Network Analysis of the US–China Hegemonic Transition

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Abstract

This study examined the hegemonic transition between the US and China in a network analysis. Indicators of gross output such as GDP, GNP, and CINC, when used in analyzing state power or hegemonic transitions between superpowers, do not accurately reflect states' influence. Unlike these traditional indicators, network centrality is useful for determining which powerful states have hegemony and whether a hegemonic transition is in progress or not. Analyzing the hegemonic transition between the US and China with this useful technique, we argue that the US still maintains hegemony in international relations. Although some indicators in the economic domain of international relations suggest that power has been shifting from the US to China at the micro level, it is obvious that the US still maintains hegemony at all levels in the political, military, and cultural sectors, and that it still dominates other states at the meso and macro levels in the economic sector. This study has two important implications. First, we present an approach to analyze and evaluate hegemonic transitions in international relations by matching hegemony, a key concept in international relations theory, and centrality, a core concept in network science. Second, this study assess the possibility of hegemonic transition between the US and China, which is a current issue in international relations research, through the very suitable method of network analysis.

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1. Introduction

Who will achieve global hegemony between the United States and China in the 21st century is a hot topic in international relations research. As competition between them to achieve global hegemony has intensified, studies have arisen using various indicators to predict the final outcome. Most studies have used GDP (Gross Domestic Product), a common representative indicator of a state's economic power, to analyze the possibilities of hegemonic transition from one state to another.[1] For example, in his book *Destined for War*, Graham Allison used GDP at purchasing power parity (PPP) as an indicator to compare the power of the US and China;[2] other researchers have also used GDP to analyze this relationship.[3]

In addition to GDP, various indicators such as GDP per capita, GNP (Gross National Product), and the CINC (Composite Index of National Capability) have been used in many studies to analyze the hegemonic transition between the US and China.[4] But these indicators alone are inadequate to assess the two states' predominance or to trace their

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[1] Philipp Lepenies, *The Power of a Single Number: A Political History of GDP* (New York: Columbia University Press, 2016), pp. 1-7.

[2] Graham Allison, *Destined for War: Can America and China Escape Thucydides's Trap?* (Boston: Houghton Mifflin Harcourt, 2017), pp. 6-11.

[3] See, for example, Yan Xuetong, "The Instability of China–US Relations," *The Chinese Journal of International Politics*, Vol. 3 (2010), p. 265; Yan Xuetong, "The Rise of China and its Power Status," *The Chinese Journal of International Politics*, Vol. 1 (2006), pp. 6-7; Ronald L. Tammen and Jacek Kugler, "Power Transition and China-US Conflicts," *The Chinese Journal of International Politics*, Vol. 1 (2006), p. 44; Martin A. Smith, *Power in the Changing Global Order: The US, Russia and China* (Malden, MA: Polity Press), pp. 154-156; William C. Wohlforth, "The Stability of a Unipolar World," *International Security*, Vol. 24, No. 1 (Summer 1999), p. 12.

[4] See, for example, Aaron L. Friedberg, "The Future of U.S.-China Relations: Is Conflict Inevitable?," *International Security*, Vol. 30, No. 2 (2005), p. 17; Steven Chan, "Is There Power Transition between the U.S. and China? The Different Faces of National Power," *Asian Survey*, Vol. 45, No. 5 (2005), pp. 689-690; Carsten Rauch, "Challenging the Power Consensus: GDP, CINC, and Power Transition Theory," *Security Studies*, Vol. 26, No. 4 (2017), pp. 654-655.

power transition in international relations. GDP is a measure indicating the sum of the market values of all the final goods and services produced in a state; it is an indicator of economic output of one state, not how much it influences other states. The others are also indicators of one state's total output or resources, and they are also inadequate indicators of the extent to which one state affects other states.

