. 'strategic purpose'), since different people will evaluate things differently. It excludes those where the input data is unclear or difficult to obtain. It excludes complicated procedures such as principal component analysis for creating an index. Replicability generally relates to approaches that feature fewer variables and simpler formulas.

The principle data source were the World Development Indicators (WDI):

http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators

For steel, the data source was the Annual crude steel production archive:

https://www.worldsteel.org/statistics/statistics-archive/annual-steel-archive.html

For detailed energy statistics, the annual editions of the *Energy Statistics of OECD Countries* as well as *Energy Statistics of Non-OECD Countries* were consulted:

http://www.oecd-ilibrary.org/energy/energy-statistics-of-oecd-countries_19962827-en

http://www.oecd-ilibrary.org/energy/energy-statistics-of-non-oecd-countries_19962851-en

## 4.1 Süßmilch 1741 DE

Johann Süßmilch was a German pastor and pioneer in statistics. In his major work *The Divine Order*[1] he wrote:

> If a country has as many inhabitants as one three times larger, so is its reputation, power and security three times greater, or the splendor of the latter three-times smaller. (Süßmilch 1765: 1/402)

Translated into a mathematical formula, this means:

power = population × population_density

*or*

power = population$^2$ / area

His central argument was that, in general, a high population density implied higher development.

**Table 1**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| land area | 2150 | 2824 | 0 | −13.6% | 40 | 1 | 4.1% |
| **Power (Süßmilch 1741)** | **930** | **4044** | **0** | **−62.6%** | **40** | **2** | **20.8%** |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: Per capita performance is negative! Using this index is worse than using no index.

[1] German title: *Die göttliche Ordnung in den Veränderungen des menschlichen Geschlechts, aus der Geburt, dem Tode und der Fortpflanzung desselben erwiesen*.

## 4.2. Wright 1955 US

Philip Quincy Wright was an American pioneer in quantitative war studies. For one of his field diagrams in his book *The Study of International Relations* he defined national power this way (Wright 1955: 547−549, further 595−603):

military_potential = population × energy_production

**Table 2**

| indicator / power index | positive | nega-tive | tie | per capita performance | observa-tions | vari-ables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| energy production | 1665 | 2282 | 0 | −15.6% | 40 | 1 | 26.2% |
| **Military Potential (Wright 1955)** | 1001 | 2946 | **0** | −49.3% | **40** | 2 | 30.8% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: Per capita performance is negative! Using this index is worse than using no index.

## 4.3. Cole 1963 UK [AU]

John Peter Cole is a political geographer born in Australia and living most of his working life in the United Kingdom. His major work *Geography of World Affairs* went through six editions. In the second edition he quantified national power this way (Cole 1963: 280−282):

world_power = area% × 250 + population% × 250 + energy_consumption% × 500

(values of each variable are standardized as percentage shares of world totals)

**Table 3**

| indicator / power index | positive | negative | tie | per capita performance | observa-tions | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| energy use | 2152 | 1795 | 0 | 9.0% | 40 | 1 | 74.3% |
| **World Power (Cole 1963)** | **1949** | **1944** | **0** | **0.1%** | **40** | **3** | **49.7%** |
| land area | 2150 | 2824 | 0 | −13.6% | 40 | 1 | 4.1% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: 'Energy use' outperforms the composite index according to both measures (per capita performance and R2). Hence this composite index is completely unnecessary, because it is better to use the single indicator.

### 4.4. Cohen 1963 / 1973 US

Saul Cohen (born in 1925) is an American political geographer. In 1963 Cohen published two editions of *Geography and Politics in a World Divided*, both of which contain various experimentation with power indexes (Cohen 1963: 7−12, 1973: 7−12). The 1963 formulas are:

national_power = ( a + d + p + u + u% + c + s ) / 7

national_power = ( a + d + u + u% + c + s ) / 6

national_power = ( a + d + u% + c + s ) / 5

national_power = ( a + u + c ) / 3

a = area; d = reciprocal of physiological population density (population divided by arable land); p = population; u = urban population; u% = urban population divided by population; c = cultivated land; s = steel production

(values are standardized prior to adding up; for standardization procedure itself see Cohen)

The replicable 1973 formula is:

national_power = ( a + p + f ) / 3
a = area; p = population; f = armed forces personnel
(values are standardized prior to adding up; for standardization procedure itself see Cohen)

**Table 4**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| **National Power (Cohen 1963 − 5 indicators)** | **3442** | **1205** | **0** | **48.1%** | **40** | **5** | **54.8%** |
| **National Power (Cohen 1963 − 6 indicators)** | **3071** | **1576** | **0** | **32.2%** | **40** | **6** | **57.8%** |
| crude steel production | 2867 | 1773 | 7 | 23.4% | 40 | 1 | 24.7% |
| **National Power (Cohen 1963 − 7 indicators)** | **2605** | **2042** | **0** | **12.1%** | **40** | **7** | **52.9%** |
| land area | 2150 | 2824 | 0 | −13.6% | 40 | 1 | 4.1% |
| **National Power (Cohen 1963 − 3 indicators)** | **1982** | **2665** | **0** | **−14.7%** | **40** | **3** | **29.8%** |
| agricultural land | 1916 | 2731 | 0 | −17.5% | 40 | 1 | 2.1% |
| arable land | 1736 | 2911 | 0 | −25.3% | 40 | 1 | 14.5% |
| **National Power (Cohen 1973)** | **1483** | **3065** | **0** | **−34.8%** | **40** | **3** | **30.4%** |
| armed forces personnel | 1135 | 3407 | 6 | −50.1% | 40 | 1 | 33.4% |
| urban population | 1183 | 3791 | 0 | −52.4% | 40 | 1 | 48.7% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: According to both per capita performance and R2, the top two out of the five composite indexes outperform all the single indicators of which are composed. Thus these two composite indexes represent an improvement, and it is probably better to use them than the single indicators of which they are composed.

