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Construction of National Security Risk Assessment System and Model in the New Era from the Perspective of System

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Abstract: Constructing a national security risk assessment index system for the new era is crucial for improving the national security framework, understanding risk dynamics, and enhancing response capabilities. This study adopts a systems theory perspective, guided by the holistic approach to national security, and develops a comprehensive and scientific index system spanning 11 dimensions: politics, military, economy, culture, society, science and technology, cyber, ecology, resources, biology, and overseas interests. By applying a game theory combination weighting (GTCW) model that integrates the analytic hierarchy process (AHP), order relationship analysis (ORA), entropy weighting (EW), and criteria importance through intercriteria correlation (CRITIC) methods, the study determines optimal weights for each indicator in the system. Additionally, combining results from technique for order preference by similarity to ideal solution (TOPSIS), principal component analysis (PCA), rank-sum ratio (RSR), grey relational analysis (GRA), and simulated annealing optimized projection pursuit (SAO-PP), a fuzzy Borda model was used to construct a combination assessment model for national security risks. The results indicate that from 2014 to 2023, China's overall national security risk has shown a declining trend in line with rising levels of security in state governance, public welfare, socio-economic sustainability, and technological advancement. This system model provides theoretical guidance and methodological support for national security risk analysis and management, aiding in maintaining national stability and implementing strategic objectives under new circumstances.

Key words: holistic approach to national security; national security; new era; systems theory; risk assessment model

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0 Introduction

The national security situation is thus becoming more complex, and prevention and control have become significantly more difficult[1]. Since the holistic approach to national security was proposed in 2014[2], its scope has continuously expanded to cover 20 core areas, including politics, military, territory, economy, finance, culture, society, science and technology, cyber, food, ecology, resources, nuclear, overseas interests, biology, space, deep sea, polar regions, artificial intelligence and data security. With socio-economic development and

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technological progress, national security risks continue to evolve. Accordingly, the holistic approach is dynamically adjusted to address the increasingly severe security challenges. National security risk assessment serves as a critical component of governance, playing a key role in improving security decision-making capabilities, preventing potential risks, and protecting core national interests[2]. Therefore, constructing a national security risk assessment index system that adapts to the demands of the new era, guided by the holistic approach and grounded in scientific analysis, is of both theoretical and practical importance for strengthening the national security governance system.

Current research on national security risk is predominantly qualitative, with relatively few quantitative studies. Among the existing quantitative approaches, there are many problems such as limited research perspectives, relatively simple index systems, or strong subjective factors. In addition, most studies focus on security risk assessment in a single field, and few studies have constructed a comprehensive risk assessment system covering multiple fields based on the holistic approach to national security. Although some scholars have developed relatively complete systems, for example, Huang *et al*[3] proposed a framework with 165 indicators, Cai[4] and Xu *et al*[5] proposed economic security and science and technology security assessment systems covering 86 and 55 indicators respectively, these frameworks still exhibit limitations. However, it is important to note that most studies still only focus on a single security field and rely on a relatively simplified index system for risk assessment[6-9]. Furthermore, in terms of the method of determining the indicator weights, existing studies mainly rely on subjective weighting methods such as the Delphi method and the analytic hierarchy process (AHP), or use objective weighting techniques such as the entropy weighting (EW) method, factor analysis, and criteria importance through intercriteria correlation (CRITIC) method. However, when integrating the weights, a simple integration method of addition or multiplication is usually used, so that the final weights still have a large subjective component[10-12]. Regarding the selection of risk assessment models, most existing studies use a single method, such as AHP, fuzzy comprehensive assessment, EW, technique for order preference by similarity to ideal solution (TOPSIS), principal component analysis (PCA), grey relational analysis (GRA), and BP neural network model[13-15]. However, different models may produce different risk assessment results. The fuzzy Borda method can analyze these results from two dimensions: score difference and ranking, thereby enhancing the robustness and scientific validity of the conclusions. Although the fuzzy Borda method has been increasingly applied across various fields in recent years, its utilization in national security risk assessment remains relatively limited[5].

To address these limitations, this study adopts a systems theory perspective under the framework of the holistic approach to national security in the new era. We comprehensively consider the availability of data and the feasibility of index construction, focusing on 11 key areas including politics, military, economy, culture, society, science and technology, cyber, ecology, resources, biology and overseas interests, and develops a scientific and systematic index system for national security risk assessment. In terms of weight determination, the game theory combination weighting (GTCW) model is adopted to integrate and optimize the AHP, order relationship analysis (ORA), EW and CRITIC methods to obtain the optimal weight of each indicator. In terms of assessment methods, TOPSIS, PCA, rank-sum ratio (RSR), grey relational analysis (GRA), and simulated annealing optimized projection pursuit (SAO-PP) assessment model are integrated, and the score difference and ranking are weighed. Finally, the fuzzy Borda model is used for combination assessment to improve the scientificity and rationality of national security risk assessment.

1 Materials and Methods

1.1 Construction of National Security Risk Assessment Index System

Among the 20 areas covered by the holistic approach to national security, indicators in seven areas (land, nuclear, space, deep sea, polar regions, artificial intelligence, and data security) are difficult to quantify due to serious data gaps. In addition, financial security is already subsumed under economic security, while food security can be incorporated into resource security. Therefore, this study focuses on 11 areas, including politics, military, economy, culture, society, science and technology, cyber, ecology, resources, biology and overseas interests, and constructs the national security risk

assessment index system based on the perspective of systems theory[3-15]. During the research process, the basic principles of comprehensive coverage, scientific rationality, system integrity, standardization and practical operation were strictly followed, and risk indicators in various fields were screened and evaluated, thus constructing a national security risk assessment index system containing 404 indicators.

1.1.1 Political security risk

Political security refers to a state in which a country's sovereignty, political system, political rights, political order and ideology are not threatened, violated or destroyed. It is related to the overall security of a country. Specifically, political security mainly includes political system security, political order security and political activity security, as shown in Table 1.