Because of these limitations, some researchers have proposed new indicators, which are really combinations of existing indicators. GDP × GDP per capita has been presented under the label 'net resources' as a complement to existing indicators.[5] The relative proportions of GDP and GDP per capita in the US and China have also been used to analyze power competition between the two states.[6]

However, these complementary indicators are also inadequate to analyze states' influence; although previous indicators may be combined in various ways, they still only represent gross production or total output. The power of a state, that is, its hegemony, must be measured by how much influence it exerts to form international orders within the structure of international relations.[7] One state affects others by forming relationships with them; the influence is not one-sided. Therefore, hegemony should be measured in the interactions between states. Hence, the influence of a dominant, powerful state in the

[5] Michael Beckley, "The Power of Nations: Measuring What Matters," *International Security*, Vol. 43, No. 2 (Fall 2018), pp. 17-19.
[6] Emilio Casetti, "Power Shifts and Economic Development: When Will China Overtake the USA?," *Peace Research*, Vol. 40, No. 6 (November 2003), pp. 667-668.
[7] Rising powers seeking hegemony ultimately desire influence. So, in order to analyze the hegemonic transition between great powers, changes in their influence should be analyzed. See William C. Wohlforth, *The Elusive Balance: Power and Perceptions during the Cold War* (Ithaca, New York: Cornell University Press, 1993), p. 12.

hierarchical structure of international relations should be measured by examining the its influence that can constitute norms, regulations, and institutions in the interactions of all states.[8]

In this study, we apply the network perspective to analyze the hegemonic transition between the US and China. In doing so, we overcome the limitations of previous studies that relied only on GDP and total output. From the network point of view, we analyze the relevant phenomena structurally and evaluate the influence of state actors from the evidence of their own interactions.[9]

Network theory is a sub-theory of complex systems theory.[10] Networks of complex systems have several intrinsic features or theoretical foundations that can help us analyze various phenomena in international relations. These intrinsic features are holism at the macro level, nonlinearity at the meso level, and hubs at the micro level, as shown in Figure 1 and Table 1.[11] Holism is applied in analysis of international phenomena in terms of structures and systems, and nonlinearity is useful in analyzing mutual relations and

[8] Carsten Rauch, "Challenging the Power Consensus: GOP, CINC, and Power Transition Theory," *Security Studies*, Vol. 26, No. 4 (2017), pp. 644-645; Robert Gilpin, *War and Change in World Politics* (Cambridge University Press, 1981), pp. 25-28.
[9] Chad Whelan, *Network and National Security: Dynamics, Effectiveness and Organisation* (New York: Routledge, 2016), pp. 12-13; Edward L. Kick, Laura A. Mckinney, Steve McDonald, and Andrew Jorgenson, "A Multiple-Network Analysis of the World System of Nations, 1995-1999," in John Scott and Peter J. Carrington, eds., *The SAGE Handbook of Social Network Analysis* (London: SAGE, 2011), p. 312.
[10] Giorgio Turchetti, "From Dynamical System to Complex Systems," in Vieri Benci, Paola Cerrai, Paolo Freguglia, Giorgio Israel, and Claudio Pellegrini, eds., *Determinism, Holism, and Complexity* (New York, Springer Science & Business Media, 2003), p. 146; Christian Stary, "System-of-System Design Thinking on Behavior," in Gianfranco Minati, Eliano Pessa, and Ignazio Licata, eds., *Second Generation General System Theory: Perspective in Philosophy and Approaches in Complex Systems* (Basel: MDPI, 2017), p. 117.
[11] On the level of networks, see Rishabh Narang, Sanjay Misra, and Ringka Goyal, "An Empirical Study on the Role of Macro-Meso-Micro Measures in Citation Networks," in Sanjay Misra, Osvaldo Gervasi, Beniamino Murgante, Elena Stankova, Vladimir Korkhov, Carmelo Torre, Ana Maria A.C. Rocha, David Taniar, Bernady O. Apduhan, and Eufemia Tarantino, eds. *Computational Science and Its Application – ICCSA 2019* (Cham: Spring, 2019), p. 344.

interactions between states. Hubs provide a basis for analyzing the influence of each state actor.

Figure 1. Levels of complex networks

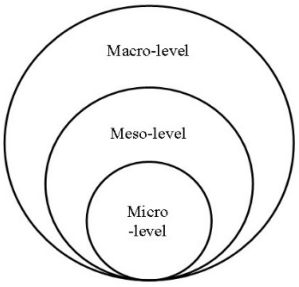


Table 1. Features and measurements of complex networks by level

Level of complex networks	Feature of complex networks	Network measurement
Macro level	Holism (structure)	Betweenness centrality
Meso level	Nonlinearity (interaction)	Eigenvector centrality
Micro level	Hub (influence)	Weighted out-degree centrality

Network analysis provides measurements to assess the influence and importance of each node at each network level, as shown in Table 1. Betweenness centrality is useful for measuring how much influence a node has in terms of structures at the macro level. Eigenvector centrality helps to measure how much a node interacts with other adjacent important nodes at the meso level. Finally, weighted out-degree centrality is focused on one single node, showing the node's influence as a hub on other nodes at the micro level.

