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Explanation of the Effective Factors in Measuring the Air Power of States

Aziz Nasirzadeh- Assistant Professor of Dafoos University, Tehran, Iran.
Mohammad Reza Hafeznia * **-** Full Professor, Dept. of Political Geography, Tarbiat Modares University, Tehran, Iran.
Ebrahim Roumina- Associate Professor, Dept. of Political Geography, Tarbiat Modares University, Tehran, Iran.
Hosein.Valivand Zamani - Associate Professor of Deffence Management, Dafoos University, Tehran, Iran.

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Abstract

And variable elements located in the territory of a geographical-political unit called a state. It is one of the most effective elements in the national power of states, their air power, and in counting the factors that influence this power. Although this issue has always been one of the concerns of experts and geopoliticians, no effective action has been taken so far. Expressing the air power quantitatively and ranking the states from this point of view is of great importance in the international system because the states can adopt appropriate strategies to pursue national goals at the global level when they are aware of their air power and that of other states.

This article tries to address the influential factors in measuring the air power of states in two "structural" and "functional" dimensions, using the descriptive-analytical method. For this purpose, a questionnaire was distributed at the internal and external levels (a statistical population of 116 experts and specialists in military and civil aviation) to make it clear that the most important factors affecting the air power of the states are fighter aircraft, intelligence, unmanned aerial vehicles, communication and information systems, bombers, active airports, interceptor aircraft, transport aircraft, navigation systems, helicopters, purpose-built tanker aircraft, fuel production, capacity and quality of runways, training, detection and early warning radars, range of equipment, and multiplicity of products in the aviation industry, respectively.

Keywords: Power, Air Power, Air Force of States.

* E-mail: Hafezn_m@modares.ac.ir

1. Introduction

Power is a concept that governments and states have been continuously seeking to gain. Scientists believe that power is the foundation of politics and that politics is a tool for gaining power; therefore, there has been a continuous synergistic relationship between politics and power. Throughout history, politicians have demanded scientists find some solutions for expanding their power, so water, land, and air have been considered as the key areas of power at different times.

In the current era, air power is made up of very wide components and the air power of different states cannot be compared and assessed based on a few types of common equipment. Therefore, scientists and professors of political geography, geopolitics, international relations, and political science have always been concerned about calculating and measuring air power and designing a model that can be used to compare the states in a certain time or compare the situation of states in two different periods. Hafeznia (2013) believes, "power is a concept that is linked with qualitative factors and variables, which are difficult to measure. Since the factors and variables of power are spread in different fields and territories, it is difficult to obtain a quantitative model of equalization, to determine values and quantitative coefficients for them."

Researchers are presently seeking the factors which define the effectiveness of air power. Therefore, the present paper seeks to count the factors affecting the measurement of the states' air power.

2. Methodology

This research was conducted using a descriptive-analytical method through both desk study (note taking was considered a tool) and survey/field study (interviews were performed through expert meetings and questionnaires were distributed as tools) in a population consisting of 116 experts in aviation with demographic characteristics as follows:

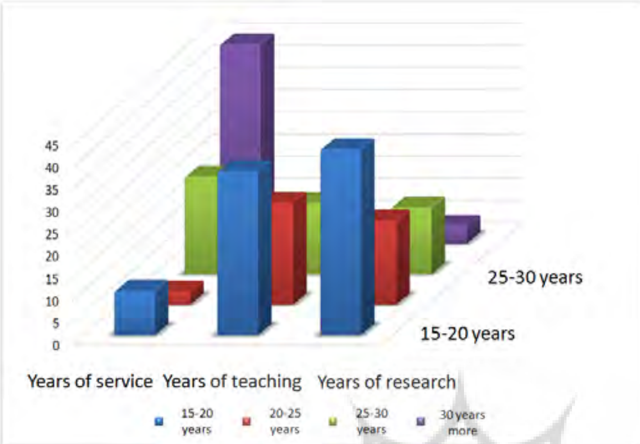

Chart 1. Frequency distribution of internal participants

As shown in chart 1, which compares internal participants, most internal participants have 30 or more years of service, and 15-20 years of teaching and research.

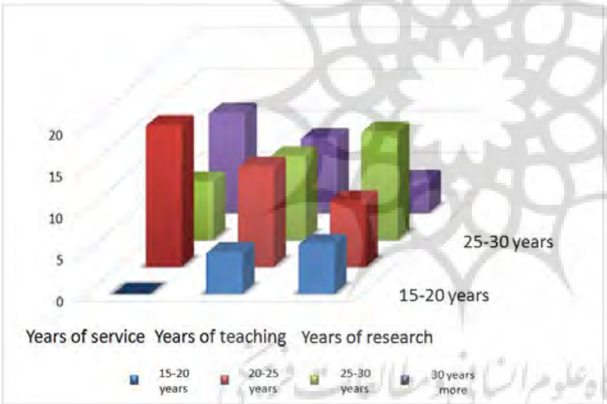

Chart 2. Frequency distribution of external participants

As shown in chart 2, which compares external participants, most external participants have 20-25 years of teaching and service, and 25-30 years of research.

3. Theoretical Formwork

3-1. Background

<table>
<tr><th colspan="3">Table (1): Research Backgrounds</th></tr>
<tr><th>Researcher</th><th>Title</th><th>Results</th></tr>
<tr><td>Touraj Zeineddine (2021)</td><td>Ph.D. Dissertation: Air Transit Strategic Plan by the Islamic Republic of Iran</td><td>This Ph.D. dissertation which was presented at the National Defense University in 2021 counted the factors affecting the civil field of air power, especially air transit, as follows:
<table>
<tr><td colspan="4">Factors affecting the civil field of air power</td></tr>
<tr><td>Field</td><td>Influential factors</td><td>Field</td><td>Influential factors</td></tr>
<tr><td rowspan="4">Economic</td><td>Tourism industry</td><td rowspan="8">Legal</td><td>Organizational structure of aviation</td></tr>
<tr><td>Political stability and economic independence</td><td>Managing and planning the strategies</td></tr>
<tr><td>GDP and economic growth</td><td>Tariff for flights passing through the state</td></tr>
<tr><td>Foreign exchange earnings</td><td>Compilation of the rules and regulations required in the field of air transit</td></tr>
<tr><td rowspan="4">Political</td><td>Political relations</td><td>Bilateral agreements</td></tr>
<tr><td>Diplomacy and regional and international relations</td><td>Safety standards and quality of airports and airplanes</td></tr>
<tr><td>The state's national power of the state</td><td>The efforts of effective organizations in the development of air transit (insurance, cultural heritage, customs)</td></tr>
<tr><td>Geopolitical location</td><td>Variety and quality of air services</td></tr>
<tr><td>Social and cultural</td><td>Cultural, religious, and tourist attractions</td><td>Infrastructure and technology</td><td>Air hubs</td></tr>
</table>
</td></tr>
</table>

