Frederick S. Pardee Institute for International Futures
UNIVERSITY OF DENVER

Relative National Power Codebook

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Introduction

This codebook describes the relative national power indices built and maintained by the Frederick S. Pardee Institute for International Futures, including: the Global Power Index (GPI), Herman-Hillebrand Index (HHI), Herman-Hillebrand-Moyer Index (HHMI), and the Diplomacy, Military, Economy (DiME) Index. For the sake of comparison, we also include several references to the Composite Indicator of National Capability (CINC) from Correlates of War project.[1]

Diplometrics

The Diplometrics research program at the Pardee Institute seeks to better understand and measure relationships in the international system by gathering data, building tools, and conducting analysis. The program identifies international interactions that measure the depth and breadth of political, diplomatic, economic, security, and cultural ties between countries.

Diplometrics began as a data building and analysis project in 2011, focusing initially on developing and forecasting the first iteration of the GPI, described in this codebook. The GPI was first featured publicly in the National Intelligence Council's Global Trends 2030 report.

Since 2011, Diplometrics has expanded significantly to include data on military capabilities, non-state actors, foreign travel by heads of government and state, diplomatic capacity, cultural affinity, power projection, and other data initiatives. With the completion of the Global Indicators of Dyadic Engagement dataset in 2020, the Pardee Institute has begun to use the combined data to analyze and forecast bilateral and networked influence across the international system. Additionally, the Institute has utilized its Formal Bilateral Influence Capacity Index, which is built in part from core Diplometrics data series, to launch reports in association with the Atlantic Council and The Henry L. Stimson Center focusing on great power competition and implications for U.S. foreign policy.

Having built a robust portfolio of data on international power and influence, diplomatic interactions, political violence, and other issues, the Diplometrics team has enhanced its efforts to share our data with academics, analysts, policymakers, and the public. Through academic publications, commentaries, media interviews, and other public engagements, we seek to share our data and analysis with the world.[2]

National Power Project

The Relative National Power project represents both an extension and a departure from the two most popular means of measuring state power in quantitative research: first, the CINC from the Correlates of War project; and second, economic size as measured by gross domestic product (GDP) at market exchange rates (MER), GDP at purchasing power parity (PPP), or gross national product (GNP) at MER. The CINC, GPI, DiME, HHMI, and HHI all capture material capabilities, but the latter indices go beyond CINC by incorporating nuclear weapons, technology, and international interactions

[1] For more on this pioneering work, see: https://correlatesofwar.org/data-sets/national-material-capabilities/.
[2] For more on Diplometrics, see: https://korbel.du.edu/pardee/content/diplometrics.

(diplomatic networks and alliance networks). The GPI, DiME, HHMI, and HHI are also integrated into the International Futures (IFs) modeling platform,[3] allowing users to forecast and build scenarios that reflect the changing distribution of power among the 188 countries in the model to 2100.

Acknowledgements

Over the years, Diplometrics has been funded by the U.S. government, including the U.S. Army Future Studies Group, the U.S. Army Research Office, the U.S. Department of Defense Minerva Research Initiative, and other partners. Along the way, hundreds of students have contributed to Diplometrics in meaningful ways. As work on Diplometrics moves forward, their continued support will ensure our institute continues to develop original analyses and advance conversations in the international relations space among policy-makers, academics, and the public.

In addition to these individuals and organizations, the authors would like to thank John McPhee for playing a key leadership role in maintaining and overseeing initial updates of the relative national power indices, along with Drew Bowlsby and Adam Enes for assisting in updates and data management for the project, and Whitney Doran for management of the project in its early stages. This project would not have been possible without their perseverance and hard work. We would also like to thank Professor Barry Hughes for his invaluable insight and support from conceptualization of this subject to data collection and analysis – not to mention his creation of the International Futures tool and founding of the Pardee Institute. Lastly, we extend our gratitude to the U.S. government for providing support for this project.

Citation

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Datasets and Variables

The relative national power indices discussed here provide country-year indices. The GPI begins in 1816, relying heavily on Correlates of War National Material Capabilities (NMC) data through 1959.[4] The HHI, HHMI, and DiME Index begin in 1960. Presently, each is forecast in the International Futures tool for 188 countries through the year 2100. Historical data prior to 2015 include additional countries that are useful for long-term historical analysis (e.g., several of the states that would later form Italy).

[3] For more on International Futures, which is freely available for download or use online, see: https://korbel.du.edu/pardee/international-futures-platform.

[4] For the latest NMC data, presently version 6, see: https://correlatesofwar.org/data-sets/national-material-capabilities/.

Table 1 lists each variable used to calculate the HHI, HHMI, DiME and GPI – as well as the CINC for sake of comparison – grouped by the following dimensions of power: military, demography, economy, technology, and international interactions. It includes a description of the variable and the weight of the variable in each composite index. The GPI is unique in that it is divided into six time periods, each of which has a different weighting scheme. The annual country-level value of each variable is divided by the world total to yield a relative figure for that country-year pairing.

Table 1. Overview of the subcomponents and respective weights of relative national power indices