### 4.5. Fucks 1965 / 1978 DE

Wilhelm Fucks was a German physicist. In 1965 he published *Formulas for Power: Predictions on Populations, Economics, Potentials*[2] (Fucks 1965, 1966), in 1978 his follow-up *Powers of Tomorrow: Force Fields, Tendencies, Consequences*[3] (Fucks 1978). The 1965 formula:

economic_power = ( $p^{1/3}$ × st + $p^{1/3}$ × e ) / 2

p = population; st = steel production (USA = 1000); e = energy production (USA = 1000)

The 1978 formula:

virtual_power = ( $p^{1/3}$ × st + 3 × $p^{1/3}$ × e ) / 4

p = population; st = steel production (USA 1960 = 100); e = energy production (USA 1960 = 100)

**Table 5**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| crude steel production | 2867 | 1773 | 7 | 23.4% | 40 | 1 | 24.7% |
| **Economic Power (Fucks 1965)** | **1768** | **2179** | **0** | **−10.4%** | **40** | **3** | **46.2%** |
| **Virtual Power (Fucks 1978)** | **1716** | **2231** | **0** | **−13.0%** | **40** | **3** | **39.1%** |
| energy production | 1665 | 2282 | 0 | −15.6% | 40 | 1 | 26.2% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: Per capita performance is negative! Using these indexes is worse than using no index.

### 4.6. [Anonymous] [1967] [US]

In 1967 Jack Sawyer published an article in which he wrote that "GNP multiplied by population […]. This product, and similar ones, have been suggested as measures of national power, which reflects that powerful nations are not only rich but large" (Sawyer 1967: 157). He does not specify the author of this formula:

national power = GNP × population

[2] German title: *Formeln zur Macht: Prognosen über Völker, Wirtschaft, Potentiale*.

[3] German title: *Mächte von Morgen: Kraftfelder, Tendenzen, Konsequenzen*.

**Table 6**

| indicator / power index | positive | negative | tie | per capita performance | observa-tions | vari-ables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| GNI | 3813 | 841 | 0 | 63.9% | 38 | 1 | 80.1% |
| **National Power (anonymous)** | **2349** | **2305** | **0** | **0.9%** | **40** | **2** | **71.6%** |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: 'GNI' outperforms the composite index according to both measures (per capita performance and R2). Hence this composite index is completely unnecessary, because it is better to use the single indicator.

### 4.7. Shinn 1969 US

Allen Shinn was assistant professor of government at the University of Texas at Austin. In 1969 he published an article titled “An Application of Psychophysical Scaling Techniques to the Measurement of National Power” (Shinn 1969) that features his power formula:

$Pt = 0.37 \times POP^{0.41} \times GNP^{0.62} \times MIL^{0.28}$

Pt = total power; POP = population; GNP = per capita GNP; MIL = military spending as percentage of GNP

The coefficients used as exponents were calibrated using a power-perception survey with 27 students in two advanced courses in international politics as surveyees; the data produced by 25 surveyees was consistent enough to be processed.

**Table 7**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| Total Power (Shinn) | 4227 | 402 | 0 | 82.6% | 40 | 3 | 67.9% |
| military expenditure | 3883 | 812 | 0 | 65.4% | 40 | 1 | 80.7% |
| GNI | 3813 | 841 | 0 | 63.9% | 38 | 1 | 80.1% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: The composite index outperforms all the single indicators it is composed of according to one measure (per capita performance). This composite index may represent an improvement and may possibly be worth using.

### 4.8. Singer / Bremer / Stuckey 1972 US

Joel David Singer (1925–2009) was an American political scientist and major contributor to quantitative international politics. He created together with colleagues the Composite Index of National Capabilities (CINC), which may well be the most prominent index (Singer et alia 1972). The formula is:

CINC = ( %ME + %MP + %IS + %NRG + %UP + %TP ) / 6

%ME = military expenditure; %MP = military personnel; %IS = 1816–1895: iron production, 1896–present: steel production; %NRG = energy consumption; %UP = urban population; %TP = total population

(percentage share of world total)

Charles Doran and Wes Parsons used basically the same variables as the CINC with the exception of military expenditures (Doran & Parsons 1980: 953–954; also Chan 2005: 691–692):

Total_Relative_Power = ( %MP + %IS + %NRG + %UP + %TP ) / 5

(percentage share of the aggregate figure summed from all a nation's counterparts at the time)

William Brian Moul excluded the two variables of the demographic dimension (total population and urban population), because he does not consider long-range potential as applicable to cases of serious dispute (Moul 1988: 246, 1989: 111–112):