			The State's aviation manpower		Aviation and airport infrastructure
			Pating attention to the experiences and actions of States in the field of air transit		Air fuel production and supply in refineries
			New occupation opportunities		Scientific-research infrastructures and knowledge-based air complex
		Defensive & security	Security and military view to the state's atmosphere		Extensive investment in aviation
			No-fly zones		Updating telecommunication, navigation, and radio aid facilities
			Coordination of military and civilian sectors in aviation		Parallel paths
			Safety and security of flight and space lines		Having the latest and best aviation technologies in the world
			The state's air power		Status of the air fleet
			Deterrence and strengthening of the defense base		Increasing the share of foreign airlines in international flights
Hadi Zarghani (2008)	An article extracted from a Ph.D. dissertation entitled: Critique and Analysis of National	Calculation and measurement of national power and formulation of a formula to compare states in a given time or to compare the situation of a state in two different periods have always been one of the intellectual concerns of scientists and professors of political geography, geopolitics, international relations, and political science. Therefore, numerous efforts have been made to measure the power of states in all postwar periods, especially in the 1960s and 1970s. These efforts can be divided into three categories: a group of experts only introduced factors affecting national power in the form of			

	Power Measurement Models	elements of national power, and introduced some variables as the most important factors affecting the national power of states. The second group presented a conceptual model to measure the national power of states based on the points gained by their assumed variables. And finally, the third group selected some factors and variables and at the same time measured the national power of states by designing a mathematical model and determining the type of relationship among the assumed variables. This paper tried to use a descriptive-analytical approach to address different theories about the elements of national power. This study aimed to specify the most important elements of national power from the perspective of different experts. Then, this study evaluated the conceptual models and mathematical models of national power assessment separately and attempted to critique and analyze these models to firstly explain the most important conceptual and structural problems of models, and secondly present solutions to design an optimal model for assessing national power by recognizing the strengths and weaknesses of each model.
Mohammadreza Hafeznia et al. (2007)	An article published in a periodical entitled: Investigating and Analyzing the Role of Population in Geopolitical Weight of Iran	This paper suggested that Iran's national power is considered average compared to other States of the world regarding its population. However, today the population figure is no mere proof of the national power of states. In this regard, the population of Iran does not generally show a balanced trend in terms of many qualitative indicators such as people's political culture, geographical distribution, homogeneity or heterogeneity of population, its structure, literacy level, immigration, and employment of the population, despite its developing trend. Iranian nationalism is the biggest reason and justification for the preservation and survival of Iran throughout its history.
Nikbakhsh Habibi (2021)	A group study performed by Ph.D. candidates entitled: Factors Affecting the Promotion of Air Force Combat Capability as One of the Pillars of Air Power	In a group study, Ph.D. candidates along with their supervisor at the National Defense University (2021) listed the factors affecting the promotion of air force combat capability as one of the pillars of air power as follows:

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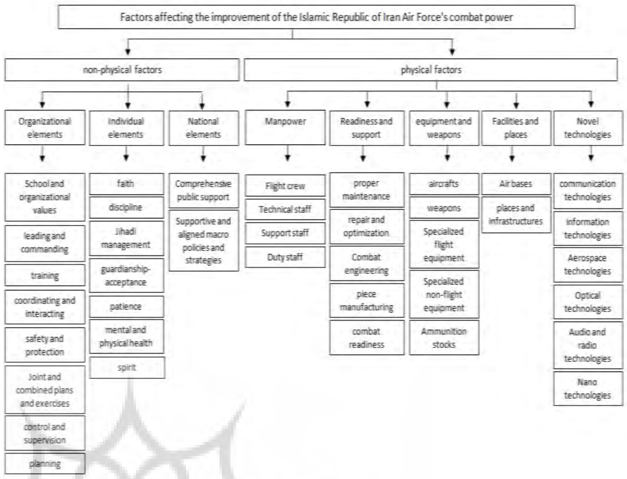
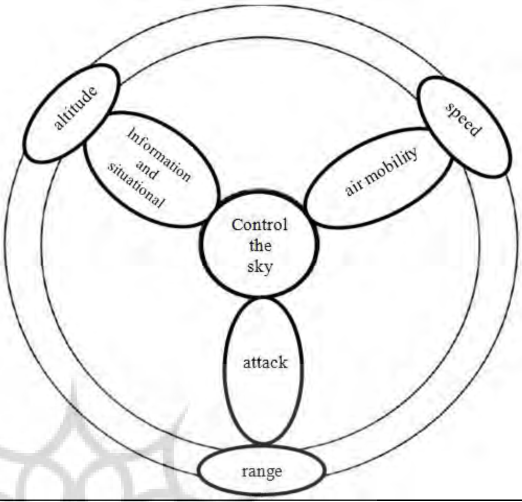
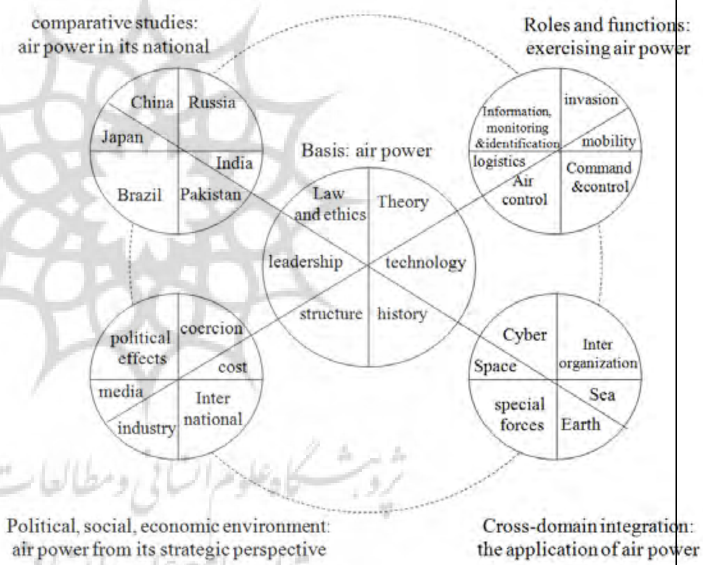


</td>
</tr>
<tr>
<td>Hamid Mohammad Hossein (2018)</td>
<td>An article published in a periodical entitled: Superior Air Power Factors in the Islamic Republic of Iran</td>
<td>This paper investigated the superior air power factors for the Islamic Republic of Iran by addressing influential dimensions, components, and indices. The first part of the research is a desk study presenting the literature on air power that shows factors such as victory, speed, surprise, flexibility, ubiquitousness on the battlefield, technological equipment, reduced insider losses, reduced costs, increased casualties for the enemy, faster surrendering of the enemy, and ultimately defeating the enemy are the main priorities in the war. And the second part indicates that the main dimensions, components, and indices of becoming a superior air power and ultimately the rapid victory in the war are: developing and strengthening the dimensions of hardware and software, combat components and combat-spiritual and non-spiritual support, and macro indices that can facilitate becoming superior air power in the region.</td>
</tr>
<tr>
<td>Christine Melville (2014)</td>
<td>An article published in a periodical entitled: Air Power Butterfly Model</td>
<td>At first glance, it expressed three key strengths of the air environment and four key roles of air power using a butterfly as a visual metaphor for the concept of air power, so it is cognitively controllable and intuitively logical.</td>
</tr>
</table>