Variable	Description	CINC	HHI	HHMI	DiME	GPI					
						1816–1944	*1945–1959*	*1960–1972*	*1973–1989*	*1990–2004*	*2005–*
Military											
Military personnel	Global share of military personnel	16.66%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Military spending	Global share of military spending	16.66%	29%	22.8%	20%	40%	35%	35%	30%	20%	20%
Nuclear weapons	Global share of the logged count of warheads	0%	0%	6.3%	20%	0%	10%	10%	10%	5%	5%
Demography											
Human capital	Global share of 15-64 pop. above poverty line × HDI	0%	0%	0%	0%	0%	0%	5%	5%	5%	5%
Total population	Global share of total population	16.66%	26%	20.3%	0%	10%	10%	0%	0%	0%	0%
Urban population	Global share of urban population	16.66%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Economy											
Energy consumption	Global share of energy consumption	16.66%	0%	0%	0%	25%	25%	0%	0%	0%	0%
Energy production	Global share of energy production (all types)	0%	0%	0%	0%	0%	0%	0%	5%	5%	5%
FDI net inflows	Global share of net FDI inflows	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%
GDP at MER	Global share of GDP at market exchange rates	0%	0%	0%	0%	0%	0%	20%	20%	30%	20%
GDP at PPP	Global share of GDP at purchasing power parity	0%	35%	27.8%	0%	0%	0%	0%	0%	0%	0%
Iron & steel production	Global share of iron and steel production	16.66%	0%	0%	0%	25%	20%	0%	0%	0%	0%
Trade	Global share of goods and services trade	0%	0%	0%	20%	0%	0%	5%	5%	5%	5%
Technology											
GDP x GDP per capita	GDP at MER times GDP at PPP per capita[5]	0%	10%	7.6%	20%	0%	0%	0%	0%	0%	0%
Gov't R&D spending	Global share of government R&D spending	0%	0%	0%	0%	0%	0%	10%	10%	10%	5%
ICT capital stock	Global share of ICT capital stock	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%
International Interactions											
Diplomatic Power Index	Global share of diplomatic power (defined below)	0%	0%	0%	0%	0%	0%	15%	15%	20%	20%
Embassies	Global share of weighted diplomatic exchange	0%	0%	7.6%	20%	0%	0%	0%*	0%*	0%*	0%*
Foreign aid	Global share of foreign ODA-like aid	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%
IGOs	Global share of weighted IGO membership	0%	0%	5.1%	0%	0%	0%	0%*	0%*	0%*	0%*
Treaties	Global share of weighted multilateral treaty signing	0%	0%	2.5%	0%	0%	0%	0%*	0%*	0%*	0%*

**Included as a sub-component of the Diplomatic Power Index.*

Note: For each variable, global share is calculated as $\frac{Variable_{it}}{\sum_{i=1}^{188} Variable_t}$ *where i = country identifier and t = year identifier.*

[5] For DiME, GDP is at MER for the per capita measure as well. This is similar to Beckley's (2018) measure of net resources. However, Beckley (2018) uses GDP at PPP time GDP at PPP per capita. For an earlier introduction of Beckley's measure, see Hughes and Hillebrand (2006: 184).

Extended Definitions and Sources

An extended description of each variable presented in Table 1 is provided below. If using variables from the COW NMC dataset, please also review the NMC documentation (Greig and Enterline 2021).

Military variables

Military personnel

Military personnel as a share of global military personnel, calculated as an estimate of the total number of individuals serving in a country's military divided by the total number of individuals serving in any military in a given year.

Data are from the COW NMC version 6 dataset.

Military spending

Military spending as a share of global military spending, calculated as a country's military spending divided by the global sum of military spending in a given year. Unless otherwise noted, these and other monetary values have been converted to constant 2017 U.S. dollars.

Data from 1816 through 1959 are from the COW NMC version 6 dataset. Data for 1960 through 2019 are from the United States Arms Control and Disarmament Agency's (ACDA) World Military Expenditures and Arms Transfers (WMEAT) series and the Stockholm International Peace Research Institute's (SIPRI) Military Expenditure Database. Data for 2020 onward are from SIPRI. For countries where military spending data are not available – Bahamas, Bahrain, Bhutan, Comoros, Cuba, Grenada, Hong Kong, North Korea, Maldives, Micronesia, Palestine, Samoa, Sao Tome and Principe, Solomon Islands, Somalia, St. Lucia, St. Vincent, Suriname, Syrian Arab Republic, Tonga, Vanuatu – military spending estimates are derived from the IFs integrated assessment model's reconciliation algorithm.

Nuclear weapons

Natural log of nuclear warheads as a share of the natural log of global nuclear warheads, calculated as the natural log of the number of non-retired nuclear warheads possessed by a country divided by the natural log of the total number of non-retired nuclear warheads possessed by all governments. Natural log of zero changed to equal 0.

Data through 2025 from the Federation of American Scientists' Nuclear Notebook series (Kristensen et al., 2024). Forecasts are based on heuristic assessments from Diplometrics researchers, informed where possible by U.S. Department of Defense projections (e.g., DOD 2023: 111). For all other variables, forecasts are produced by chaining projected growth for each variable in the most recent version of IFs to the most recent historical data.

Demography variables

Human capital

Effective human capital as a share of global effective human capital, calculated as the number of working-age people not living in poverty who are residing within a country, multiplied by the square of a country's Human Development Index (HDI) score in a given year. The 2010 formulation of the HDI is calculated as the geometric average of a life expectancy index, education index, and income index for a country in a given year. The poverty line is defined here as $3.65/day in 2017 U.S. dollars, backfilled by $2.00/day in 2005 U.S. dollars from 2005 through 2014 and $3.10/day in 2011 U.S. dollars from 2015 through 2019 where $3.65 threshold data are missing.

Data for working-age population (ages 15-64) from the United Nations Population Division (UNPD) World Population Prospects (WPP). Data for poverty from the World Banks' World Development Indicators (WDI). Data for the HDI from the United Nations Development Programme's (UNDP) Human Development Report.

Total population

Population as a share of global population, calculated as a country's population divided by the global population in a given year.

Data from 1816 through 1959 are from the COW NMC version 6 dataset. Data from 1960 onward are from the UNPD WPP.

Urban population

Urban population as a share of global urban population, calculated as an estimate of the total number of individuals living in a country's cities divided by the total number of individuals living in all cities worldwide in a given year.

Data are from the COW NMC version 6 dataset.

Economy variables

Energy consumption

Energy consumption as a share of global energy consumption, calculated as an estimate of a country's total energy consumption from all energy types divided the estimate of global energy consumption in a given year.

Measured in metric ton of coal equivalents, data are from the COW NMC version 6 dataset.