Table 1 Assessment index system for Political security and Military security risks

Level 1 indicator	Level 2 indicator	Level 3 indicator
Political security risk	Political system security risk	Public trust in government, political stability, government credit rating
	Political order security risk	Government efficiency, regulatory quality, rule of law, corruption control, time in power, group grievance index, information quality
	Political activity security risk	Civic participation, military intervention in politics, democratic accountability, friendly relations with neighboring countries, external conflict, geopolitical risk index, Global Terrorism Index, Global Peace Index, Positive Peace Index, Fragile States Index
Military security risk	Military equipment security risk	Global Firepower Index, armed forces personnel as a percentage of total labor force, nuclear weapons stockpile, number of main battle tanks, number of naval vessels, number of military aircraft, number of aircraft carriers, number of submarines
	Military facilities security risk	Global Militarization Index ranking, military expenditure per capita, military burden, military spending as a percentage of government spending, arms exports, arms imports

1.1.2 Military security risk

Military security refers to a state in which a country is not threatened by war and other external military invasions in the military field, and has the ability to maintain this security state. It constitutes a key guarantee for the security of important areas in the national security system and other areas. Specifically, military security mainly includes military equipment security and military facility security, as shown in Table 1.

1.1.3 Economic security risk

Economic security refers to a state in which a country's economic development, economic strength and economic interests are not threatened or infringed. As an important part of the national security system, economic security is the cornerstone of ensuring national security. Only by continuously enhancing a country's overall economic strength and competitiveness can it enhance resistance to challenges and threats, and thus continuously improve the level of economic security. Specifically, economic security mainly includes basic economic system security, fiscal and financial security, and external economic security, as shown in Table 2.

1.1.4 Cultural security risk

Cultural security refers to a state in which a country's culture is not threatened or infringed, and it has the ability to maintain this security state. It is also an important part of national security. Specifically, cultural security mainly includes cultural undertakings security, cultural industry security, public cultural security, cultural heritage security, and cultural communication security, as shown in Table 2.

1.1.5 Social security risk

Social security refers to a state that covers four basic aspects of a country's social stability. As an important part of national security, social security involves preventing threats to the lives and maintaining social public order. Specifically, social security mainly includes public security, traffic security, life security and production security, as shown in Table 3.

1.1.6 Science and technology security risk

Science and technology security refers to a country's sound science and technology system, the safety and controllability of key core technologies, and the ability to protect the country's core interests and security from

Table 2 Assessment index system for Economic security and Cultural security risks

Level 1 indicator	Level 2 indicator	Level 3 indicator
Economic security risk	Basic economic system security risk	Economic Policy Uncertainty Index, gini coefficient
	Fiscal and financial security risk	Financial institution index, non-performing loan ratio of commercial banks, return on assets, general government revenue as a percentage of GDP, domestic taxes as a percentage of domestic budget, interest rate spread, GDP per capita, GDP deflator, volatility of GDP growth rate, capital account openness, monetary independence index, exchange rate stability index, debt index, consumer price index, inflation rate, external debt repayment rate, M_1 growth rate, M_2 growth rate
	External economic security risk	Trade competitiveness, foreign exchange reserves per capita, foreign direct investment, investment openness, Global Competitiveness Index, terms of trade, foreign trade dependence, industrial dependence on foreign capital
Cultural security risk	Cultural undertakings security	Number of cultural and tourism institutions, number of employees in cultural and tourism institutions, number of cultural social organizations, per capita cultural and tourism expenditure, per capita cultural relics expenditure, per capita cultural entertainment consumption expenditure
	Cultural industry security	Cultural and related industries' added value as a percentage of GDP, number of cultural and related industries institutions, total number of patents granted in cultural and related industries, total import and export volume of cultural products, trade balance of cultural products, trade competitiveness index of cultural products
	Public cultural security	Number of public libraries, per capita public library collection, number of mass cultural institutions, number of museums, per capita museum collection, number of performing arts troupes
	Cultural heritage security	Number of cultural relics institutions, cultural relics collections in cultural relics institutions, national intangible cultural heritage representative projects, national intangible cultural heritage inheritors, number of intangible cultural heritage protection institutions
	Cultural communication security	Number of national book publishing institutions, number of copyright import projects, number of copyright export projects, copyright industry added value as a percentage of GDP, comprehensive population coverage of radio programs, comprehensive population coverage of TV programs

threats and maintain this security state. Since the 18th National Congress of the Communist Party of China, science and technology innovation and its security have always been at the core of national development. Specifically, science and technology security mainly includes science and technology achievements security, science and technology talents security, science and technology environment security and science and technology activities security, as shown in Table 3.

1.1.7 Cyber security risk

Cyber security refers to the fact that the software and hardware of a system and the data in the system are not destroyed, altered, or leaked due to accidental or malicious reasons, and the system operates continuously, reliably, and normally. The rapid development of science and technology has brought about increasingly prominent cyber security issues. Cyber-crimes such as infringement of personal privacy, infringement of intellectual property rights, cyber monitoring, cyber-attacks, and cyber-terrorism have become global public hazards. Cyber security mainly includes cyber infrastructure security, cyber vulnerability security, malicious program security, and website monitoring security, as shown in Table 4.

1.1.8 Ecological security risk

Ecological security refers to a state of a country's ecological system being relatively complete, healthy, sustainable, and free from internal and external hazards and threats, as well as the ability to maintain this state, including basic elements such as drinking water and

Table 3 Assessment index system for Social security and Science and technology security risks

Level 1 indicator	Level 2 indicator	Level 3 indicator
Social security risk	Public security risk	International homicide rate (per 100 000), crime index, internal conflict intensity, number of victims of intentional homicide (per 100 000), juvenile crime rate as a percentage of total criminal cases, number of cases accepted by public security organs per 10 000 persons, number of criminal cases filed by public security organs
	Traffic security risk	Number of traffic accidents, number of traffic accident injuries, direct property loss from traffic accidents, traffic accident deaths per 10 000 vehicles, traffic index
	Life security risk	Quality of Life Index, incidence rate of class A and B notifiable infectious diseases (1/100 000), mortality rate of class A and B notifiable infectious diseases (1/100 000), proportion of children with moderate or severe stunting, healthcare index, social security coverage rate, infant mortality rate, under-5 mortality rate, neonatal mortality rate, maternal mortality rate, number of health technicians per 1 000 population, number of health institution beds per 1 000 population, per capita health expenditure, number of refugees per 100 000 population, unemployment rate, new disaster-related internally displaced persons, number of sudden environmental incidents, number of geological disasters
	Production security risk	Annual deaths from various production safety accidents, deaths from production safety accidents per unit GDP, deaths from production safety accidents per 100 000 employees in industrial, mining and commercial enterprises, and deaths from coal production per million tons of coal output
Science and technology security risk	Science and technology achievements security risk	Share of SCI papers in world total, ESI citation rate, highly cited papers index, number of invention patents per 10 000 population, number of PCT patent applications, number of major science and technology achievements, number of national science and technology awards
	Science and technology talent security risk	Number of S&T human resources per 10 000 population, number of R&D researchers per million population, number of R&D researchers per 10 000 employees, full-time equivalent of R&D personnel, number of R&D personnel with master's degree or above, full-time equivalent of R&D personnel in high-tech industries
	Science and technology environment security risk	Global innovation index, contribution rate of science and technology progress, national financial allocation for S&T, gross domestic expenditure on R&D, R&D expenditure as a percentage of GDP, technology contract transaction value as a percentage of GDP, number of national venture capital institutions, number of international S&T cooperation projects going abroad, number of international S&T cooperation projects coming to China
	Science and technology activities security risk	Number of academic exchange activities organized by China Association for Science and Technology system, number of science popularization lectures held, number of participants in foreign S&T activities, number of foreign experts and scholars received, number of decision-making consultation reports provided by China Association for Science and Technology system, number of S&T journals hosted, number of science and technology museums