		
John Andras Olsen (2015)	An article published in a periodical entitled: Air Power, International Law and Ethical Standards	Although no specific treaty governs the use of air power, a substantial set of international humanitarian laws (IHL) restricts the use of air power in military conflicts (HPCR, 2013). The application of international humanitarian law in the Air Force is divided into two main categories. The first category comprises the laws specific to the airfield, including airspace control, sovereignty, as well as specially protected aircraft, and the second category consists of the laws governing air-to-ground strikes.
Kegan (2017)	An article published in a periodical entitled: Development of National Power in Space (A Theoretical Model)	This article stated that as we progress in the 21st century, our geographic space is also developing and progressing. Components such as transportation, climate, trade, and military operations are visible in this space. Therefore, today the role of space power is significant even in modern warfare, which can increase or decrease the national power of states.
University of Warsaw/ 2019	National Power Rankings of States	Since the actions and estimates of the national power of states have always been of interest to the military commanders, rulers, and political leaders of the world, this study addressed the changes in the balance of power of states after the Cold War and between 1992 and 2017. This paper did not separate hard, soft, intelligent, or any other kind of power, and set aside non-national powers. To measure the states' power, the researcher compared the economic, military, and geopolitical power of states.
Höhn (2011)	A Ph.D. dissertation	This study stated that economic, military, and spatial-collective factors play an important role in the national power of states, and

	entitled: Measuring National and Geopolitical Power	changes were observed in the rankings of states. For example, the United States of America is ranked first in military affairs and the United States, Germany, and Japan are ranked first in economic affairs, and India is ranked first in spatial-demographic affairs.
John Andras Olsen (2018)	An article entitled: Rutledge Air Force Guide	This article, which was written by a group of international experts, provided a superior, important, and comprehensive review of aerospace power. The paper was designed to help people properly understand the strengths, limitations, and potential of the Air Force compared to other forces. In the process, the power leverages demonstrate the air force's increasing importance to national security, outline how it has changed the war, and emphasize its possible importance in the upcoming war. 

4. Literature and Theoretical Foundations

4-1.Power

Power consists of various factors and sources or in other words, originates from them. These factors are: economic, individual, scientific, spiritual, social, etc. And the most important source of power is feeling needless of others. In general, various theories have been proposed concerning the sources of power. Some theories refer to objective and tangible factors, while some others rely on subjective factors and others point to both factors (Hafeznia,2014:231).

Table (2): A Glance at Sources of Power (Salehabadi, 2017, 61)

Component/Index/Variable	Expert	Year	Component/Index/Variable	Expert	Year
Economic capacity, executive competence, and motivation to fight	Klaus Nour	1956	Economic, natural or territorial geography, political, scientific and technological, social, cultural, military, cross-border, spatial	Mohammadreza Hafeznia	2006
The land vastness, population, income, defense expenditures, international trade volume and size of armed forces	Viné Ferris	1973	Land, population, government, economy, communications, military power, foreign relations	Martin Glassner	1993
Geographical borders, natural resources, population, military power, and security	Mr. Samson	2016	Military expenditures, military forces, iron production, energy consumption, city population	Singer	1972
Geography, location, topography, population, resources, war, national spirit, government quality, resource allocation, leadership	Boston University	2015	Geographical location, population, industrial capacity, natural resources, national spirit, military readiness, quality of diplomacy	Hans Morgenta	1973
Exchange of information power	Chin Langchang	2004	State area, borders, population, existence or absence of raw materials, economic and industrial development, financial power, racial homogeniety, social cohesion, political stability, national ethics	Nicholas Spikeman	1944
Technology, investment, human resources, financial resources, physical resources, military capability, military skill	Jones	2005	Nuclear power, land, military, industrial characteristics	German	1960
Geography, population, government revenue, defense expenditures, trade, armed forces	Flack Berr	1973	Military, economic, cultural, political power	Ian	2008
Economic, information, military, nuclear, diplomatic	Mills	2006	Geography, resources, population, economy, military, diplomacy, cultural	Thomas Reynad	2009

Production, population, economy, military factors	Farrar	1981	Geographical, military, economic, colonial, social, political	John Wake Lane	1999
Geography, map, size, climate, topography, border, raw materials, population, economy, technology, communications, information, nuclear, military leadership, etc.	Dinesh	2016	Morphological, population, economy, organization, military, foreign relations	Richard Muir	1975

4-2. Air Power Theories

Alexander P. Deseversky (1894-1974) was an American and Russian military man and one of those who founded the geopolitical landscape of the world based on air power. He expressed the geographical-spatial pattern of his theory in 1949. He stated in his two books entitled "Victory through Air Power" and "Air Power, the Key to Survival" that sea and land powers were subgroups of air power. Seversky presented his spatial pattern in the form of maps that were drawn based on the Azimuth system with an emphasis on the Arctic Heartland. He proved that the distance between sensitive Soviet and American centers is nearer to the top of the Arctic. In his space model, he specified two air power territories for the United States and the Soviet Union, each of which regarded the geographic territory of the other as part of its territory, and at the same time considered some areas outside the territory of its rival as its own territory, as well. Seversky named this common area "the region of decision" and declared that in the event of a full-fledged war between the world powers, the fate of the war will be determined by the region of decision (Hafeznia,2014:240).

From Severesky’s point of view, military air power has the following characteristics:

- Air power can have a determining role without the interference of others.
- Air power is capable of obsoleting long-term wars.
- Controlling the sky and destroying the potential power of the enemy's war machine is one of its main tasks.
- Supporting land and marine forces is part of the sub-tasks of air power.

John Varden: America's defeat in Vietnam prompted U.S. military forces to critique themselves, though it should be said that the U.S. Air Force acted slower than other forces in this regard. But over time, some air force leaders concluded that they failed to act according to Clausewitz's thoughts. They had tried to fight a conventional and regular war in a paramilitary and irregular manner, so they had focused on the number of air operations and other incorrect criteria of combat capability. Also, they ignored the delicate and sophisticated political-military dimensions of this political war. Therefore, American policymakers noticed colonel John Varden's theories. He graduated in 1965 from the U.S. Air Force University and worked as the frontline air controller on 266 combat missions in South Asia. After commanding the G36, he returned to the Pentagon in 1988 and eventually served as deputy director of war management for the Air Headquarters and also as the director of projects. He was also the head of the planning group against Iraq. After the Persian Gulf War, Colonel Varden worked as a special advisor to the President on technology and command of the U.S. Air Force Faculty and Headquarters from 1992 to 1995.

John Varden's emphasis on technology and precise weaponry directly challenged the long-running belief that war is becoming an unworkable and outdated political tool. In other words, Varden believes that air power is essentially the American form of war and can lead to rapid and relatively bloodless victories in war. In this view, an air fight is no longer a blind tool or a political mistake, but it is a flexible way for the United States to maintain its dominance, and if America wants to continue its dominance, it must maintain its invincible awe. In other words, America should never be defeated. In the late 1980s and early 1990s, Varden combined the abovementioned opinions and presented a series of workshop topics that played the cornerstone of a modern theory of air power. They are:

- All organizations are vulnerable at the strategic level, so they are subjected to intimidation and coercion.
- Attacking enemy systems is better than attacking enemy components and elements.
- Loss of air superiority at strategic and operating levels is dangerous and fatal.
- Strategic air strikes are an important component of modern warfare, a strategic airstrike usually ignores or fails to target enemy military forces.
- Parallel warfare has devastating and destructive effects, and currently, air force personnel can simultaneously attack a broad set of targets instead of

attacking serially and orderly. Synchronicity compresses combat operations in terms of time and space. In that case, the enemy will fail to react and will be strategically paralyzed. As a result, chaos is the end of airstrikes.