Energy production

Energy production as a share of global energy production, calculated as a country's total energy production of all energy types divided by the global sum of total energy production in a given year.

Energy is measured in billion of barrels of oil equivalents (BBOE). Data and conversion factors are from the International Energy Agency.

FDI net inflows

Foreign direct investment (FDI) net inflows as a share of global FDI inflows, calculated as the net of a country's FDI inflows divided by the global sum of net FDI inflows in a given year. Net inflows are equal to inflows minus outflows. Negative inflows are changed to zero to avoid negative global shares.

Data from the World Bank's WDI. For countries where data are not available, estimates are derived from the IFs integrated assessment model's reconciliation algorithm.

GDP at MER

Gross domestic product (GDP) at market exchange rates (MER) as a share of global GDP at MER, calculated as a country's GDP at MER divided by world domestic product at MER. MER determined by the annual average official exchange rate to U.S. dollars.

Data are from the World Bank's WDI and the International Monetary Fund's (IMF) World Economic Outlook. For countries where data are not available, estimates are derived from the IFs integrated assessment model's reconciliation algorithm.

GDP at PPP

GDP at purchasing power parity (PPP) as a share of global GDP at PPP, calculated as a country's GDP at PPP divided by world domestic product at PPP. PPP determined by a conversion to international dollars by the World Bank's International Comparison Program.

Data are from the World Bank's WDI and the Maddison Project Database (Bolt and Van Zanden 2024).

Iron & steel production

Iron and steel production as a share of global iron and steel production, calculated as a country's a country's total pig iron (1816-1899) or steel (1900-1959) production divided by global iron and steel production in a given year.

Data from the COW NMC version 6 dataset.

Trade

Total trade as a share of global trade, calculated as the sum of a country's total imports and exports of goods and services divided by the global sum of imports and exports in a given year.

Data are from the World Bank's WDI and the IMF Direction of Trade Statistics. For countries where data are not available, estimates are derived from the IFs integrated assessment model's reconciliation algorithm.

Technology variables

GDP × GDP per capita

A country's share of GDP times GDP per capita divided by the global total of all countries' GDP times GDP per capita in a given year. For the HHI and HHMI, GDP is in MER terms and GDP per capita is in PPP terms – the former to measure global market power and the latter to measure development. For the DiME Index, both GDP and GDP per capita are in MER terms. For Beckley's (2018) measure of net resources, both GDP and GDP per capita are in PPP terms.

Data are from the World Bank's WDI, the IMF's World Economic Outlook, and the Maddison Project Database (Bolt and Van Zanden 2024). For countries where data are not available, estimates are derived from the IFs integrated assessment model's reconciliation algorithm.

Government R&D spending

Government spending on research and development (R&D) as a share of global government R&D spending, calculated as a country's government spending on R&D spending divided by the global sum of government R&D spending in a given year.

Data are from the World Bank's WDI and the Organisation for Economic Co-operation and Development's (OECD) Main Science and Technology Indicators, formerly known as Basic Science and Tech Stats. For countries where data are not available, estimates are derived from the IFs integrated assessment model's reconciliation algorithm.

ICT capital stock

Capital stock of information and communication technology (ICT) as a share of global ICT stock, calculated as a country's total capital stock of ICT divided by the global sum of capital stock of ICT in a given year.

Data are from the World Bank's WDI, IFs reconciliation of inputs from the Global Trade Analysis Project from 2010 for most countries, and the EUKLEMS & INTANProd database (Bontadini et al. 2023) from 2005 through 2021 for European Union member countries.

International interactions variables

Diplomatic Power Index

Diplomatic power index (DPI) score as a share of the global diplomatic power, where the DPI is a composite measure of: 1) weighted diplomatic representation in the form of embassies as a share of the total possible score in a given year; 2) weighted international governmental organization membership as a share of the total possible score in a given year; and 3) weighted number of treaties signed by a country as a share of the total possible score in a given year—the combined sum of which is weighted by a country's government revenue in a given year. Specifically, the formula for the DPI is:

$$DPI_{it} = \left(\left(99.83 * \left(\frac{Weighted\ Embassies_{it}}{Max\ Weighted\ Embassies_t}\right)^2\right) + \left(35.49 * \left(\frac{Weighted\ IGOs_{it}}{Max\ Weighted\ IGOs_t}\right)^2\right) + \left(7.34 * \left(\frac{Weighted\ Treaties_{it}}{Max\ Weighted\ Treaties_t}\right)^{1.5}\right)\right) * Government\ Revenue_{it}$$

DPI data are from the Frederick S. Pardee Institute for International Futures at the University of Denver's Diplometrics program. Sources and weights for embassies, IGOs, and treaties are described further in their respective sections below. Source data for government revenue are from the IMF's Government Finance Statistics. For countries where data are not available, estimates are derived from the IFs integrated assessment model's reconciliation algorithm.

Embassies

Diplomatic representation as a share of global diplomatic representation, calculated as the weighted sum of a country's embassies abroad divided by the weighted sum of all embassies in a given year. Weights for each embassy are determined as follows: ambassador or nuncio with a single focus = 1; charges d'affaires or minister with singular focus = 0.75; ambassador or nuncio with multiple focus = 0.5; charge d'affaires or minister with multiple focus = 0.375; interest desk = 0.125; interests served by others = 0.1; expelled, recalled, or withdrawn = 0 (Moyer et al. 2021). Maximum weighted embassies is equal to having an embassy with an appointed ambassador with a singular focus in all other countries in a given year.

Data are from the Frederick S. Pardee Institute for International Futures at the University of Denver's Diplometrics program, as coded from the Europa World Yearbook series.

Foreign aid

Foreign aid donations as a share of global foreign aid donations, calculated as a country's net positive foreign aid donations divided by the global sum of net positive foreign aid donations in a given year. Aid in this context includes Official Development Assistance (ODA) and ODA-like flows, which are sufficiently concessional grants and loans.