CINC = ( %ME + %MP + %IS + %NRG + %UP + %TP ) / 4

(percentage share of world total)

Finally there is Geometric Index of National Capabilities (GINC) proposed by Kelly Kadera and Gerald Sorokin (Kadera & Sorokin 2004). The difference between GINC and CINC is that the CINC uses the arithmetic mean and the GINC the geometric mean. The formula is:

GINC = $( \%ME \times \%MP \times \%IS \times \%NRG \times \%UP \times \%TP )^{1/6}$

(percentage share of world total)

**Table 8**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| military expenditure | 3883 | 812 | 0 | 65.4% | 40 | 1 | 80.7% |
| crude steel production | 2867 | 1773 | 7 | 23.4% | 40 | 1 | 24.7% |
| energy use | 2152 | 1795 | 0 | 9.0% | 40 | 1 | 74.3% |
| CINC modification (Moul) | 1778 | 1810 | 0 | −0.9% | 40 | 4 | 80.6% |
| GINC (Kadera/Sorokin) | 1648 | 1938 | 2 | −8.1% | 40 | 6 | 13.3% |
| CINC (Singer/Bremer/Stuckey) | 1330 | 2258 | 0 | −25.9% | 40 | 6 | 66.5% |
| armed forces personnel | 1135 | 3407 | 6 | −50.1% | 40 | 1 | 33.4% |
| urban population | 1183 | 3791 | 0 | −52.4% | 40 | 1 | 48.7% |
| Total Relative Power (Doran/ Parsons) | 889 | 2905 | 0 | −53.1% | 40 | 5 | 53.5% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: Per capita performance is negative for all four indexes! Using these indexes is worse than using no index. The CINC modification by Moul is an improvement to the original CINC, but not enough to make it viable. Further, 'military expenditure' outperforms all four composite indexes according to both measures (per capita performance and R2).

### 4.9. Organski / Kugler 1978 US

A.F.K. Organski was an American political scientist known for his power transition theory. In 1978 Organski and Kugler published an article that adds a subindex of governmental extraction as a measure for political development (Organski & Kugler 1978, also 1980: 64−103, 227−233):

Tax_Effort = Real_Tax_Ratio / Tax_Capacity

*or*

Relative_Political_Capacity = Actual_Extraction / Expected_Extraction

The subindex plays a central role in converting GDP into a measure of national power:

National_Power = ( GNP + Foreign_Aid ) × Tax_Effort

*or, alternatively (without foreign aid),*

Power = GDP × RPE

Relative Political Capacity (RPC) had been later styled Relative Political Extraction (RPE). There have been three RPE variations computed (Arbetman-Rabinowitz et alia 2011).

**Table 9**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| Relative Political Extraction (GDP) | 3056 | 633 | 0 | 65.7% | 40 | 5 | 77.6% |
| Relative Political Extraction (agriculture) | 3051 | 638 | 0 | 65.4% | 40 | 5 | 79.2% |
| Relative Political Extraction (OECD) | 3046 | 643 | 0 | 65.1% | 40 | 5 | 80.2% |
| GDP | 3882 | 853 | 0 | 64.0% | 39 | 1 | 80.7% |

Source: compiled and calculated by author.

Bottom line: The three composite indexes outperform the single indicator they are composed of according to one measure (per capita performance). These composite indexes may represent an improvement and may possibly be worth using.

## 4.10. Farrar 1981 US

Lancelot Farrar is an American historian. In his book *Arrogance and Anxiety: The Ambivalence of German Power, 1848−1914* he quantifies national power (Farrar 1981). British historian Paul Kennedy interpreted this to construct the formula this way (Kennedy 1987: 571):

power = population × manufacturing_production

**Table 10**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| manufacturing, value added | 2943 | 726 | 0 | 60.4% | 34 | 1 | 84.8% |
| **Power (Farrar)** | **1874** | **1795** | **0** | **2.2%** | **40** | **2** | **81.4%** |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: 'Manufacturing, value added' outperforms the composite index according to both measures (per capita performance and R2). Hence this composite index is completely unnecessary, because it is better to use the single indicator.

### 4.11. Yu / Wang 1989 CN

In Yu Hongyi and Wang Youdi were members of the Hubei Science Commission in China. They published two articles titled "Evaluation of Comprehensive National Strength Measure" (Yu & Wang 1989a, 1989b).[4] Their formula is:

$CNS = LS \times FD$

$LS = 0.5\ X_1 + 0.79\ X_2 + X_3$

$FD = F^{0.5} \times D^{0.5}$

CNS = comprehensive national strength; LS = structure level; FD = function dimension; $X_1$ = percent employment in agricultural sector; $X_2$ = percent employment in industrial sector; $X_3$ = percent employment in service sector; F = GNP; D = energy consumption

**Table 11**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| GNI | 3813 | 841 | 0 | 63.9% | 38 | 1 | 80.1% |
| CNS (Yu/Wang) | 1733 | 653 | 0 | 45.3% | 40 | 5 | 81.1% |
| energy use | 2152 | 1795 | 0 | 9.0% | 40 | 1 | 74.3% |

Source: compiled and calculated by author.

Bottom line: According to one measure (per capita performance), the composite index underperforms relative to the single indicator 'GNI' of which it is composed. This composite index may represent no improvement, thus using the single indicator seems preferable.