- At the strategic and operating levels, information warfare has vital importance (information dominance and superiority in sequential and parallel warfare have fundamental importance).
- Precise weapons are valuable and reduce the ambiguity and friction of war.

- **General William Billy Mitchell** published an article in 1924 entitled "Air Power Development". He defines air power as "the ability to do something in the air" and considers it to include transporting everything from one place to another by an aircraft, emphasizing that since the air can be found all over the world, nowhere is immune from aircraft penetration.
- Twenty years after Mitchell, **General H. H. Arnold** presented his latest report as commander general of the U.S. Air Force and defined air power as follows, "Air power includes a state's ability to transport cargo, destroying missiles, and the capacity to wage aerial warfare to achieve the desired outcome and purpose... Air power is not only composed of aerial warfare but embraces the entire aerial activity, including potential and active, civilian and military, public and private aerial activities."
- **Ghiuhon** defined air power in the following decades as, "the ability to use the third dimension (altitude) to influence a situation or enemy." In this definition, space can also be considered a part of the third dimension and altitude (Ghiuhon,1995:8).
- Air power was defined by the U.S. military in the 1970s as ability of a state or the ability to carry out aerial transport, defense, support, coverage, and monitoring operations to achieve the desired result and purpose. Moreover, it can be interpreted as a state's overall ability to fly and operate aerial and spatial operations using a controlled flight of aircraft, for national purposes in the military and civilian domains.

Air power is not only composed of the components of aerial warfare but consists of the entire aerial activities, including potential and active, military and civil, public and private commercial aerial activities.

Air power is the unified exercise of all air and space forces to control and exploit the aerospace environment to achieve national security objectives.

Air power utilizes its unique operational features in the operational environment and has unique capabilities to nationally employ a wide range of military options (Jones,2002:2).

According to the abovementioned definitions, air power is the ability to influence, change and impose will through air or space.

From the perspective of the researchers of this paper, the overall power of a state to fly and operate aerial operations using a controlled aircraft serves to achieve national objectives in the military and civilian domains and its characteristics are as follows:

. It is based on the exercise of will, change and influence;
- It is exercised to achieve the desired (political, military, technological, social-cultural…) goals;
- Its functioning domain is in the sky and space;
- It requires special equipment;
- Its users need special capabilities and training;
- It is essentially strategic;
- It relies on national interests and long-term goals;
- It is developed in regional and international environments;
- It interacts with nations and politicians;
- Air power resources and tools are inclusive and derived from national and available sources;
- It includes all components of a state's national power.

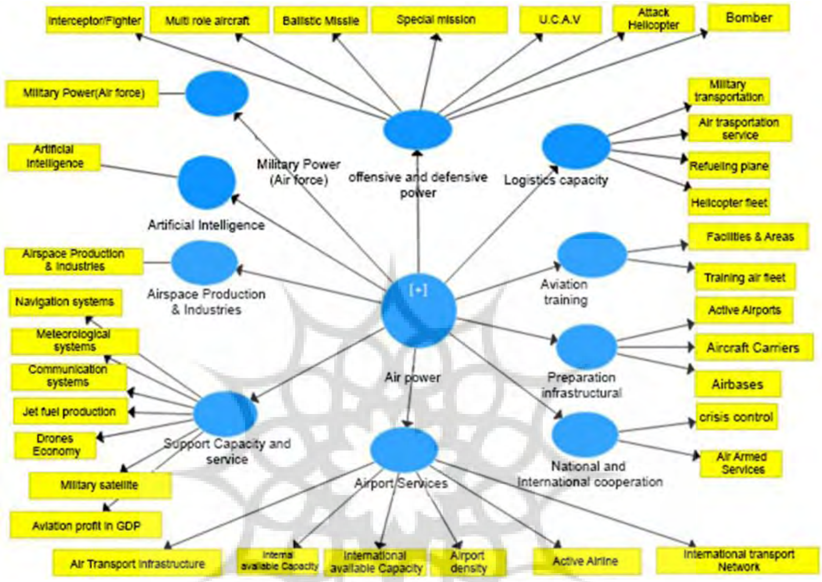
And the four fundamental factors related to air power are:

➢ Air power is the overall power of a state to fly;
➢ A state’s air power (its military air force and civil aviation) is indivisible;
➢ The physical flying power to exercise political rights, the sovereignty of flight, and to dominate the airspace is necessary;
Self-reliance to supply systems, equipment, and technical and human training is necessary.

5. Research Findings

This study aims to present a model for evaluating and measuring the air power of states. Therefore, the components and indices extracted from the theoretical foundations are designed in the form of a hierarchical model. As shown in Figure 1, this air power model consists of 10 components and 34 indices that measure the air power structure using first-order and second-order models.

Figure (1): The Air Power Model



6. Research Analysis

The air power is fitted using structural equation modeling and multivariate analysis technique. Structural equation modeling is a very general and robust multivariate analysis technique belonging to the multivariate regression family. More precisely, it extends the general linear model that allows the researcher to test a set of regression equations at the same time. Structural equation modeling combines factor analysis, focal correlation, and multivariate regression.

Through this method, the credibility of theoretical models in specific communities can be tested using correlation, non-experimental, and experimental data. This method estimates the model parameters (path coefficients and error expressions), introduces several indices to measure the goodness of fit, makes it possible to test the developed models as a whole by using empirical data, and guides the researcher in modifying and improving the model through the indices that are introduced.

Methodology of Model Evaluation and Estimation:
The model estimation includes techniques used to estimate model parameters (path coefficients, factor loads, errors). The model estimation method is partial least squares (PLS). The first generation of modeling is variance-driven, and these methods, known as covariance-driven methods, are introduced by Joursgook (1969). The second-generation methods are variance-driven or component-driven. Component-driven methods, which were later renamed to partial least squares, were developed by Weld (1974). This approach focuses on maximizing the variance of dependent variables predicted by independent variables instead of reprocessing the experimental covariance matrix.
Descriptive statistics:
Descriptive statistics of each component and index consist of minimum and maximum scores, lowest and highest scores, mean, standard deviation, and variance. These components and indices are calculated and reported in Table 3. As reported in the table, the highest mean belongs to unmanned offensive aerial vehicle (4.0±83.462), and the lowest one belongs to the training air fleet (4.04±1.03).