food safety, air quality, and green environment. Specifically, according to the pressure-state-response model, ecological security mainly includes ecological pressure security, ecological state security, and ecological response security, as shown in Table 4.

1.1.9 Resource security risk

Resource security refers to a state in which a country or region can obtain the required natural resources in a sustainable, stable, timely, sufficient and economical manner. At present, the efficiency of resource development and utilization in China has been improved, but waste is serious. Innovations in key science and technology fields such as resource conservation and protection are far from meeting actual needs. Specifically, resource security mainly includes water resource security, energy resource security, land resource security, mineral re-

Table 4 Assessment index system for Cyber security and Ecological security risks

Level 1 indicator	Level 2 indicator	Level 3 indicator
Cyber security risk	Cyber infrastructure security risk	Global Cybersecurity Index, percentage of population covered by at least 2G mobile network, percentage of population covered by at least 3G mobile network, percentage of population covered by at least 4G mobile network, fixed broadband internet subscribers per 100 inhabitants, internet users per 100 inhabitants
	Cyber vulnerability security risk	Number of security vulnerabilities recorded by CNVD, number of high-risk vulnerabilities recorded by CNVD, number of vulnerability patches recorded by CNVD, number of vulnerability risk incidents handled by CNVD in related industries, number of vulnerability incidents handled independently by CNVD
	Malicious program security risk	Number of Trojan and botnet control terminals, total number of controlled host IP addresses by Trojans and botnets, number of large-scale botnets shut down, monthly average number of host IP addresses infected with "Feike" worm, number of hacker-controlled infected hosts disconnected, number of malicious Apps removed, number of computer malicious programs captured, number of new mobile internet malicious programs obtained through independent capture and vendor exchange
	Website monitoring security risk	Number of cybersecurity incidents reported to CNCERT/CC domestically and internationally, number of cybersecurity incidents handled by CNCERT/CC, number of special cleanup operations against Trojans and botnets conducted by CNCERT/CC, number of domestic websites implanted with backdoors, number of domestic websites tampered with, number of DDoS attacks, total DDoS attack traffic, proportion of global botnet control terminals
Ecological security risk	Ecological pressure security risk	Population density, natural population growth rate, energy consumption per unit GDP, water consumption per unit GDP, CO_2 emissions, SO_2 emissions, total nitrogen oxide emissions, total particulate emissions, annual average of urban fine particulate matter (e.g., $PM_{2.5}$), hazardous waste generated per unit GDP, industrial wastewater discharge, Industrial waste gas discharge, soil erosion area, urban sewage discharge
	Ecological state security risk	Proportion of county areas with excellent and good ecological quality to total land area, proportion of arable land area, per capita grain possession, per capita water resources, water-soil coordination degree, proportion of ambient air quality meeting standards, forest coverage rate, proportion of local species classified as endangered, number of invasive alien species, number of known biological species, number of national nature reserves, Ocean Health Index, proportion of sea area with Class I water quality to total jurisdictional sea area, biocapacity
	Ecological response security risk	Urban sewage treatment rate, harmless treatment rate of domestic waste, per capita park green area, total afforestation area, amount of hazardous waste treated or disposed, investment in environmental pollution control as a percentage of GDP, treatment capacity of industrial wastewater treatment facilities, treatment capacity of industrial waste gas treatment facilities, Environmental Performance Index, amount of recycled sewage, soil erosion control area, clean energy usage rate, comprehensive utilization rate of industrial solid waste, environmental protection investment index

source security, biological resource security, marine resource security and environmental resource security, as shown in Table 5.

1.1.10 Biosecurity risk

Biosecurity refers to the measures and policies taken by a country to protect the security of biological resources and the sustainable use of biotechnology, prevent and control the occurrence of biological disasters and biosecurity risks, and ensure the relative security of the country's public health. According to the Biosecurity Law, biosecurity mainly includes major emerging infectious diseases and animal/plant epidemics, biotechnology development, genetic resources and biological resources security, as well as invasive alien species and

Table 5 Assessment index system for Resource security risk

Level 1 indicator	Level 2 indicator	Level 3 indicator
Resource security risk	Water resources security risk	Average precipitation, per capita water resources, water production modulus, amount of recycled sewage, water stress level, urban water coverage rate, water use efficiency, changes in permanent water bodies of lakes and rivers
	Energy resources security risk	Total primary energy production, energy production elasticity coefficient, energy consumption elasticity coefficient, clean energy usage rate, primary energy intensity level, urban gas coverage rate, electricity production elasticity coefficient, energy consumption per unit GDP, primary energy self-sufficiency rate, net energy imports (a percentage of energy use), energy balance, energy external dependence ratio, energy import dependence ratio
	Land resources security risk	Per capita arable land area, proportion of high-grade arable land area to total arable land area, food production index, livestock production index, soil and water conservation rate, per capita park green area, built-up area green coverage rate, water-soil coordination degree, proportion of state-owned construction land area
	Mineral resources security risk	Adjusted savings: Mineral depletion (a percentage of GNI), per capita domestic material consumption of metal ores, domestic material consumption of metal ores per unit GDP, per capita domestic material consumption of non-metallic minerals, domestic material consumption of non-metallic minerals per unit GDP, geological exploration investment in oil and gas minerals, geological exploration investment in non-oil and gas minerals
	Biological resources security risk	Biocapacity, balance fishing index, ecological footprint, proportion of local species classified as endangered, number of known biological species, per capita domestic material consumption of biomass, domestic material consumption of biomass per unit GDP, proportion of key biodiversity sites covered by protected areas, National Red Species List Index, domestic material consumption of wild catch per unit GDP
	Marine resources security risk	Sea area under jurisdiction not meeting Class I seawater quality standards, added value of major marine industries, offshore crude oil production, offshore natural gas production, number of marine nature reserves, percentage of marine protected areas to total sea area, number of marine disasters, total sewage discharge from direct sea pollution sources, average protected area coverage of key marine biodiversity areas, proportion of sea area with Class I water quality to total jurisdictional sea area
	Environmental resources security risk	Average proportion of days with good ambient air quality, $PM_{2.5}$ pollutant concentration, SO_2 pollutant concentration, industrial wastewater discharge, treatment capacity of industrial wastewater treatment facilities, industrial waste gas discharge, treatment capacity of industrial waste gas treatment facilities, domestic waste harmless treatment rate, per capita CO_2 emissions, forest coverage rate, total afforestation area, environmental protection investment index, urban sewage treatment rate