Data are from the World Bank's WDI, the OECD's Query Wizard for International Development Statistics, AidData at William & Mary, India's Ministry of External Affairs, Russia's Ministry of Finance, and the China in Africa Research Initiative at Johns Hopkins School of Advanced International Studies—sourced from China's Ministry of Finance.

IGOs

Weighted international governmental organizations (IGO) membership as a share of global weighted IGO membership, calculated as the count of a country's membership in IGOs in a given year, weighted by IGO importance, divided by the global total for all countries in that year. IGO inclusion criteria are based on Volgy et al. (2008). IGO importance is determined by: 1) summing the number of mentions each year within the Foreign Broadcast Information Service (1941–1995), World News Connection (1996–2019), and ProQuest (2020–) databases, 2) dividing that sum by the ratio of

common word hits in that year to the number of common word hits in 2010 to scale across time; and 3) normalizing that value a taking a 3-year moving average. Maximum weighted IGOs is equal to full membership in all IGOs in a given year.

Data are from the Frederick S. Pardee Institute for International Futures at the University of Denver's Diplometrics program, as coded from the Yearbook of International Organizations series, Union of International Associations website, and World Statesmen.org.

Treaties

Weighted treaty signing and ratification as a share of global treaty signing and ratification, calculated as the count of multilateral treaties to which a given country was party to (signed or ratified – the former receiving only a half-point) as of a given year, weighted by treaty importance, divided by the global sum for all countries in a given year. Treaty importance is determined by: 1) summing the number of mentions in a given year in articles stored within the HeinOnline (1945–2019) and ProQuest (2020–) databases; 2) deflating those mentions by the total number of articles published in HeinOnline in the year 2006 (year with the most publications as of 2016); 3) and taking the 3-year moving average. A minimum weight of 0.01 is applied to a treaty if there were no mentions of it in a given year.

Data are from the Frederick S. Pardee Institute for International Futures at the University of Denver's Diplometrics program, as coded from the United Nations Treaty Collection's record of Multilateral Treaties Deposited with the Secretary-General.

Gap filling

As noted in several sections above, where gaps in data exist, estimates from IFs are used, when available. IFs estimates are produced through an extensive reconciliation algorithm, at the heart of which is a social accounting matrix (SAM) that balances inputs and outputs at the household, firm, and government level within and across 188 countries (Hughes 2019). For more on the SAM specifically, see: https://pardeewiki.du.edu/index.php?title=Social_Accounting_Matrix_(SAM).

Data Vetting

At every stage of data collection and/or updates to the Relative Power Indices, data are examined to ensure: 1) new data is from the same series and source as the original; 2) there are no major inconsistencies between the original data and new data (both pre- and post-transformation); 3) country aggregation was successful for all series; 4) there are no outliers or inconsistencies due to errors in the raw data or data input process; 5) any other data-integrity issues.

Once all input series have been updated, each year is vetted to ensure the index consistently sums to 100 and that the index history and forecast are reasonable and consistent with our theoretical framework. Moreover, vetting requires examining the values for several example states to ensure logical consistency within historical data and forecast trends. This includes data visualization.

To report potential errors in the GPI, DiME, HHI, or HHMI, please email Pardee.Institute@du.edu, or use our error reporting form here: https://github.com/PardeeCenterDU/Diplometrics-data-issue-tracker?tab=readme-ov-file#diplometrics-data-issue-tracker.

Comparing Indices

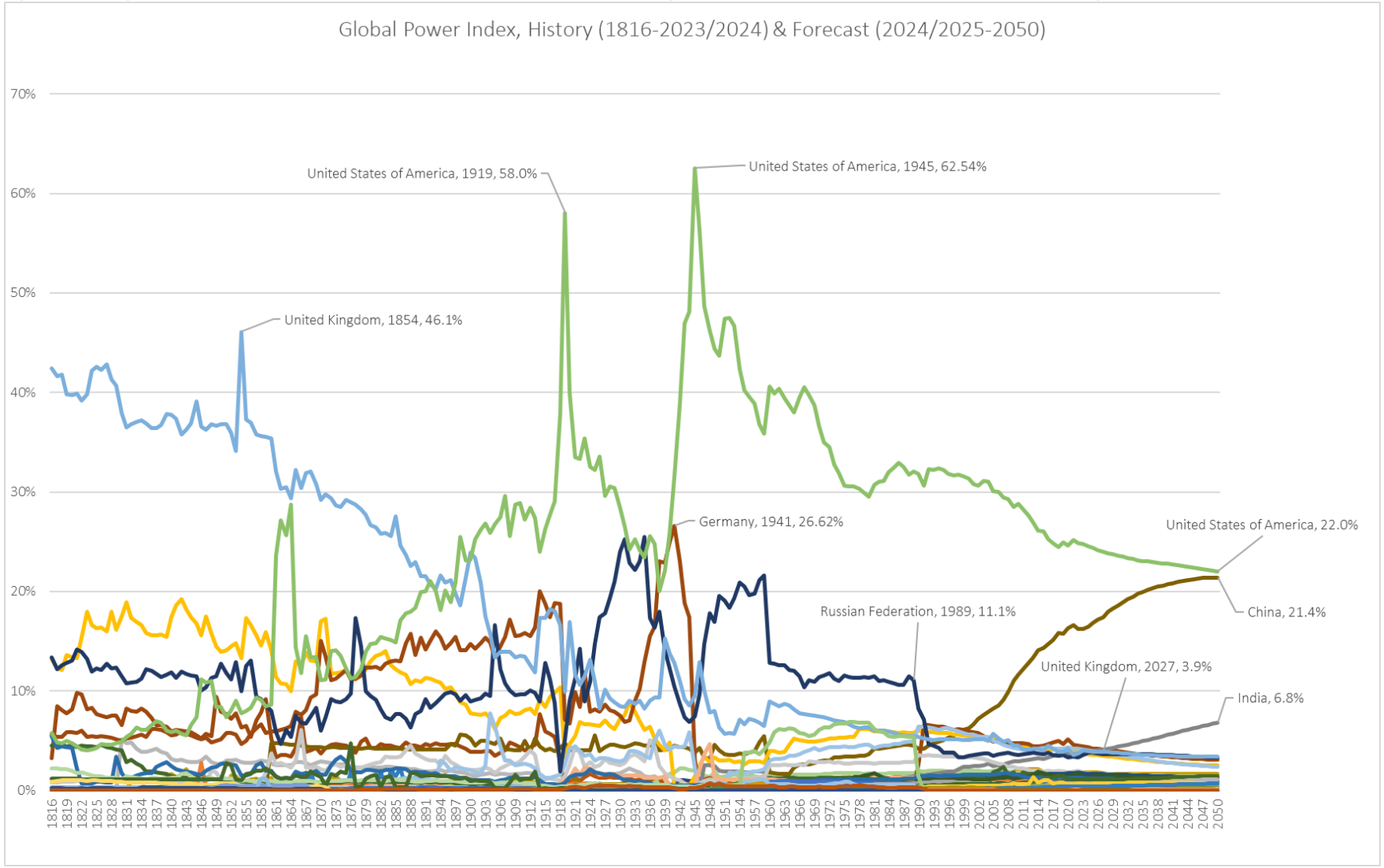
Each relative power index yields unique values for each country-year that reflects their differential incorporation of input variables and weighting schemes, and there are advantages and disadvantages to using each for analysis. Often, there is a tradeoff between specificity for any given year and applicability across a broad range of years. What matters for relative national power has shifted across time. The broader the time period of interest, the more general the indicators used to measure power must be. However, the more accurately one wishes to assess relative power in a given year and between a specific set of countries, the more specific the indicators used to measure power must be.