### 4.12. Sułek 1990 PL

Mirosław Sułek is a Polish defense economist. He developed two formulas to measure power. His formula for coordinative power (military power) is (Sułek 2010: 118):

$Pk\dot{z} = W^{0.652}\ \dot{Z}^{0.217}\ p^{0.109}$

Pkż = coordinative power; W = military expenditures; Ż = number of soldiers in active service; p = territory

The auxiliary formula for disposable power (economic power) is:

$Pd = D^{0.652}\ L^{0.217}\ p^{0.109}$

Pd = disposable power; D = nominal GDP; L = population; p = territory

[4] Chinese title: "综合国力测度评价".

**Table 12**

| indicator / power index | positive | negative | tie | per capita performance | observa-tions | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| military expenditure | 3883 | 812 | 0 | 65.4% | 40 | 1 | 80.7% |
| GDP | 3882 | 853 | 0 | 64.0% | 39 | 1 | 80.7% |
| **Economic Power (Sułek)** | **3194** | **1541** | **0** | **34.9%** | **40** | **3** | **75.4%** |
| **Military Power (Sułek)** | **2706** | **1585** | **0** | **26.1%** | **40** | **3** | **82.4%** |
| land area | 2150 | 2824 | 0 | −13.6% | 40 | 1 | 4.1% |
| armed forces personnel | 1135 | 3407 | 6 | −50.1% | 40 | 1 | 33.4% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: According to one measure (per capita performance), the composite index 'Military Power' underperforms relative to the single indicator 'military expenditure' of which it is composed. This composite index may represent no improvement, thus using the single indicator seems preferable. 'GDP' outperforms the composite index 'Economic Power' according to both measures (per capita performance and R2). Hence this composite index is completely unnecessary, because it is better to use the single indicator.

### 4.13. Chaczaturov 1997 RU

Vladimir Chaczaturov is professor of mathematics and physics in Russia. In 1997 he published the article "Russia and the geopolitical stability of the world" (Chaczaturov 1997).[5] He settled on four indicators of potential, which are (A) area, (B) population, (C) annual consumption of primary energy resources, and the (D) annual consumption of electricity in the residential and service sectors (household electricity). These four indicators provide for 15 possible combinations: A, B, C, D, $(A\,B)^{0.5}$, $(A\,C)^{0.5}$, $(A\,D)^{0.5}$, $(B\,C)^{0.5}$, $(B\,D)^{0.5}$, $(C\,D)^{0.5}$, $(A\,B\,C)^{1/3}$, $(A\,B\,D)^{1/3}$, $(A\,C\,D)^{1/3}$, $(B\,C\,D)^{1/3}$, $(A\,B\,C\,D)^{0.25}$. In the table, as for the input, area is abbreviated 'lnd', population as 'pop', energy consumption as 'egy' and household electricity as 'hou'.

[5] Russian title: "Россия и геополитическая стабильность мира".

**Table 13**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| commercial and public services electricity | 3291 | 993 | 0 | 53.6% | 35 | 1 | 80.6% |
| Chaczaturov (hou) | 3101 | 1217 | 0 | 43.6% | 37 | 2 | 82.1% |
| residential electricity | 2909 | 1400 | 0 | 35.0% | 36 | 1 | 83.7% |
| Chaczaturov (egy, hou) | 2335 | 1314 | 0 | 28.0% | 40 | 3 | 81.3% |
| Chaczaturov (lnd, egy, hou) | 2187 | 1462 | 0 | 19.9% | 40 | 4 | 53.5% |
| Chaczaturov (lnd, hou) | 2526 | 1792 | 0 | 17.0% | 40 | 3 | 41.6% |
| energy use | 2152 | 1795 | 0 | 9.0% | 40 | 1 | 74.3% |
| Chaczaturov (lnd, pop, egy, hou) | 1914 | 1735 | 0 | 4.9% | 40 | 5 | 48.6% |
| Chaczaturov (pop, egy, hou) | 1828 | 1821 | 0 | 0.2% | 40 | 4 | 70.4% |
| Chaczaturov (lnd, pop, hou) | 2161 | 2157 | 0 | 0.1% | 40 | 4 | 40.2% |
| Chaczaturov (lnd, egy) | 1901 | 2046 | 0 | −3.7% | 40 | 2 | 33.5% |
| Chaczaturov (pop, hou) | 2011 | 2307 | 0 | −6.9% | 40 | 3 | 69.5% |
| land area | 2150 | 2824 | 0 | −13.6% | 40 | 1 | 4.1% |
| Chaczaturov (lnd, pop, egy) | 1572 | 2375 | 0 | −20.3% | 40 | 3 | 33.9% |
| Chaczaturov (lnd, pop) | 1678 | 3296 | 0 | −32.5% | 40 | 2 | 14.4% |
| Chaczaturov (pop, egy) | 1179 | 2768 | 0 | −40.3% | 40 | 2 | 56.5% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: 'Chaczaturov (hou)' outperforms one single indicator in per capita performance and another single indicator in R2. This composite index may represent no improvement, thus using the single indicator seems preferable. For five composite indexes the per capita performance or R2 is negative! Using these five indexes is worse than using no indexes. According to both measures (per capita performance and R2), the remaining six composite indexes underperform relative to at least one single indicator of which they are composed. Hence these six composite indexes are unnecessary, because it is better to use the single indicator.