biodiversity, as shown in Table 6.

1.1.11 Overseas interests security risk

Overseas interests security is an important part of national interests, which refers to the state and ability of a country to maintain and protect its various interests in international affairs (including economy, security, culture, and environment) in overseas regions. The goal of overseas interests security is to ensure the country's position and influence on the international stage, protect the country's core interests from being damaged, and create a favorable external environment for the country's development and prosperity. Specifically, overseas interests security mainly includes overseas economic interests security, overseas political interests security, overseas security interests security, overseas cultural interests security and overseas environmental interests security, as shown in Table 7.

1.2 Determination of National Security Risk Assessment Indicators Weights

1.2.1 Analytic hierarchy process

The analytic hierarchy process (AHP) decomposes

Table 6 Assessment index system for Biosecurity risk

Level 1 indicator	Level 2 indicator	Level 3 indicator
Biosecurity risk	Major emerging infectious diseases and animal/plant epidemic security risk	Incidence rate of Class A and B notifiable infectious diseases (1/100 000), mortality rate of Class A and B notifiable infectious diseases (1/100 000), incidence rate of epidemic hemorrhagic fever (1/100 000), incidence rate of epidemic encephalitis B (1/100 000), incidence rate of malaria (1/100 000), incidence rate of dengue fever (1/100 000), number of foodborne disease outbreaks caused by animals, plants or toxic mushrooms, number of foodborne disease outbreaks caused by microbial factors
	Biotechnology development security risk	Biopharmaceutical market size, added value of biopharmaceutical industry, number of biopharmaceutical patent applications, number of high-tech enterprises in biopharmaceutical manufacturing, full-time equivalent of R&D personnel in biopharmaceutical manufacturing high-tech industry, R&D expenditure in biopharmaceutical manufacturing high-tech industry, number of patent applications in biopharmaceutical manufacturing high-tech industry, number of valid invention patents in biopharmaceutical manufacturing high-tech industry
	Genetic resources and biological resources security risk	Number of national nature reserves, number of cultivated crop varieties, number of native ornamental plant varieties, number of domestic animal breeds, number of standard material transfer agreements reported for plant genetic resources for food and agriculture, per capita domestic material consumption of biomass, domestic material consumption of biomass per unit GDP, average protected area coverage of key marine biodiversity areas, forest aboveground biomass, national red species list index
	Invasive alien species and biodiversity security risk	Ecological footprint, biodiversity barometer, proportion of key terrestrial biodiversity sites covered by protected areas, proportion of key freshwater biodiversity sites covered by protected areas, coverage of key mountain biodiversity sites in protected areas, proportion of local species classified as endangered, number of known biological species, proportion of threatened higher plants to total assessed species, proportion of threatened higher animals to total assessed species, proportion of threatened macro fungi to total assessed species, number of invasive alien species

the assessment problem into a multi-level analytical structure model and subjectively ranks the relative importance of each indicator[16]. It is a qualitative and quantitative, hierarchical, and systematic analysis method. The main steps include: (i) Establish a hierarchical structure model; (ii) Construct judgment matrix $\boldsymbol{A}$; (iii) Conduct single-level sorting and consistency checks; (iv) Perform overall hierarchical sorting and consistency checks.

1.2.2 Order relationship analysis method

The order relationship analysis (ORA) method is an improved subjective weighting method based on AHP[5]. It determines the ratio of importance between indicators, and determines the order relation of relative importance between indicators based on the magnitude of the ratios. The main steps include: (i) Determine the order relation: rank the relative importance of each assessment indicator according to the assessment criteria; (ii) Determine the relative importance between adjacent indicators; (iii) Use the sequence synthesis method to determine the structural weights of each indicator.

1.2.3 Entropy weighting method

The basic idea of the entropy weighting (EW) method is to determine objective weights based on the variability of indicators. By calculating the information entropy of each indicator and then determining the impact of each indicator's relative change on the overall system, the weight coefficients of indicators are finally obtained[17]. Key steps include: (i) Construct a decision matrix for each assessment indicator; (ii) Standardize indicators; (iii) Calculate the information entropy of indicators; (iv) Calculate the weight coefficients of indicators.

1.2.4 Criteria importance through intercriteria correlation method

The criteria importance through intercriteria correlation (CRITIC) method is also an objective weighting method. Its basic approach is to determine the objective weight coefficients of indicators based on two dimensions: the magnitude of the difference in values between