Importantly, the GPI includes a broader range of more specific variables than does the HHI. For example, it adjusts absolute population by the number of people who live in poverty and includes energy production and ICT capital stock. In contrast, the HHMI is adapted from the HHI and uses fewer and more generalized variables. Because the GPI uses more specific inputs, forecast scenarios that explore the impact of specific policy choices can be made using the index. On the other hand, the HHMI's more general set of variables means that it is less prone to changes in specific technologies associated with the national projection of power. The same is true of the DiME Index, which was built to split the difference between the specificity of the GPI and the general nature of Beckley's (2018) measure of net resources. For more comparisons with the DiME Index, see Moyer et al. (2023).

For a fuller comparison of relative national power indices, including an early version of the GPI, see Höhn (2011). Readers may note the strong similarities between the GPI and Chinese analysts' conception of Comprehensive National Power.

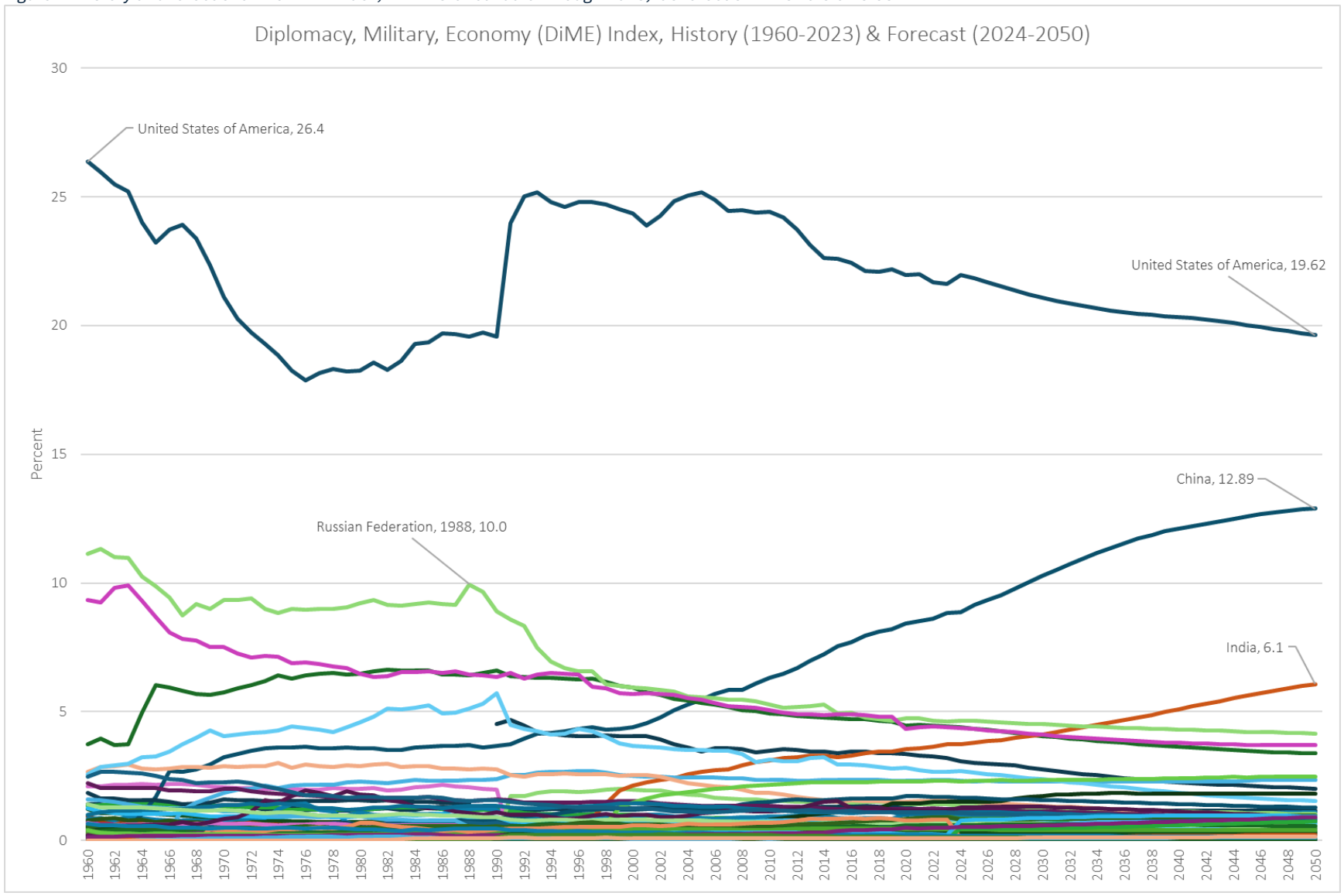
Below, we present a few graphs illustrating various measures of relative national power across time. Users may download the GPI data, adjust the weighting toggles to build their own relative national power indices, and conduct further comparisons as they see fit. Presently, the GPI data are available here: https://korbel.du.edu/pardee/content/national-power.