### 4.14. Caro 1998 FR

Jean-Yves Caro is a French economist. In 1998 he conducted a perception survey on national power and used the results to calibrate the exponents in at least six formulas. The military and the civilian-military formulas contain variables based on author's evaluation, thus they are not replicable, but two civilian formulas he developed can be replicated. His 1999 formula is (Caro 2000c: 98):

$power_i = 1.45 \times technology_i^{0,18} \times population_i^{0.19}$

i = respective country; technology = 'personal computers' per capita plus 'fixed line and mobile cellular subscriptions' per capita

The 2000 formula is (Caro 2000a: 28):

$\text{exponent}(\text{power}_i) = \text{GNP\_PPP}_i^{1.15} \times \text{international\_trade\_PPP}_i^{0.39}$

i = respective country

**Table 14**

| indicator / power index | posi-tive | nega-tive | tie | per capita performance | observa-tions | vari-ables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| trade, PPP | 68 | 22 | 0 | 51.1% | 40 | 1 | 65.2% |
| personal computers | 928 | 310 | 10 | 48.7% | 38 | 1 | 80.4% |
| Power (Caro 2000) | 63 | 27 | 0 | 40.0% | 40 | 2 | 76.9% |
| Power (Caro 1999) | 764 | 484 | 0 | 22.4% | 40 | 3 | 80.4% |
| GDP, PPP | 2618 | 1857 | 0 | 17.0% | 37 | 1 | 76.2% |
| fixed line and mobile cellular subscriptions | 1209 | 1599 | 0 | −13.9% | 40 | 1 | 76.9% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: According to one measure (per capita performance), both composite indexes each underperform relative to one single indicator of which they are composed. The composite indexes may represent no improvement, thus using the single indicators seems preferable.

### 4.15. Volgy / Bailin 2003 US

Thomas Volgy is an American political scientist. In 2003 he published together with Alison Bailin, one of his graduate students, *International Politics & State Strength* (Volgy & Bailin 2003). Their power formula is as straightforward as it simple:

RS = ( GDP / GroupGDP + MilSpend / GroupMilSpend ) / 2

RS = relative strength; MilSpend = military spending; Group = aggregate scores for designated group powers

**Table 15**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| Relative Strength (Volgy/Bailin) | 3898 | 797 | 0 | 66.0% | 40 | 2 | 82.6% |
| military expenditure | 3883 | 812 | 0 | 65.4% | 40 | 1 | 80.7% |
| GDP | 3882 | 853 | 0 | 64.0% | 39 | 1 | 80.7% |

Source: compiled and calculated by author.

Bottom line: According to both measures (per capita performance and $R^2$), the composite index outperforms the single indicators of which it is composed. This composite indexes represents an improvement and is probably worth using.

### 4.16. Chang 2004

Chang Chin-Lung is a Taiwanese scholar. He implemented modifications of Ray Cline's equation in a conference paper (Chang 2004), given that this equation is nonreplicable due to elements that required the author's evaluation. Cline's formula from 1975:

$P_p = ( C + E + M ) \times ( S + W )$

$P_p$ = perceived power; C = critical mass = population + territory; E = economic capability; M = military capability; S = strategic purpose; W = national will

Chang proposed the formulas, the first one consisting of GNP as a single indicator. Model 2 is a hybrid between the CINC (section 13.15) and Cline's equation:

$P = ( \%POPU \times 100 + \%AREA \times 100 + \%GNP \times 200 + \%ME \times 200 ) / 3$

P = power; %POPU = population as percentage of world total; %AREA = area as percentage of world total; %GNP = GNP as percentage of world total; %ME = military expenditures as percentage of world total

Model 3 is a variation of model 2, multiplying it with an energy coefficient:

P = Model_2 × %ENGY

P = power; %ENGY = per capita energy consumption / world average

**Table 16**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| Power (Chang Model 3) | 3150 | 505 | 0 | 72.4% | 40 | 5 | 77.7% |
| military expenditure | 3883 | 812 | 0 | 65.4% | 40 | 1 | 80.7% |
| GNI | 3813 | 841 | 0 | 63.9% | 38 | 1 | 80.1% |
| Power (Chang Model 2) | 3302 | 1327 | 0 | 42.7% | 40 | 4 | 76.3% |
| energy use | 2152 | 1795 | 0 | 9.0% | 40 | 1 | 74.3% |
| land area | 2150 | 2824 | 0 | −13.6% | 40 | 1 | 4.1% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: According to both measures (per capita performance and $R^2$), the composite index 'Model 2' underperforms relative to two of the four single indicators of which it is composed. Hence this composite index is completely unnecessary, because it is better to use the single indicators. According to one measure (per capita performance), the composite index 'Model 3' outperforms the single indicators of which it is composed. This composite index may represent an improvement and may possibly be worth using.