Table 7 Assessment index system for Overseas interests security risk

Level 1 indicator	Level 2 indicator	Level 3 indicator
Overseas interests security risk	Overseas economic interests security risk	Global Competitiveness Index, use of IMF credit, share of developing countries in membership and voting power in international organizations, RMB cross-border index of Bank of China, Capital account openness, Monetary independence index, Exchange rate stability index, external debt repayment rate, foreign trade dependence, trade surplus, trade competitiveness, foreign exchange reserves per capita, investment openness, terms of trade, industrial dependence on foreign capital, foreign direct investment, outward investment performance index, net inflows of foreign direct investment, total import and export volume of goods, total import and export volume of services, overseas M&A transaction value of Chinese enterprises, number of China's overseas economic and trade cooperation zones
	Overseas political interests security risk	External intervention, geopolitical risk index, Global Terrorism Index, Global Peace Index, Positive Peace Index, Fragile States Index, External Conflict, friendly relations with neighboring countries, number of dispute complaints participated in WTO consultation mechanism
	Overseas security interests security risk	Number of peacekeeping troops, number of piracy incidents, number of consular protection and assistance cases handled for Chinese nationals overseas, incidence rate of consular protection and assistance cases for Chinese nationals overseas, frequency of problematic Chinese overseas investments, amount of problematic Chinese overseas investments, number of overseas students, scale of inbound tourism, scale of outbound tourism, number of labor service personnel dispatched through foreign labor cooperation, number of overseas Chinese citizen safety incidents handled by Ministry of Foreign Affairs and embassies/consulates abroad, number of inbound/outbound personnel inspected by border inspection authorities
	Overseas cultural interests security risk	Number of overseas Chinese cultural centers, total import and export volume of cultural industries, trade balance of cultural industries, trade competitiveness index of cultural industries, number of copyright import projects, number of copyright export projects, total import volume of creative products, total export volume of creative products, number of global Confucius Institutes, number of global Confucius classrooms
	Overseas environmental interests security risk	Primary energy self-sufficiency rate, energy consumption per unit GDP, net energy imports as a percentage of energy use, energy balance, energy external dependence ratio, energy import dependence ratio, fuel exports as a percentage of merchandise exports, fuel imports as a percentage of merchandise imports, coal self-sufficiency rate, coal balance, coal external dependence ratio, coal import dependence ratio, oil self-sufficiency rate, oil balance, oil external dependence ratio, oil import dependence ratio, natural gas self-sufficiency rate, natural gas balance, natural gas external dependence ratio, natural gas import dependence ratio

assessment schemes for the same indicator and the conflict between assessment indicators[5]. Its main steps are: (i) Standardize indicators; (ii) Calculate the correlation coefficients between pairs of indicators; (iii) Calculate the amount of information contained in the indicators; (iv) Calculate the weight coefficients of each indicator.

1.2.5 Game theory combination weighting model

Game theory provides a framework for balancing the rational behavior and decision-making among interdependent actors, and is widely used in risk assessment. This study adopts the game theory combination weighting (GTCW) model to integrate the AHP, ORA, EW, and CRITIC methods to obtain the comprehensive weights[18]. By minimizing deviations between individual weight vectors and the combined weight vector, the GTCW approach mitigates the subjectivity or objectivity inherent in a single method, and enhances the scientific rigor and rationality of indicator weighting.

In this study, we optimize the linear combination coefficient α_i of the weight vector to minimize the devia-

tion between $\alpha_i \boldsymbol{w}_i^{\mathrm{T}}$ and $\boldsymbol{w}_i$, that is:

$$\min \left\| \sum_{i=1}^{4} (\alpha_i \boldsymbol{w}_i^{\mathrm{T}} - \boldsymbol{w}_i) \right\|_2, \tag{1}$$

where $\boldsymbol{w}_i$ is the weight vector obtained by the four methods of determining indicator weights.

The optimal first-order derivative is:

$$\begin{pmatrix} \boldsymbol{w}_1\boldsymbol{w}_1^{\mathrm{T}} & \boldsymbol{w}_1\boldsymbol{w}_2^{\mathrm{T}} & \boldsymbol{w}_1\boldsymbol{w}_3^{\mathrm{T}} & \boldsymbol{w}_1\boldsymbol{w}_4^{\mathrm{T}} \\ \boldsymbol{w}_2\boldsymbol{w}_1^{\mathrm{T}} & \boldsymbol{w}_2\boldsymbol{w}_2^{\mathrm{T}} & \boldsymbol{w}_2\boldsymbol{w}_3^{\mathrm{T}} & \boldsymbol{w}_2\boldsymbol{w}_4^{\mathrm{T}} \\ \boldsymbol{w}_3\boldsymbol{w}_1^{\mathrm{T}} & \boldsymbol{w}_3\boldsymbol{w}_2^{\mathrm{T}} & \boldsymbol{w}_3\boldsymbol{w}_3^{\mathrm{T}} & \boldsymbol{w}_3\boldsymbol{w}_4^{\mathrm{T}} \\ \boldsymbol{w}_4\boldsymbol{w}_1^{\mathrm{T}} & \boldsymbol{w}_4\boldsymbol{w}_2^{\mathrm{T}} & \boldsymbol{w}_4\boldsymbol{w}_3^{\mathrm{T}} & \boldsymbol{w}_4\boldsymbol{w}_4^{\mathrm{T}} \end{pmatrix} \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{pmatrix} = \begin{pmatrix} \boldsymbol{w}_1\boldsymbol{w}_1^{\mathrm{T}} \\ \boldsymbol{w}_2\boldsymbol{w}_2^{\mathrm{T}} \\ \boldsymbol{w}_3\boldsymbol{w}_3^{\mathrm{T}} \\ \boldsymbol{w}_4\boldsymbol{w}_4^{\mathrm{T}} \end{pmatrix}. \tag{2}$$

Then the optimal combination weight is obtained by:

$$\boldsymbol{w}^* = \sum_{i=1}^{4} \alpha_i^* \boldsymbol{w}_i^{\mathrm{T}}, \tag{3}$$

where $\boldsymbol{w}^*$ is the optimal combination weight. α_i^* is the optimal weight distribution ratio coefficient obtained after normalization.

1.3 Construction of National Security Risk Assessment Model

1.3.1 Technique for order preference by similarity to ideal solution assessment model

The technique for order preference by similarity to ideal solution (TOPSIS) assessment model ranks each assessment year by calculating the distance between each assessment year and the positive and negative ideal solutions of the assessment problem[19]. The main steps of this model are: (i) Preprocess indicators and construct a weighted normalized matrix; (ii) Determine the positive and negative ideal solutions of the model; (iii) Calculate the Euclidean distance between each assessment year and the positive and negative ideal solutions; (iv) Calculate the comprehensive assessment index.

1.3.2 Principal component analysis assessment model

The principal component analysis (PCA) assessment model[20] is a popular multivariate statistical technique. It has gradually developed into a multi-index assessment technology. Its main steps are as follows: (i) Standardize the original data; (ii) Calculate the correlation coefficient matrix; (iii) Determine the eigenvalues and eigenvectors; (iv) Select p principal components and calculate the information contribution rate and cumulative contribution rate of the eigenvalues; (v) Calculate the comprehensive assessment value.