Figure 1. History and forecast of the Global Power Index, with historical data through 2023, and where available 2024, with forecasted growth from IFs version 8.49*



**Note: nuclear warhead estimates are through 2025. Most other global datasets lag the present by one to two years.*

Figure 2. History and forecast of the DiME Index, with historical data through 2023, as forecast in IFs version 8.53*



** For the DiME Index data presented above, the Soviet Union's data are spread across all former Soviet republics rather than with the GPI in Figure 1, where the Soviet Union's assets are all allocated to Russia.*

Figure 3. History and forecast of the HHI, with historical data through 2023, as forecast in IFs version 8.53

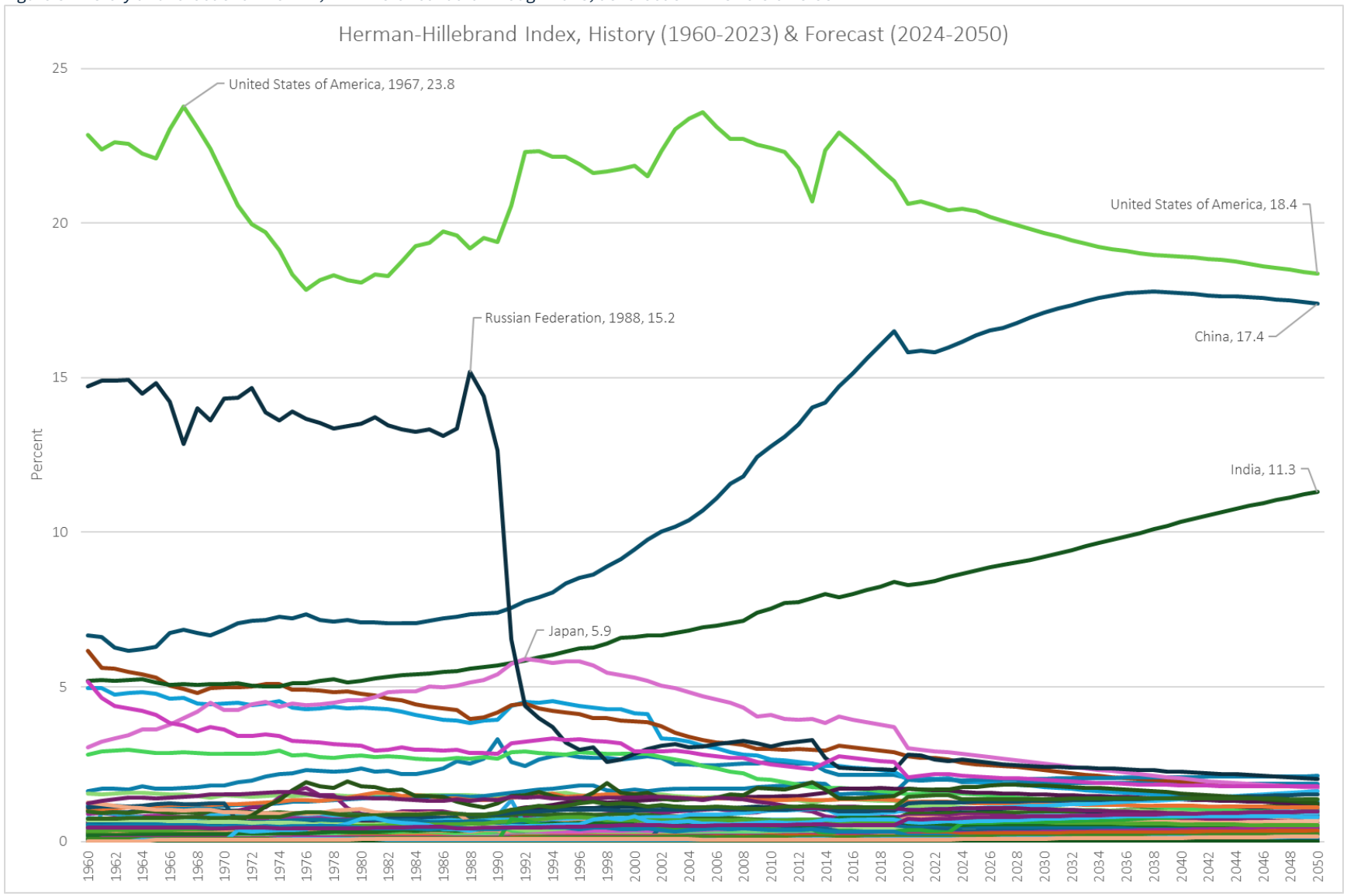


Figure 4. History and forecast of the HHMI, with historical data through 2023, as forecast in IFs version 8.53