### 4.17. Virmani 2004 IN

Arvind Virmani (born in 1949) is an Indian economist. He wrote five papers (one a lecture) on his idea of how to measure power potential (Virmani 2004, 2005a, 2005b, 2005c, 2005d):

$VIP^2 = Y \times y^{0.5}$

*or*

$VIP^2 = L \times y^{1.5}$

$VIP^2$ = Virmani Index of Potential Power; Y = GDP-PPP; L = population; y = per capita GDP-PPP

**Table 17**

| indicator / power index | positive | negative | tie | per capita performance | observations | variables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| Potential Power (Virmani) | 3402 | 1073 | 0 | 52.0% | 40 | 2 | 79.2% |
| GDP, PPP | 2618 | 1857 | 0 | 17.0% | 37 | 1 | 76.2% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: The composite index outperforms the single indicators it is composed of according to both measures (per capita performance and R2). This composite index represents an improvement and is probably worth using.

### 4.18. CIA / IFs [2005] US

Barry Hughes is the director of the Pardee Center for International Futures (IFs). Evan Hillebrand was chief economist in the CIA's Strategic Assessment Group (SAG). There has been ongoing collaboration between parts of the United States intelligence community and the IFs. The formula for the CIA index was developed by Hillebrand in collaboration with Paul Herman is (Hughes & Hillebrand 2006: 184):

TechPower = GDPP / POP

power = 0.8 POP + 1.1 GDPP + 0.3 TechPower + 0.9 GDS

POP = population; GDPP = GDP at PPP; GDS = military spending

(values as percentage shares of world total)

The National Intelligence Council (NIC) is the center for mid-term and long-term strategic thinking within the United States intelligence community. The NIC developed the Global Power Index (GPI), which was also modified at least once. Here the formula as from the IFs (Hughes 2015):[6]

power = 0.2 GDPP + 0.2 GDS + 0.05 NPOW + 0.05 ENE + 0.05 TT

[6] For more information about the GPI, check the various *Global Trends* reports by the NIC on the Director of National Intelligence website, http://www.dni.gov/index.php/about/organization/national-intelligence-council-global-trends (31.10.2015).

+ 0.05 FDI + 0.05 FA + 0.05 I + 0.05 C + 0.15 DPI + 0.1 EHC

GDPP = GDP at PPP; GDS = military spending; NPOW = nuclear warheads (logged); ENE = energy net export; TT = trade total; FDI = FDI inflows; FA = foreign aid; I = innovation R&D; C = connectivity ICT; DPI = Diplomatic Power Index; EHC = effective human capital

(values as percentage shares of world total)

Jonathan Moyer, Hughes' assistant, developed the Hillebrand-Herman-Moyer Index (HHMI), which represents more or less a synthesis of the previous two power formulas (Cilliers et alia 2015: 25):

TechPower = GDPP / POP

power = 0.8 POP + 1.1 GDPP + 0.3 TechPower + 0.9 GDS

+ 0.3 EMBASSY + 0.25 NPOW + 0.2 IGO + 0.1 TREATY

POP = population; GDPP = GDP at PPP; EMBASSY = number of embassies; NPOW= nuclear warheads (logged); IGO = intergovernmental organization memberships; TREATY = treaties signed or ratified

(values as percentage shares of world total)

**Table 18**

| indicator / power index | posi-tive | nega-tive | tie | per capita perfor-mance | observa-tions | vari-ables | adjusted $R^2$ |
|---|---|---|---|---|---|---|---|
| TechPower (Hillebrand) | 3741 | 734 | 0 | 67.2% | 40 | 2 | 74.3% |
| military expenditure | 3883 | 812 | 0 | 65.4% | 40 | 1 | 80.7% |
| Global Power Index (NIC) | 1758 | 480 | 0 | 57.1% | NA | NA | NA |
| embassies | 2604 | 1195 | 43 | 35.6% | 40 | 1 | 68.9% |
| IGO memberships | 2694 | 1145 | 3 | 40.2% | 40 | 1 | 27.3% |
| Hillebrand-Herman-Moyer-Index | 2403 | 1437 | 2 | 25.1% | 40 | 7 | 80.6% |
| treaties signed or ratified | 2899 | 892 | 0 | 52.9% | 40 | 1 | 17.2% |
| GDP, PPP | 2618 | 1857 | 0 | 17.0% | 37 | 1 | 76.2% |
| CIA Index (Hillebrand/Herman) | 3094 | 2505 | 7 | 10.4% | 40 | 3 | 77.6% |
| nuclear warheads | 667 | 241 | 2934 | −65.3% | 40 | 1 | 38.5% |
| population | 0 | 4974 | 0 | −100.0% | 40 | 1 | 31.2% |

Source: compiled and calculated by author.

Bottom line: 'Military expenditure' outperforms the composite indexes 'CIA index' (by Hillebrand/Herman) and the 'Hillebrand-Herman-Moyer-Index' according to both measures (per capita performance and R2). Hence these composite indexes are completely unnecessary, because it is better to use the single indicator. 'Military expenditure' also outperforms the composite index 'Global Power Index' according to one measure (per capita performance). According to one measure (per capita performance), the composite subindex 'TechPower' outperforms the other composite indexes as well as the single indicators of which it is composed. This composite subindex may represent an improvement and may possibly be worth using.