Table (3): Central Statistics and Distribution of Components and Indices of the Model

Component	Index	Minimum	Maximum	Mean	Std. Deviation	Variance
Planning	Air bases	2	5	4.71	.575	.331
	Active airports	2	5	4.46	.703	.494
	Aircraft carriers	2	5	4.41	.699	.488
Offensive and defensive capability	Fighter aircraft	1	5	4.65	.794	.631
	Multirole aircraft	1	5	4.78	.541	.292
	Ballistic missile	1	5	4.59	.813	.660
	Special mission aircraft	2	5	4.82	.584	.341
	Unmanned offensive aerial vehicle	3	5	4.83	.462	.213
	Offensive helicopter	1	5	4.57	.826	.682
	Bomber	1	5	4.59	.884	.782
Support and service capability	Navigation system	1	5	4.56	.738	.544
	Meteorological system	1	5	4.29	.791	.626
	Communication	2	5	4.80	.563	.317

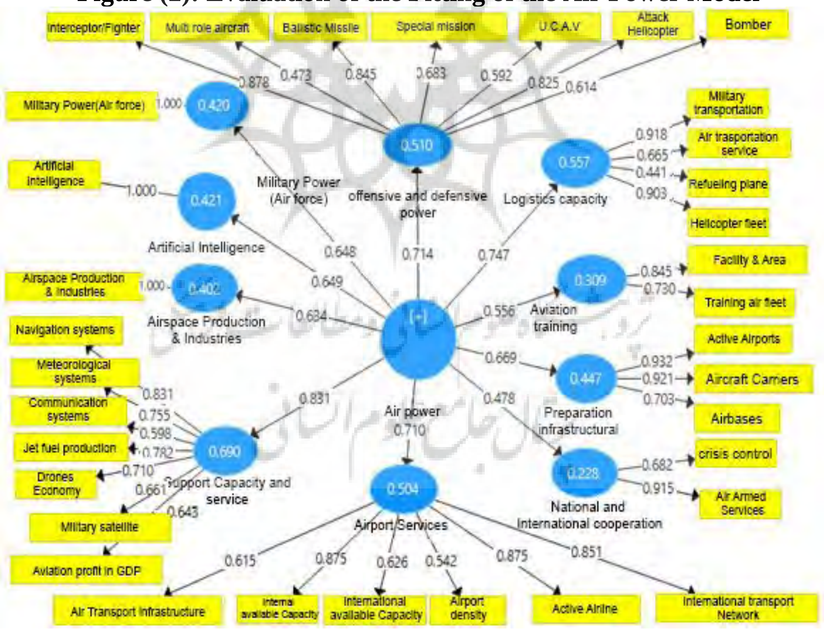
Component	Index	Minimum	Maximum	Mean	Std. Deviation	Variance
	and information system					
	Fuel production	1	5	4.53	.763	.582
	Economics of unmanned aerial vehicle	1	5	4.23	.806	.650
	Military telecommunication satellites	1	5	4.31	.838	.703
	Aviation profits in GDP	2	5	4.41	.758	.575
Logistics capability	Military transport	1	5	4.63	.764	.583
	Civilian transport	1	5	4.10	.964	.928
	Purpose-built tanker	1	5	4.70	.635	.404
	Helicopter fleet	1	5	4.56	.783	.614
Aviation training	Facilities and educational areas	2	5	4.68	.654	.428
	Training air fleet	1	5	4.04	1.033	1.068
National and international cooperation	Crisis control	1	5	4.19	.854	.729
	Types of armed air services	1	5	4.30	.847	.717
Airport services	Quality of aviation infrastructure	1	5	4.30	.887	.786
	Available domestic capacity	3	5	4.30	.760	.578
	Available international capacity	1	5	4.77	.595	.354
	Airport density	2	5	4.72	.572	.327
	Number of active airlines	3	5	4.34	.747	.558
	International air transport network	3	5	4.29	.769	.592
Aviation industries and aerospace products	-	1	5	4.22	.835	.697
Military power (Air Force)	-	1	5	4.22	.876	.767
Artificial	-	1	5	4.26	.825	.680

Component	Index	Minimum	Maximum	Mean	Std. Deviation	Variance
Intelligence						

Second-order confirmatory factor analysis:

Second-order models are models consisting of two layers of structures. Reflective-reflective model is a type of second-order model. In the second-order confirmatory factor analysis models, two parts of the model should be examined, the internal model and the external model. Therefore, to fit the second-order models, the criteria of the structural part (the relationships among structures) should also be examined along with the criteria for fitting the measurement domain (the relationships among the structures and indices). As shown in figure 2, the air power model consists of 10 components and 34 indices tested in the form of a hierarchical model.

Figure (2): Evaluation of the Fitting of the Air Power Model



Evaluation of model measurement domain

Reliability of measurement model

Cronbach's Alpha: measures the internal consistency and indicates to what extent all the components of a scale express the same concept and shows the internal relationship of these components. The high internal consistency is the result of the amount of the abovementioned variance which is determined by the structure, as well as the low measurement error. The range of alpha coefficient is (+1-0), then if the coefficient equals zero, reliability does not exist, and if it equals 1, full reliability is approved.

$$\alpha = \frac{K}{K-1}\left[1 - \frac{\sum S_i^2}{S_T^2}\right]$$

As shown in the formula, two factors (i.e. sampling and the number of test items) have a great impact on the value of Cronbach's alpha. When the value of Cronbach's alpha is higher than 0.7, reliability is high. However, when the items testing the variables are few, 0.6 can be considered a credible value for Cronbach's alpha. Moreover, when hierarchical models, in which some structures have only one indicator, are analyzed, only the indices of the second-order model should be investigated. Due to the limitations of Cronbach's alpha formula, composite reliability is a more common method for structural equations.

Composite reliability: is a more accurate criterion than Cronbach's alpha in structural equation modeling, because the contribution of indices varies according to the correlation value in the calculation. When the value of CR is higher than 0.7 for each structure, the internal consistency of the structure is approvable. Both criteria should be reported for internal consistency. As reported in Table 4, the value of composite reliability is desirable for all structures, but the value of Cronbach's alpha is low, and most experts believe that composite reliability is more accurate than other methods in the PLS approach.

$$CR = \frac{\left(\sum_{i=1}^{n} \lambda_i\right)^2}{\left(\sum_{i=1}^{n} \lambda_i\right)^2 + \left(\sum_{i=1}^{n} \delta_i\right)}$$

Factor loading coefficient: is the correlation between the index and the structure. A value higher than 0.4 is approvable. Some researchers recommend a value of 0.5. As reported in Table 4 and Figure 2, all factor loadings are higher than 0.4 and are significant at an alpha level of 0.05 and a confidence level of 0.95.