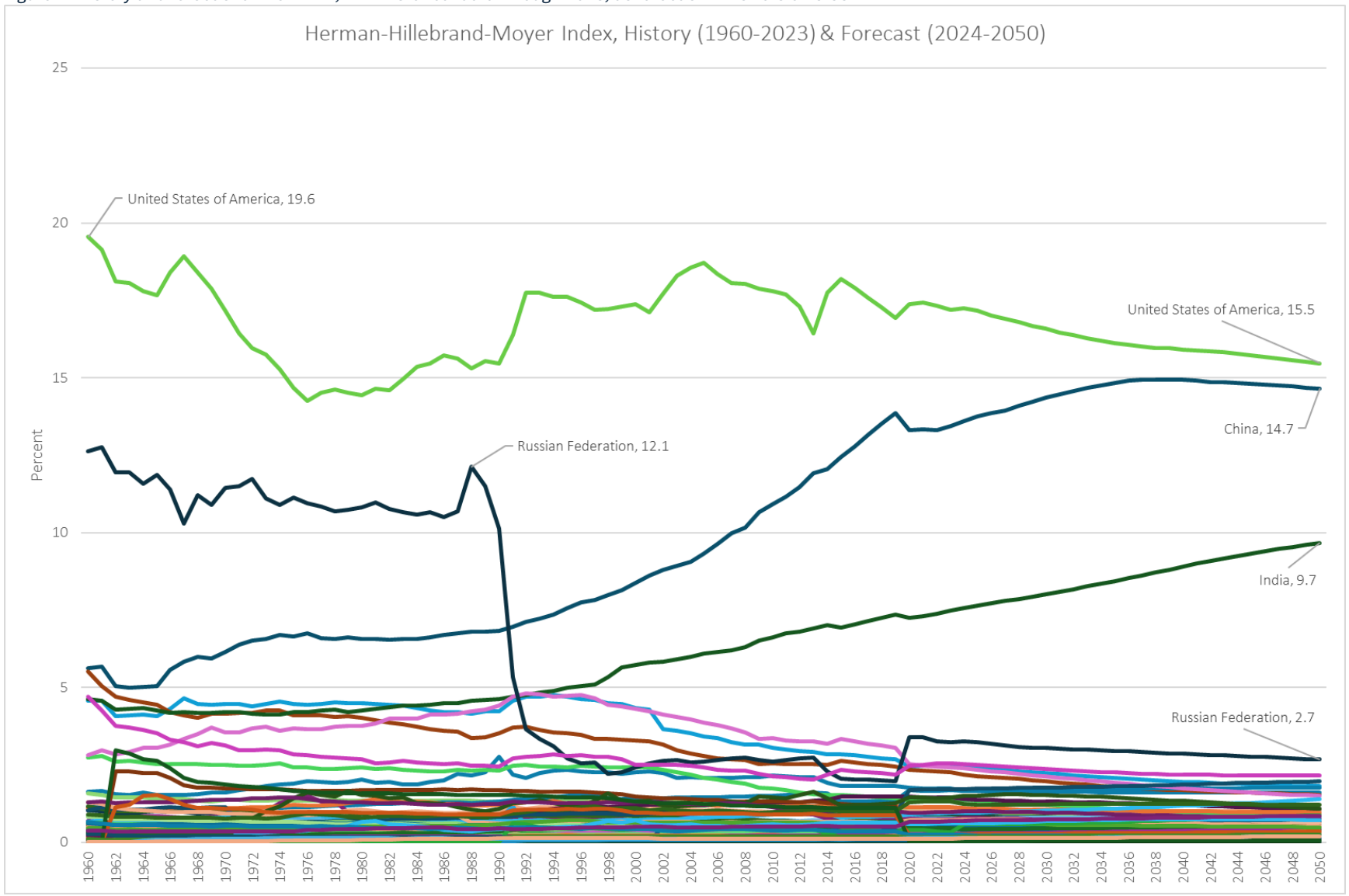
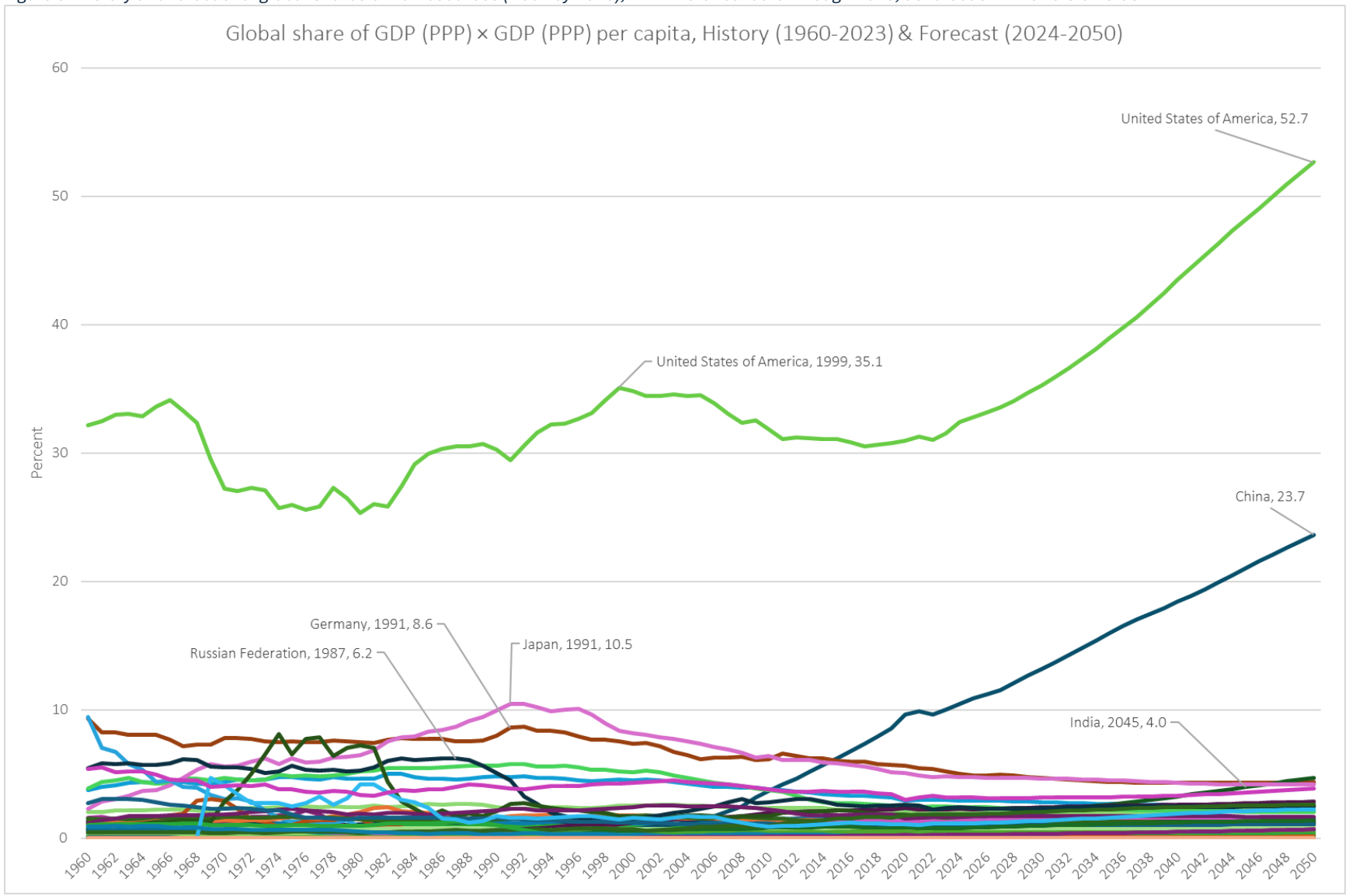
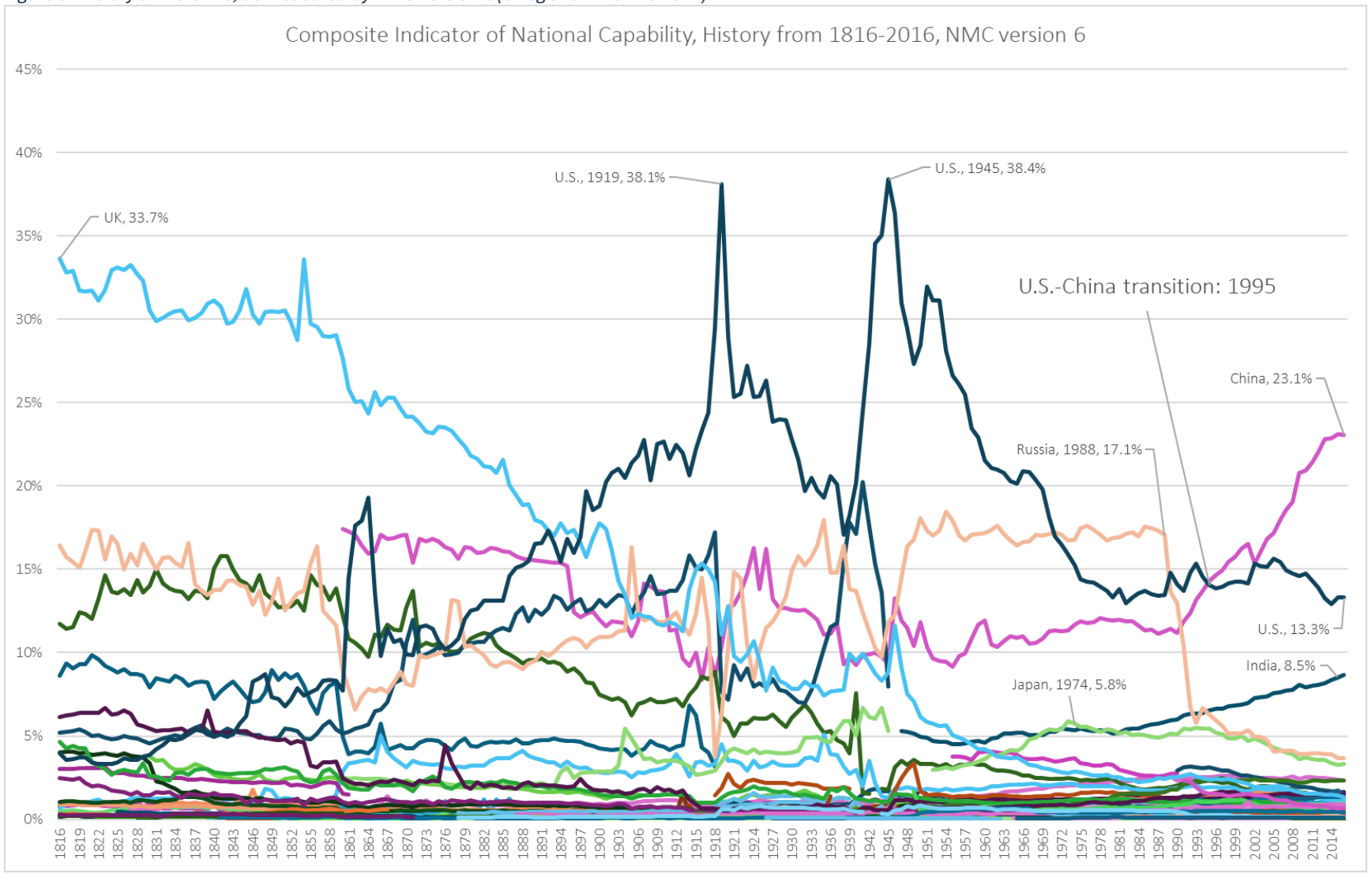


Figure 5. History and forecast of global shares of net resources (Beckley 2018), with historical data through 2023, as forecast in IFs version 8.53*



**Note: PPP data for Figure 5 are from the World Bank's WDI. PPP calculations from the Maddison Project Database are very different for some countries, particularly the Soviet Union (depicted above as a continuous Russian Federation data series).*

Figure 6. History of the CINC, as measured by NMC version 6 (Grieg and Enterline 2021).



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