## 5. Conclusion: Calibration is necessary for quality improvement

Overall results have been calculated for 45 composite indexes and 23 single indicators. Looking over the results in the previous section, the construction of power indexes has not been a successful enterprise. A third (15/45) of all composite power indexes tend to place weaker countries higher than the stronger ones if those countries are of equal size, this is signified by negative performance per capita. To say that in such cases it is better to use no index than to use these indexes is an understatement. The only reason these dreadful indexes do not immediately appear to be as dreadful as they actually are is that they cover up their lack of quality by adequately appreciating size. In effect, this means that these size indexes can appear adequate by showing India to be more powerful than Pakistan on account of population size, while failing completely when it comes to cases like Israel and Egypt, where the less populous country happens to be the more powerful.

Out of the remaining 30 power indexes that produce positive results per capita, two thirds (19/30) do not manage to put the variables together in such a way, that the whole is better than its parts. That is at least one input variable in those composite indexes is performing better than the composite index itself. The idea of a composite index is to put variables together in the hope that the information contained will be more comprehensive and less prone to idiosyncrasies and errors. This is not the case: Most users of composite indexes would be better off using a single indicator (say 'military expenditure') than a composite power index (say the 'CIA Index' by Hillebrand and Herman that has military expenditure as one of four components). Using Occam's Razor, simplicity is to be preferred if given results are of equal quality. In these cases the simpler single indicators outperform the more complicated composite indexes across the board. Given that additional work is also associated with more variables and making things more complicated, single indicators are clearly to be preferred.

Based on the information in the prior section, the following table sums up the general ranking of all 68 single indicators and composite indexes. The three composite indexes 'Shinn', 'Caro 2000', and 'Caro 1999' are highlighted, because the weights of variables therein are calibrated, as opposed to the other 42 composite indexes where the weights are arbitrary. Whereas the per capita performance of non-calibrated composite indexes relative to single-indicators is more or less 1:1 (precisely 492:474 in terms of dyadic comparisons), the performance of the calibrated composite indexes relative to single-indicators is about 3:1 (precisely 51:18). The performance of the calibrated composite indexes relative to non-calibrated composite indexes is also about 3:1 (precisely 96:30). It shows that power indexes can be improved if calibrated. Calibration rather than adding more variables could do the trick. Further the selection of the right variables is aided by calibration too.