Table (4): Reliability Indices of First-Order Model

Component	Index	**Loadings (>0.4?)**	**Significance (t>1.96?)**	**CR (>0.7?)**	**A (>0.7?)**
Planning	Air bases	Yes (0.703)	Yes (28.130)	Yes (0.892)	Yes (0.812)
	Active airports	Yes (0.932)	Yes (10.402)		
	Aircraft carriers	Yes (0.921)	Yes (24.940)		
Offensive and defensive capability	Fighter aircraft	Yes (0.878)	Yes (9.296)	Yes (0.876)	Yes (0.829)
	Multirole aircraft	Yes (0.473)	Yes (4.214)		
	Ballistic missile	Yes (0.845)	Yes (8.325)		
	Special mission aircraft	Yes (0.683)	Yes (6.482)		
	Unmanned offensive aerial vehicle	Yes (0.592)	Yes (5.006)		
	Offensive helicopter	Yes (0.825)	Yes (7.734)		
	Bomber	Yes (0.614)	Yes (6.889)		
Support and service capability	Navigation system	Yes (0.831)	Yes (14.429)	Yes (0.879)	Yes (0.839)
	Meteorological system	Yes (0.755)	Yes (11.392)		
	Communication and information system	Yes (0.598)	Yes (6.313)		
	Fuel production	Yes (0.785)	Yes (10.586)		
	Economics of unmanned aerial vehicle	Yes (0.710)	Yes (9.219)		
	Military telecommunication satellites	Yes (0.661)	Yes (10.611)		
	Aviation profits in GDP	Yes (0.643)	Yes (7.895)		
Logistics	Military transport	Yes	Yes	Yes	Yes

Component	Index	**Loadings (>0.4?)**	**Significance (t>1.96?)**	**CR (>0.7?)**	**A (>0.7?)**
capability		(0.918)	(40.923)	(0.834)	(0.725)
	Civilian transport	Yes (0.665)	Yes (8.186)		
	Purpose-built tanker	Yes (0.441)	Yes (3.237)		
	Helicopter fleet	Yes (0.903)	Yes (31.961)		
Aviation training	Facilities and educational areas	Yes (0.845)	Yes (10.994)	Yes (0.767)	No (0.403)
	Training air fleet	Yes (0.730)	Yes (6.515)		
National and international cooperation	Crisis control	Yes (0.682)	Yes (4.477)	Yes (0.785)	No (0.495)
	Types of armed air services	Yes (0.915)	Yes (15.100)		
Airport services	Quality of aviation infrastructure	Yes (0.615)	Yes (8.634)	Yes (0.878)	Yes (0.826)
	Available domestic capacity	Yes (0.875)	Yes (15.922)		
	Available international capacity	Yes (0.626)	Yes (9.115)		
	Airport density	Yes (0.542)	Yes (5.770)		
	Number of active airlines	Yes (0.875)	Yes (17.449)		
	International air transport network	Yes (0.851)	Yes (13.498)		
Aviation industries and aerospace products	-	(1)	0.000	(1)	(1)
Military power (Air Force)	-	(1)	0.000	(1)	(1)
Artificial Intelligence	-	(1)	0.000	(1)	(1)

Convergent validity of measurement model:

When a set of indices measures a single trait, there should be a high correlation between that structure and its indices and the structure should be able to explain at least 50% of the variance. When the model does not have convergent variability, then the indices do not reflect a single structure.

The average variance extracted (AVE) is used to measure convergent validity. When the value of AVE is higher than 0.5, the convergent validity of measurement models is approvable. As reported in Table 5, the value of the AVE index for all structures is higher than 0.5.

$$AVE = \frac{\sum_{i=1}^{n} L_i^2}{n}$$

Table (5): Mean Pooled Variance of the First-Order Model

AVE (>0.5?)	Structure
Yes (0.738)	Planning
Yes (0.624)	Aviation training
Yes (0.512)	Offensive and defensive capability
Yes (0.574)	Logistics capability
Yes (0.512)	Support and service capability
Yes (0.553)	Airport services
Yes (1)	Aviation industries and aerospace products
Yes (1)	Military power
Yes (0.651)	National and international cooperation
Yes (1)	Artificial Intelligence

Divergent validity of model:

When a set of indices are designed to measure a single trait, there should be a high correlation between that set of indices and that structure and there should be a low correlation between that set of indices and other structures. Three methods are used to assess the divergent validity of the model:

1. The Fornell-Larcker criterion:

According to the Fornell-Larcker criterion, the value of the pooled mean variance root should be higher than the correlation of each structure with other structures. As reported in Table 6, in all structures the value of the pooled variance is higher than the correlation of structures.

Table (6): The Fornell-Larcker Index Matrix

	Planning	Aviation training	Offensive and defensive capability	Logistics capability	Support capability	Airport services	Aviation industries	Military power	Cooperation	Artificial Intelligence
Planning	**0.859**									
Aviation training	0.383	**0.790**								
Offensive and defensive capability	0.414	0.400	**0.716**							
Logistics capability	0.321	0.440	0.601	**0.758**						
Support capability	0.512	0.362	0.364	0.540	**0.716**					
Airport services	0.605	0.406	0.461	0.460	0.425	**0.744**				
Aviation industries	0.216	0.238	0.332	0.384	0.624	0.177	**1.000**			
Military power	0.240	0.195	0.334	0.394	0.631	0.214	0.823	**1.000**		
National and international cooperation	0.296	0.295	0.128	0.238	0.463	0.480	0.210	0.213	**0.807**	
Artificial Intelligence	0.241	0.226	0.356	0.387	0.628	0.189	0.875	0.906	0.149	**1.000**
S.R AVE>LVC?	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**

2. Cross-loadings:

Based on cross-loadings, the correlation between each index and its own structure should be higher than its correlation with other structures. As shown in Table 7, this criterion is met in all structures.

Table (7): Cross-loadings matrix

	Planning	Aviation training	Offensive and defensive capability	Logistics capability	Support capability	Airport services	Aviation industries	Military power	National and internation al cooperatio	Artificial Intelligence
Active airports	**0.932**	0.343	0.356	0.253	0.372	0.552	0.180	0.228	0.263	0.214
Aircraft carriers	**0.921**	0.338	0.373	0.255	0.367	0.586	0.182	0.202	0.270	0.205
Air bases	**0.703**	0.299	0.330	0.315	0.575	0.407	0.192	0.183	0.225	0.198
Facilities and educational areas	0.374	**0.845**	0.393	0.352	0.321	0.366	0.180	0.141	0.213	0.186
Training air fleet	0.216	**0.730**	0.222	0.346	0.246	0.267	0.200	0.172	0.262	0.170
Fighter aircraft	0.322	0.386	**0.878**	0.524	0.202	0.327	0.212	0.215	0.095	0.207
Special mission aircraft	0.350	0.213	**0.683**	0.347	0.199	0.443	0.173	0.199	0.045	0.188
Multirole aircraft	0.093	0.070	**0.473**	0.237	0.382	0.209	0.320	0.342	0.053	0.360
Ballistic missile	0.293	0.351	**0.845**	0.478	0.174	0.314	0.199	0.190	0.056	0.210
Offensive helicopter	0.296	0.341	**0.825**	0.473	0.166	0.268	0.217	0.231	0.078	0.242
Bomber	0.393	0.286	**0.614**	0.497	0.464	0.408	0.265	0.287	0.125	0.336
Unmanned offensive aerial vehicle	0.247	0.285	**0.592**	0.358	0.204	0.284	0.281	0.204	0.179	0.232
Civilian transport	0.268	0.316	0.267	**0.665**	0.526	0.413	0.349	0.323	0.407	0.327
Military transport	0.271	0.419	0.598	**0.918**	0.442	0.357	0.350	0.372	0.109	0.374
Purpose-built tanker	0.135	0.178	0.407	**0.441**	0.168	0.247	0.047	0.107	0.044	0.051
Helicopter fleet	0.269	0.368	0.543	**0.903**	0.427	0.363	0.325	0.322	0.133	0.326
Communication system	0.433	0.492	0.513	0.532	**0.598**	0.442	0.280	0.285	0.406	0.317
Navigation system	0.504	0.246	0.214	0.363	**0.831**	0.378	0.317	0.342	0.418	0.346
Meteorological system	0.299	0.161	0.139	0.359	**0.755**	0.296	0.426	0.394	0.360	0.362
Fuel production	0.450	0.199	0.194	0.325	**0.782**	0.326	0.318	0.317	0.433	0.321
Economics of unmanned aerial vehicle	0.243	0.139	0.101	0.300	**0.710**	0.221	0.387	0.357	0.320	0.327