1.3.3 Rank-sum ratio assessment model

The rank-sum ratio (RSR) assessment model is a method that obtains dimensionless statistics through rank transformation and makes a comprehensive assessment of the assessment years[5]. The main steps include: (i) Standardize the original data and construct the data matrix; (ii) Rank the data matrix column by column in ascending order to obtain the rank matrix; (iii) Calculate the value of the weighted rank-sum ratio (WRSR); (iv) Determine the WRSR distribution and derive the regression equation.

1.3.4 Grey relational analysis assessment model

The grey relational analysis (GRA) assessment model is a quantitative method based on grey theory to measure the correlation degree between indicators. Its essence is to compare and rank assessment years by using the magnitude of the correlation degree between each scheme and the optimal scheme[21]. The key steps include: (i) Standardize the original data and construct the assessment matrix; (ii) Determine the comparison sequence and reference sequence; (iii) Calculate the grey correlation coefficient; (iv) Calculate the grey correlation degree; (v) Rank the assessment years based on the magnitude of the grey correlation degree.

1.3.5 Simulated annealing optimized projection pursuit assessment model

The simulated annealing optimized projection pursuit (SAO-PP) assessment model combines the simulated annealing algorithm with the projection pursuit assessment method. It projects high-dimensional data onto low-dimensional space with a certain combination and obtains comprehensive assessment values based on the best projection values[5]. The main steps of this model include: (i) Standardize indicators. (ii) Construct the indicator function for the projection of assessment years. (iii) Optimize the projection indicator function. (iv) Calculate comprehensive assessment results.

$$\begin{aligned} &\max Q(a) = S(a) \cdot B(a) \\ &\text{s.t.} \begin{cases} \sum_{j=1}^{9} a_j^2 = 1, \\ a_j^2 \geqslant 0, \end{cases} \end{aligned} \tag{4}$$

$$\begin{cases} S(a) = \sqrt{\dfrac{1}{n-1} \sum_{i=1}^{n} (z_i - \bar{z})^2}, \\ B(a) = \sum_{i=1}^{n} \sum_{j=1}^{m} (R - r_{ij}) \cdot I(R - r_{ij}), \end{cases} \tag{5}$$

where $S(a)$ is the sample standard deviation of the projected eigenvalue z_i. $B(a)$ is the local density of the projected eigenvalue. R is the radius of the local density window. r_{ij} is the distance between projected eigenvalues. $I(R - r_{ij})$ is the unit step function.

1.3.6 Fuzzy Borda combination assessment model

Since the results of a single assessment model may

be biased, and different models may yield inconsistent outcomes, relying on a single method can lead to disputed conclusions. To address this issue, this study employs the fuzzy Borda model for combined assessment, making the final assessment results more scientific and accurate[33]. The main steps of this model are: (i) Conduct pre-consistency check using Kendall correlation analysis; (ii) Calculate the degree of membership superiority; (iii) Calculate the fuzzy frequency and fuzzy frequency rate of the i-th item at position h; (iv) Convert rankings into scores; (v) Calculate the fuzzy Borda number; (vi) Conduct post-consistency check using Spearman correlation analysis.

The membership degree of each assessment model's score λ_{ik} is calculated using the extreme difference transformation formula:

$$\lambda_{ik}=\frac{y_{ik}-\min\limits_{i}\{y_{ik}\}}{\max\limits_{i}\{y_{ik}\}-\min\limits_{i}\{y_{ik}\}}, \tag{6}$$

where y_{ik} is the score of the i-th assessment object under the k-th assessment model.

The fuzzy frequency ρ_{hi} and fuzzy rate W_{hi} of the i-th item at position h (h=1,2,⋯, n) are respectively:

$$\begin{cases}\rho_{hi}=\sum\limits_{k=1}^{K}\delta_{hi}\lambda_{ik},\\ W_{hi}=\dfrac{\rho_{hi}}{\sum\limits_{h=1}^{n}\rho_{hi}},\end{cases} \tag{7}$$

where K is the number of established assessment models, K = 5 in this study. δ_{hi} is a 0-1 matrix constructed based on the assessment model.

The Borda score Q_h corresponding to rank h is defined as:

$$Q_h=\frac{1}{2}(n-h)(n-h+1). \tag{8}$$

Finally, the fuzzy Borda number of the i-th assessment object B_i is calculated by:

$$B_i=\sum_{h=1}^{n}W_{hi}\cdot Q_h, \tag{9}$$

where a larger B_i indicates a higher national security risk level.

1.4 Data Source and Processing

Considering data availability and missing values in certain indicators, this study systematically evaluates the national security risk status of China from 2014 to 2023. The research data mainly comes from databases and research reports such as the World Bank, World Development Indicators, China Statistical Yearbook, China Science and Technology Statistical Yearbook, China Culture and Related Industries Statistical Yearbook, China Environment Statistical Yearbook, China Energy Statistical Yearbook, BP World Energy Statistical Yearbook, China Health Statistical Yearbook, China Internet Network Security Report, DDoS Attack Situation Report, Global Governance Index, China Overseas Investment Country Risk Rating Report, SIPRI Military Expenditure Database, World Economic Outlook, Global Competitiveness Index, Global Innovation Index, Global Patent Database, 2030 Agenda for Sustainable Development, and Wind Database. For years with missing data, cubic spline interpolation and linear extrapolation are applied for estimation. For economic variables that are greatly affected by external factors such as prices and seasons, the natural logarithm is applied to reduce the interference of abnormal fluctuations, thereby improving model stability and accuracy. In addition, the range standardization is used to eliminate the impact of dimensional differences among indicators and to ensure data comparability.

2 Results

2.1 Optimal Weight Results

This study first uses the AHP and ORA methods to calculate the subjective weight of each index, then employs the EW and the CRITIC methods to calculate the objective weight, and finally uses the GTCW model to integrate the subjective and objective weights to obtain the comprehensive weight. The optimal weight distribution ratio coefficients after normalization are obtained by formula (3) as $\alpha_1^*=0.249\,4$, $\alpha_2^*=0.249\,2$, $\alpha_3^*=0.248\,8$, $\alpha_4^*=0.252\,6$, and the optimal combination weights are shown in Table 8.