**Table 19**

| indicator / power index | per capita perfor-mance | adjusted $R^2$ | per capita perfor-mance rank | adjusted $R^2$ rank | minimum | ro-bust-ness rank |
|---|---|---|---|---|---|---|
| **Chang Model 3** | 72.4% | 77.7% | 2 | 20 | 72.4% | 1 |
| **Shinn** | 82.6% | 67.9% | 1 | 34 | 67.9% | 2 |
| **Hillebrand TechPower** | 67.2% | 74.3% | 3 | 28 | 67.2% | 3 |
| **Volgy / Bailin** | 66.0% | 82.6% | 4 | 3 | 66.0% | 4 |
| **Relative Political Extraction (GDP)** | 65.7% | 77.6% | 5 | 22 | 65.7% | 5 |
| **Relative Political Extraction (agriculture)** | 65.4% | 79.2% | 6 | 19 | 65.4% | 6 |
| military expenditure | 65.4% | 80.7% | 7 | 9 | 65.4% | 7 |
| **Relative Political Extraction (OECD)** | 65.1% | 80.2% | 8 | 16 | 65.1% | 8 |
| GDP | 64.0% | 80.7% | 9 | 10 | 64.0% | 9 |
| GNI | 63.9% | 80.1% | 10 | 17 | 63.9% | 10 |
| manufacturing, value added | 60.4% | 84.8% | 11 | 1 | 60.4% | 11 |
| **Global Power Index** | 57.1% | NA | 12 | NA | 57.1% | 12 |
| commercial and public services electricity | 53.6% | 80.6% | 13 | 13 | 53.6% | 13 |
| **Virmani** | 52.0% | 79.2% | 15 | 18 | 52.0% | 14 |
| trade, PPP | 51.1% | 65.2% | 16 | 36 | 51.1% | 15 |
| personal computers | 48.7% | 80.4% | 17 | 15 | 48.7% | 16 |
| **Cohen 1963 (5 indicators)** | 48.1% | 54.8% | 18 | 39 | 48.1% | 17 |
| **Yu / Wang** | 45.3% | 81.1% | 19 | 8 | 45.3% | 18 |
| **Chaczaturov (hou)** | 43.6% | 82.1% | 20 | 5 | 43.6% | 19 |
| **Chang Model 2** | 42.7% | 76.3% | 21 | 25 | 42.7% | 20 |
| **Caro 2000** | 40.0% | 76.9% | 23 | 23 | 40.0% | 21 |
| embassies | 35.6% | 68.9% | 24 | 33 | 35.6% | 22 |
| residential electricity | 35.0% | 83.7% | 25 | 2 | 35.0% | 23 |
| **Sułek (economic power)** | 34.9% | 75.4% | 26 | 27 | 34.9% | 24 |
| **Cohen 1963 (6 indicators)** | 32.2% | 57.8% | 27 | 37 | 32.2% | 25 |
| **Chaczaturov (egy, hou)** | 28.0% | 81.3% | 28 | 7 | 28.0% | 26 |
| IGO memberships | 40.2% | 27.3% | 22 | 58 | 27.3% | 27 |
| **Sułek (military power)** | 26.1% | 82.4% | 29 | 4 | 26.1% | 28 |
| **Hillebrand / Herman / Moyer** | 25.1% | 80.6% | 30 | 12 | 25.1% | 29 |
| crude steel production | 23.4% | 24.7% | 31 | 60 | 23.4% | 30 |
| **Caro 1999** | 22.4% | 80.4% | 32 | 14 | 22.4% | 31 |
| **Chaczaturov (lnd, egy, hou)** | 19.9% | 53.5% | 33 | 41 | 19.9% | 32 |
| treaties signed or ratified | 52.9% | 17.2% | 14 | 62 | 17.2% | 33 |
| GDP, PPP | 17.0% | 76.2% | 34 | 26 | 17.0% | 34 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Chaczaturov (lnd, hou)** | **17.0%** | **41.6%** | **35** | **47** | **17.0%** | **35** |
| **Cohen 1963 (7 indicators)** | **12.1%** | **52.9%** | **36** | **42** | **12.1%** | **36** |
| **Hillebrand / Herman (CIA Index)** | **10.4%** | **77.6%** | **37** | **21** | **10.4%** | **37** |
| energy use | 9.0% | 74.3% | 38 | 29 | 9.0% | 38 |
| **Chaczaturov (lnd, pop, egy, hou)** | **4.9%** | **48.6%** | **39** | **45** | **4.9%** | **39** |
| **Farrar** | **2.2%** | **81.4%** | **40** | **6** | **2.2%** | **40** |
| **Anonymous** | **0.9%** | **71.6%** | **41** | **30** | **0.9%** | **41** |
| **Chaczaturov (pop, egy, hou)** | **0.2%** | **70.4%** | **42** | **31** | **0.2%** | **42** |
| **Cole 1963** | **0.1%** | **49.7%** | **43** | **43** | **0.1%** | **43** |
| **Chaczaturov (lnd, pop, hou)** | **0.1%** | **40.2%** | **44** | **48** | **0.1%** | **44** |
| **Moul (CINC modification)** | **−0.9%** | **80.6%** | **45** | **11** | **−0.9%** | **45** |
| **Chaczaturov (lnd, egy)** | **−3.7%** | **33.5%** | **46** | **52** | **−3.7%** | **46** |
| **Chaczaturov (pop, hou)** | **−6.9%** | **69.5%** | **47** | **32** | **−6.9%** | **47** |
| **GINC (Kadera / Sorokin)** | **−8.1%** | **13.3%** | **48** | **65** | **−8.1%** | **48** |
| **Fucks 1965** | **−10.4%** | **46.2%** | **49** | **46** | **−10.4%** | **49** |
| **Fucks 1978** | **−13.0%** | **39.1%** | **50** | **49** | **−13.0%** | **50** |
| **land area** | **−13.6%** | **4.1%** | **51** | **66** | **−13.6%** | **51** |
| fixed line and mobile cellular subscriptions | −13.9% | 76.9% | 52 | 24 | −13.9% | 52 |
| **Cohen 1963 (3 indicators)** | **−14.7%** | **29.8%** | **53** | **57** | **−14.7%** | **53** |
| energy production | −15.6% | 26.2% | 54 | 59 | −15.6% | 54 |
| agricultural land | −17.5% | 2.1% | 55 | 67 | −17.5% | 55 |
| **Chaczaturov (lnd, pop, egy)** | **−20.3%** | **33.9%** | **56** | **51** | **−20.3%** | **56** |
| arable land | −25.3% | 14.5% | 57 | 63 | −25.3% | 57 |
| **CINC (Singer/Stuckey/Bremer)** | **−25.9%** | **66.5%** | **58** | **35** | **−25.9%** | **58** |
| **Chaczaturov (lnd, pop)** | **−32.5%** | **14.4%** | **59** | **64** | **−32.5%** | **59** |
| **Cohen 1973** | **−34.8%** | **30.4%** | **60** | **56** | **−34.8%** | **60** |
| **Chaczaturov (pop, egy)** | **−40.3%** | **56.5%** | **61** | **38** | **−40.3%** | **61** |
| **Wright** | **−49.3%** | **30.8%** | **62** | **55** | **−49.3%** | **62** |
| armed forces personnel | −50.1% | 33.4% | 63 | 53 | −50.1% | 63 |
| urban population | −52.4% | 48.7% | 64 | 44 | −52.4% | 64 |
| **Doran/Parsons (CINC modification)** | **−53.1%** | **53.5%** | **65** | **40** | **−53.1%** | **65** |
| **Süßmilch** | **−62.6%** | **20.8%** | **66** | **61** | **−62.6%** | **66** |
| nuclear warheads | −65.3% | 38.5% | 67 | 50 | −65.3% | 67 |
| population | −100.0% | 31.2% | 68 | 54 | −100.0% | 68 |

Source: compiled and calculated by author.

Chang's model 3 (rank 1) represents a lucky guess, Shinn's equation (rank 2) is the result of careful methodology. The case for method and calibration is hereby made. It will not be easy, nor can it happen quickly, but if there is no serious advancement in this field in terms of methods and objectives, and everything merely continues along the same lines as those laid down over the last 100 years, namely, with the continuous production and promotion of garbage, then the very endeavor of power measurement will become pointless.

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