	Planning	Aviation training	Offensive and defensive capability	Logistics capability	Support capability	Airport services	Aviation industries	Military power	National and internation al cooperatio	Artificial Intelligence
Military telecommunication satellites	0.234	0.242	0.364	0.416	**0.661**	0.183	0.608	0.511	0.167	0.564
Aviation profits in GDP	0.352	0.262	0.190	0.342	**0.643**	0.234	0.402	0.475	0.187	0.397
International air transport	0.446	0.208	0.306	0.290	0.239	**0.851**	0.086	0.095	0.240	0.085
Number of active airlines	0.497	0.242	0.334	0.336	0.290	**0.875**	0.126	0.160	0.283	0.122
Airport density	0.433	0.338	0.285	0.195	0.259	**0.542**	0.153	0.094	0.278	0.120
International capacity	0.463	0.535	0.516	0.403	0.355	**0.626**	0.123	0.184	0.354	0.177
Quality of aviation infrastructure	0.343	0.215	0.238	0.441	0.439	**0.615**	0.178	0.248	0.609	0.201
Domestic capacity	0.474	0.220	0.317	0.314	0.259	**0.875**	0.112	0.133	0.271	0.110
Aviation industries and products	0.216	0.238	0.332	0.384	0.624	0.177	**1.000**	0.823	0.210	0.875
Military power (Air Force)	0.240	0.195	0.334	0.394	0.631	0.214	0.823	**1.000**	0.213	0.906
Armed air services	0.325	0.369	0.195	0.251	0.419	0.428	0.223	0.178	**0.915**	0.136
Crisis control	0.105	0.022	-0.054	0.103	0.324	0.348	0.086	0.175	**0.682**	0.103
Artificial Intelligence	0.241	0.226	0.356	0.387	0.628	0.189	0.875	0.906	0.149	**1.000**

3. The Heterotrait-Monotrait (HTMT) Ratio:

The HTMT criterion or HTMT index is a criterion for measuring heterotrait-monotrait ratio. This criterion is proposed by Hensler et al. (2015) to evaluate divergent validity. The HTMT is a good replacement for the old Fornell-Larcker method.

$$\mathrm{HTMT}_{ij} = \underbrace{\frac{1}{K_i K_j} \sum_{g=1}^{K_i} \sum_{h=1}^{K_j} r_{ig,jh}}_{\substack{\text{average} \\ \text{heterotrait-} \\ \text{heteromethod}}} \div \underbrace{\left(\frac{2}{K_i(K_i-1)} \cdot \sum_{g=1}^{K_i-1} \sum_{h=g+1}^{K_i} r_{ig,ih} \cdot \frac{2}{K_j(K_j-1)} \cdot \sum_{g=1}^{K_j-1} \sum_{h=g+1}^{K_j} r_{jg,jh} \right)^{\frac{1}{2}}}_{\substack{\text{geometric mean of the average monotrait-heteromethod} \\ \text{correlation of construct } \xi_i \text{ and the average} \\ \text{monotrait-heteromethod correlation of construct } \xi_j}}.$$

The HTMT is approvable in the range of (0.85-0.90). If the value of this criterion is lower than 0.9, divergent validity is approvable.

Table (8): The HTMT Matrix

	Planning	Aviation training	Offensive and defensive capability	Logistics capability	Support capability	Airport services	Aviation industries	Military power	Cooperation	Artificial Intelligence
Planning										
Aviation training	0.652									
Offensive and defensive capability	0.495	0.661								
Logistics capability	0.416	0.803	0.778							
Support and services	0.614	0.594	0.441	0.664						
Airport services	0.739	0.685	0.547	0.591	0.495					
Aviation industries and aerospace products	0.241	0.379	0.373	0.424	0.667	0.195				
Military power	0.266	0.312	0.372	0.446	0.674	0.229	0.823			
National and international cooperation	0.416	0.633	0.259	0.408	0.703	0.734	0.270	0.308		
Artificial intelligence	0.268	0.355	0.396	0.427	0.664	0.205	0.875	0.906	0.208	

As reported in Table 8, the HTMT is observed for all structures except military power and artificial intelligence. Considering that Fornell-Larcker indices and cross-loadings confirm the validity of the measurement model of these two structures, and also since the difference from the desired level is very small, it can be ignored.

Evaluation of the structural part of the model:

Coefficient of Determination: The coefficient of determination is the amount of dependent variable variance, which is explained by the independent variable(s). The coefficient of determination is calculated only for the dependent variables in the model and should be calculated for all dependent variables. Chin (1998) considers the criterion values for the coefficient of determination as follows: weak: 0.19; average: 0.33; and strong: 0.67.

As reported in Table 9, all the values of coefficients of determination are average and approvable.

Standardized path coefficients: Standardized path coefficients are used to investigate the intensity or relationship between two variables or hidden structures.

Cross-Validated Redundancy (Q^2): Stone-Geisser index indicates the predictive power of the model regarding the indices of endogenous structures. If the model can predict the indices of endogenous structures properly, the structural model has an optimal and desired fit. It indicates the accuracy of the relationship between the endogenous variable to be calculated and other variables of the model. The value of cross-validated redundancy (CV-Red) is used as the estimate of the Stone-Geisser index (Chin, 1998:318). The coefficient of determination (R^2) determines the accuracy of the prediction and the Q^2 determines the correlation of the prediction. The Q^2 criterion is calculated for all endogenous structures of the reflective model.