As shown in Table 8, science and technology security is the most important, with a weight of 11.91%. Military security and economic security rank second and third, with weights of 11.55% and 10.21% respectively. Political security and overseas interests security rank fourth and fifth respectively, with weights of 9.70% and 9.62%. Cyber security, ecological security and cultural security have weights of 8.85%, 8.84% and 8.06%. By contrast, social security, biosecurity and resource security are relatively less important, accounting for only 7.29%, 6.99% and 6.98%, respectively.

Table 8 Optimal combination weights for each dimension of national security risk assessment

Dimensions	Subjective weight		Objective weight		Optimal weight
	AHP	ORA	EW	CRITIC	GTCW
Political security risks	0.104 5	0.100 0	0.093 2	0.090 4	0.097 0
Military security risks	0.072 7	0.075 0	0.147 9	0.165 8	0.115 5
Economic security risks	0.104 5	0.100 0	0.064 0	0.139 3	0.102 1
Cultural security risks	0.072 7	0.075 0	0.053 3	0.121 0	0.080 6
Social security risks	0.072 7	0.075 0	0.074 1	0.069 7	0.072 9
Science and technology security risks	0.145 5	0.150 0	0.100 2	0.081 3	0.119 1
Cyber security risks	0.072 7	0.075 0	0.127 8	0.078 5	0.088 5
Ecological security risks	0.104 5	0.100 0	0.083 5	0.065 9	0.088 4
Resource security risks	0.072 7	0.075 0	0.081 6	0.050 3	0.069 8
Biosecurity risks	0.072 7	0.075 0	0.079 3	0.052 9	0.069 9
Overseas interests security risks	0.104 5	0.100 0	0.095 1	0.085 1	0.096 2

2.2 Analysis of Five Single Assessment Model Results

This study uses the TOPSIS, PCA, RSR, GRA and SAO-PP assessment models to calculate the country's national security risk level from 2014 to 2023. The results and ranking are shown in Table 9.

As shown in Table 9, the standard deviation of the national security risk assessment ranking of the five assessment models is between 0 and 1.304, among which the ranking difference in 2023 is the most significant, with a standard deviation of 1.304. The standard deviations of the rankings in 2020-2022 are 0.447, 0.447 and 0.548 respectively, with slightly different rankings. The standard deviations of the rankings in 2014-2019 are all 0.000, indicating that the rankings of each assessment model tend to be stable at this stage. Among the five assessment models, since the TOPSIS model requires the indicator data to be as monotonic as possible and the indicators to be as independent as possible, in fact, there is a mutual influence relationship between the indicators in the national security risk assessment index system, resulting in a large difference between its assessment ranking results and the results of the other four models. Therefore, it is necessary to conduct a combined assessment of the ranking results of the five assessment models to improve the robustness and rationality of the assessment results.

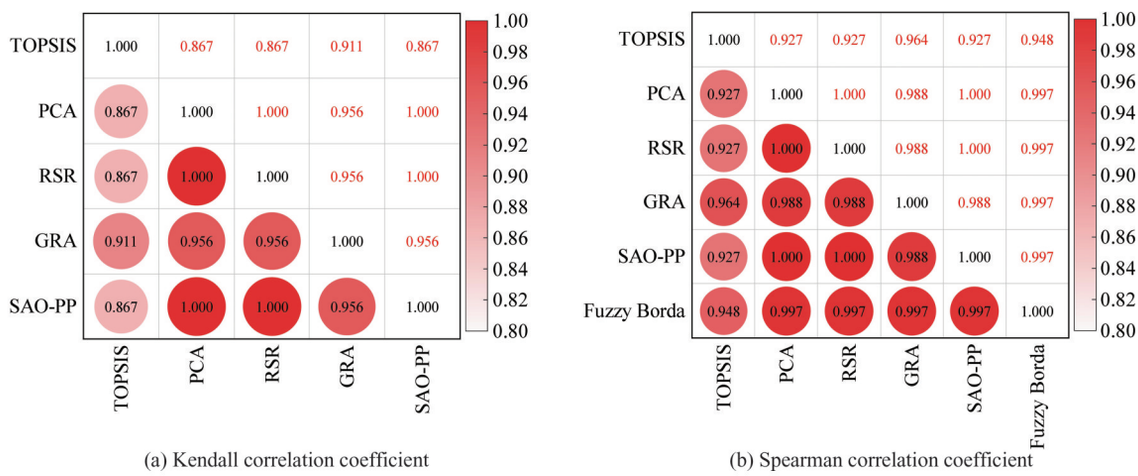
Table 9 Results of five single assessment models

Year	TOPSIS model		PCA model		RSR model		GRA model		SAO-PP model		Standard deviation of rankings
	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	
2014	0.621	1	24.820	1	0.739	1	0.825	1	17.170	1	0.000
2015	0.571	2	18.127	2	0.683	2	0.773	2	15.790	2	0.000
2016	0.520	3	12.766	3	0.639	3	0.744	3	14.836	3	0.000
2017	0.512	4	7.037	4	0.611	4	0.716	4	13.637	4	0.000
2018	0.465	5	0.064	5	0.562	5	0.681	5	11.886	5	0.000
2019	0.425	6	−4.590	6	0.525	6	0.671	6	11.269	6	0.000
2020	0.403	8	−8.518	7	0.482	7	0.656	7	10.382	7	0.447
2021	0.382	9	−12.078	8	0.449	8	0.652	8	9.681	8	0.447
2022	0.372	10	−16.344	9	0.408	9	0.645	10	8.744	9	0.548
2023	0.406	7	−21.284	10	0.403	10	0.651	9	8.202	10	1.304

2.3 Fuzzy Borda Combination Assessment Model Results

When solving the fuzzy Borda combination assessment model, Kendall correlation analysis and Spearman correlation analysis are used to perform pre- and post-consistency tests respectively. The test results are shown in Fig. 1.

Figure 1(a) shows that the correlation coefficients of the five assessment models are between 0.867 and 1.000, indicating that the assessment results of the five models are highly consistent, and the prior test has passed, and the fuzzy Borda assessment model can be further carried out. In Fig. 1(b), the correlation coefficients between the fuzzy Borda combination assessment model and the five assessment models are 0.948, 0.997, 0.997, 0.997 and 0.997, respectively, indicating that the fuzzy Borda combination assessment model has a significant positive correlation with the five assessment models, and the post-test has passed.



(a) Kendall correlation coefficient (b) Spearman correlation coefficient

Fig. 1 Results of pre-event and post-event consistency tests

Based on these findings, the fuzzy Borda model is used to comprehensively calculate the ranking of the five assessment models, and the national security risk assessment results are obtained, as shown in Fig. 2.