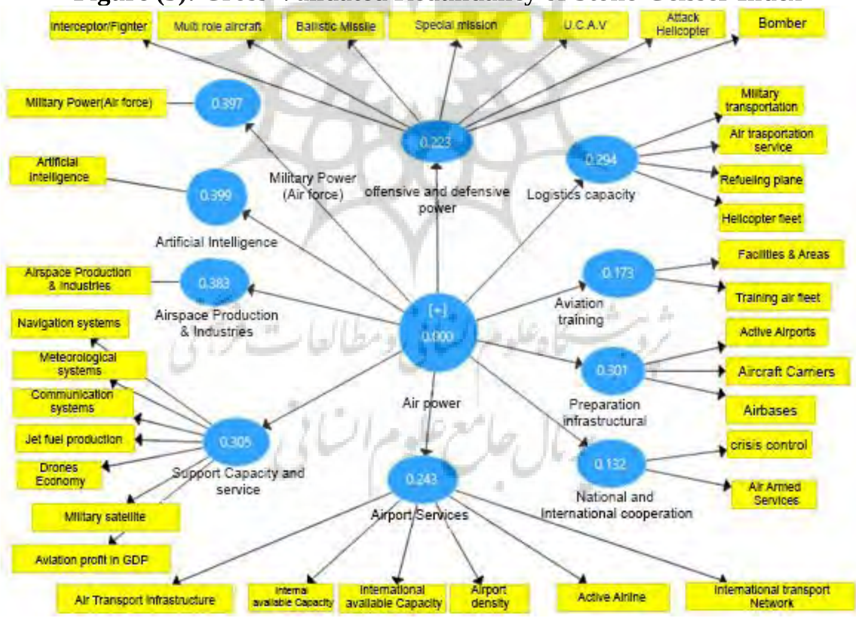
Hayer et al. (2014) approved the values greater than zero (positive values) for the predictive validity criterion. The negative values indicate a very poor estimate of the hidden variable. Hansler et al. (2009) introduced three values of 0.02, 0.15, and 0.35 for the predictive power of the model. As reported in Table 9, all Q^2 indices are at an optimal level and indicate the strength of the model to predict relations.

Table (9): Fitting Indices for the Second-Order Model or Structural Domain of the Model

Significance (t>1.96?)	R2	B	Q^2			
			SSO	SSE	Q^2 (=1-SSE/SSO)	Structures
Yes (9.349)	0.447	0.669	348	243.333	0.301	**Planning**
Yes (5.915)	0.309	0.556	232	191.885	0.173	**Aviation training**
Yes	0.510	0.714	812	630.559	0.223	**Offensive and**

(10.926)						**defensive capability**
Yes (15.471)	0.557	0.747	464	327.449	0.294	**Logistics capability**
Yes (25.875)	0.690	0.831	812	464.412	0.305	**Support capability**
Yes (7.808)	0.504	0.710	696	526.942	0.243	**Airport services**
Yes (9.263)	0.402	0.634	116	71.541	0.383	**Aviation industries**
Yes (10.165)	0.420	0.648	116	69.897	0.397	**Military power**
Yes (4.134)	0.228	0.478	232	201.260	0.132	**National and international cooperation**
Yes (9.947)	0.421	0.649	116	69.732	0.399	**Artificial intelligence**

Figure (3): Cross-Validated Redundancy of Stone-Geisser Index



Redundancy: indicates the variability of the indices of an endogenous structure that is affected by several exogenous structures. The higher the redundancy mean, the more favorable the fit of the structural domain of the model. As reported in Table 10, the redundancy of the model is 0.312, indicating the optimal fit of the structural domain.

Table (10): Redundancy of the Structural Domain of the Model

Red	R2	AVE	**Structure**
0.329	0.447	0.738	1) Planning
0.192	0.309	0.624	2) Aviation training
0.261	0.510	0.512	3) Offensive and defensive capability
0.319	0.557	0.574	4) Logistics capability
0.353	0.690	0.512	5) Support and service capability
0.278	0.504	0.553	6) Airport services
0.402	0.402	1	7) Aviation industries and aerospace products
0.420	0.420	1	8) Military power
0.148	0.228	0.651	9) National and international cooperation
0.421	0.421	1	10) Artificial intelligence
$\overline{Red} = 0.312$	M= 0.449	M= 0.716	

GOF: This criterion evaluates the fit of the whole model. That is, after evaluating the measurement domain of the model and the structural domain of the model, the whole model should finally be evaluated using GOF.

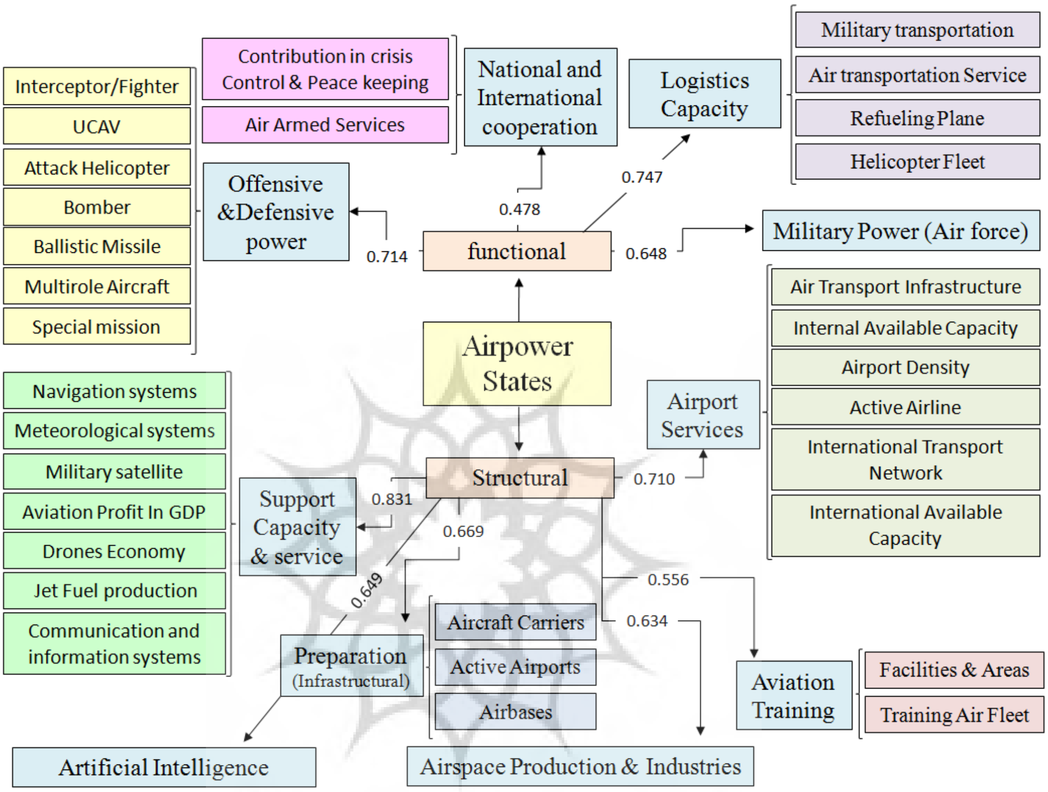
$$GOF = \sqrt{\overline{R^2} * \overline{Communality}}$$

Wetzles et al. (2009) considered three values for evaluating GOF: weak: if it is between 0.1 and 0.25. Average: if it is between 0.25 and 0.36. Strong: if it exceeds 0.36. The GOF value of the model is 0.566, indicating the overall optimal fit of the model.

7. Conclusion

Since the air power assessment model is hierarchical and has second-order structures, the fitting indices of both structural and measurement domains of the model should be investigated to evaluate the model. The indices of the measurement domain of the model show that the model has acceptable validity and reliability. The indices of the structural domain of the model also show that the relationships between hidden structures are correctly mapped. The overall fitness index of the model also shows that the overall air power model has an acceptable fit.

Figure (4): Air Power Measurement Model of States



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