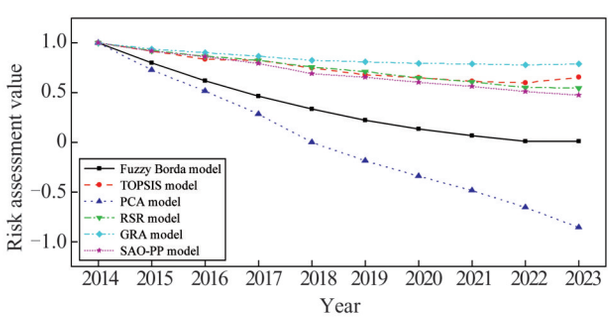


Fig. 2 Results of national security risk assessment model from 2014 to 2023

Overall, between 2014 and 2023, the country's national security risk has generally shown a downward trend, and the rate of decline has gradually slowed down. In the past 10 years, under the broad vision of the holistic approach to national security, China has been building a new era of national security. With the continuous improvement of the security level of the state power, people's well-being, sustainable economic and social development, and science and technology development, the overall national security risk has continued to decrease, indicating that China has gradually moved toward a relatively stable security state with reduced internal and external threats. The research results show that the national security risk assessment index system and combination assessment model constructed in this paper can accurately reflect the overall situation of the country's national security risks. The assessment results are basically consistent with the actual national security situation, providing valuable reference for national security risk management. At the theoretical level, this study expands the research framework of national security risk assessment, and at the practical level, it helps to strengthen national security risk identification, optimize security governance decisions, and further enhance the country's ability to prevent and respond to national security risks, which is of great significance to promoting the modernization of the national security system and promoting the high-quality development of the country.

3 Discussion

This study provides important reference value for advancing theoretical research on national security, strengthening the risk assessment system, and improving the governance modernization. It also offers positive guidance for promoting the high-quality development of national security work in the new era.

(i) From the perspective of the weight analysis of national security risk assessment indicators, science and technology security risks, military security risks and economic security risks constitute the key areas of national security, with a total weight of 33.67%. This highlights the central role of science and technology innovation capabilities, military strength and economic foundation in the new era of national security, and also confirms the close relationship between these three areas. Therefore, when formulating national security strategies, we should give priority to improving scientific and technological independent innovation capabilities, promoting military modernization and ensuring high-quality economic development.

(ii) The five single assessment models applied in this study showed highly consistent ranking results (standard deviation of 0) from 2014 to 2019, but there was a certain degree of difference from 2020 to 2023 (the highest standard deviation was 1.304). This reflects the increasing complexity and multidimensionality of national security risks caused by the sudden international changes, the impact of the epidemic, and the increasing domestic and external uncertainties. The traditional single assessment method may be difficult to fully capture the evolution characteristics of security risks. Thus, this multi-model cross-validation method provides a reliable technical path for future national security risk assessment.

(iii) The results of the fuzzy Borda combination assessment model show that China's national security risk has shown an overall downward trend from 2014 to 2023, and the rate of decline has gradually slowed down. This not only verifies the effectiveness of various security governance measures under the guidance of the holistic approach to national security, but also reminds us to remain vigilant about new challenges arising from the slowdown in risk decline. Therefore, policymakers should continue to adhere to the holistic approach to national security, and actively respond to security risks under the new situation on the basis of consolidating existing achievements, especially paying attention to the intertwined influences between various security risks.

(iv) The assessment index system and combination assessment model constructed in this study provide useful analytical tools for national security risk management. Therefore, in future research, we should continue to improve the assessment model, strengthen the ability to identify and quantify new security risks, and provide more scientific support for national security decision-making. At the same time, we should also pay attention to combining theoretical research with practical needs to enhance the application value and policy implications of research results.

4 Conclusion

The world is undergoing profound changes unseen in a century, and the national security situation is becoming increasingly complex and severe. In order to effectively respond to the ever-changing security challenges and accelerate the modernization of the national security system and capabilities, it is urgent to explore a more scientific, systematic and forward-looking national security risk assessment model. Based on the perspective of systems theory, this study constructs a national security risk assessment index system covering multiple dimensions around 11 key areas, including politics, military, economy, culture, society, science and technology, cyber, ecology, resources, biology and overseas interests, and proposes a combination assessment model to quantitatively assess China's national security risks. The results not only help improve the national security risk management system and provide a decision-making basis for policy making, but also enrich the theoretical and empirical foundations of national security research. The main contributions of this study are as follows:

(i) Guided by the holistic approach to national security in the new era, the national security risk assessment index system is sorted out and summarized from the perspective of systems theory. Covering 404 specific indicators across 11 core domains, this study provides solid theoretical support for security risk identification and quantification.

(ii) Based on the GTCW model, the four subjective and objective weighting methods are integrated and opti-

mized to obtain the optimal weight of each risk assessment indicator. Subsequently, the fuzzy Borda model is used to integrate five single assessment models to construct a more scientific and reasonable national security risk combination assessment framework. This model is better than traditional methods in terms of both accuracy and robustness, and provides more practical theoretical tools and methodological support for national security risk analysis and management.

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系统视域下新时代国家安全风险评估体系与模型构建研究

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摘要：构建符合新时代要求的国家安全风险评估指标体系，对于完善国家安全治理体系、精准研判安全风险态势、提升安全应对能力具有重要意义。本文基于系统论视角，以新时代总体国家安全观为指导，从政治、军事、经济、文化、社会、科技、网络、生态、资源、生物以及海外利益共11个领域出发，构建了一套系统化且科学合理的国家安全风险评估框架。通过运用博弈论组合赋权法，将层次分析法、序关系分析法、熵值取权法和CRITIC法集成优化，获取各指标的系统最优权重；同时，综合优劣解距离、主成分分析、秩和比、灰色关联度分析和模拟退火优化投影寻踪评估模型的排序结果与得分差异，应用模糊Borda组合评估模型构建了国家安全风险的评估模型。结果表明，随着国家政权、人民福祉、经济社会可持续发展和科技水平的提升，2014-2023年我国总体国家安全风险呈下降趋势。所构建的系统模型可为国家安全风险的科学评估与管理提供理论依据和方法支撑，为应对复杂多变的安全挑战提供决策参考。

关键词：总体国家安全观；国家安全；新时代；系统论；风险评估模型

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