Our reasons for applying a network perspective in the analysis of the hegemonic transition between the US and China are as follows. First, we can analyze the influence of these states and hegemonic transitions between them in the context of structured

international relations from the perspective of holism.[12] Network analysis allows measurement of structures and systems that can be described with relational concepts.[13] Network analysis does not focus on just one state actor, but rather on how much influence the state exerts in structured and systemic international relations, also encompassing the concept of interdependence. As globalization has progressed, interdependence among states has increased; more powerful states are able to use this structured interdependence to coerce others.[14]

Second, applying a network perspective allows us to analyze the hegemonic transition between two powerful states among the interactions of all states in nonlinear terms, which is a fundamental advantage of complex networks theory. The basic premise in network analysis is that each node interacts with all others, allowing researchers to explain complex phenomena and map the puzzling behavior of various actors.[15] Researchers have examined various examples, such as the US and its allies or the policies of NATO in international relations;[16] as we shall see, network analysis is also applicable to global

[12] "The basic insight of social network analysis is that social structure is an emergent property of the networks of relationships in which individuals are embedded." Peter J. Carrington, "Social Network Research," in Silvia Domínguez and Betina Hollstein, eds., *Mixed Methods Social Networks Research: Design and Application* (New York: Cambridge University Press, 2014), p. 35.
[13] Stanley Wasserman and Katherine Faust, *Social Network Analysis: Methods and Application* (New York: Cambridge University, 1994), p. 17.
[14] Henry Farrell and Abraham L. Newman, "Weaponized Interdependence: How Global Economic Networks Shape Coercion," *International Security*, Vol. 44, No. 1 (Summer 2019), pp. 45-53.
[15] Robert Jervis, "Complexity and the Analysis of Political and Social Life," *Political Science Quarterly*, Vol. 112, No, 4 (1997-1998), p. 578.
[16] Zeev Maoz, Lesley G. Terris, Ranan D. Kuperman, and Ilan Talmud, "International Relations: A Network Approach," in Alex Mintz and Bruce Russett, eds., *New Directions for International Relations: Confronting the Method-of-Analysis Problem* (Lanham, MD: Lexington Books), pp. 38-39.

economic systems.[17] It seems intuitive that superpowers[18] exert influence over other states, but they also interact with each other and are influenced by small or medium powers.[19]

Lastly, use of network centrality in the analysis is very appropriate in analyzing changes in influence and hegemonic transitions between superpowers. The first task is to find a hub within the topology from a network point of view. Network centrality implies a high position in a status hierarchy and different degrees of control over valued resources.[20] Using this concept of network centrality, we can identify central states as hubs in international relations and analyze the possibility of hegemonic transitions between superpowers.

The goal of this research is twofold. First, we present a network analysis of the hegemonic transition between the US and China, demonstrating that the complex networks perspective can be applied to the study of international relations. Then, we define hegemony and network centrality and suggest that these two concepts can be mutually coincident. Finally, we identify network indicators to measure the hegemonic

[17] "In the global economic system, countries and other economic institutions are connected through various economic channels ranging from commodity and capital trading to political and administrative partnerships." Kyu-min Lee, Jae-suk Yang, Gunn Kim, Jaesung Lee, Kwang-il Goh, and In-mook Kim, "Impact of the Topology of Global Macroeconomic Network on the Spreading of Economic Crises," *PLoS ONE*, Volume 6, Issue 3 (March 2011), p. 1.

[18] "The criteria for superpower status are demanding in that they require broad spectrum capabilities exercised across the whole of the international system. Superpowers must possess first class military-political capabilities, and the economies to support such capabilities." Barry Buzan, "Great Powers," in Alexandra Gheciu and William C. Wohlforth, eds., *The Oxford Handbook of International Security* (Oxford: Oxford University Press, 2018), p. 640.

[19] "The interactions among the actors (states) in the system may range from intermittent armed conflict to the high levels of economic and cultural interdependence of the modern world. Together, diplomatic, military, economic, and other relationships among states constitute the functioning of the international system." See Robert Gilpin, p. 27.

[20] R. S. Burt, *Toward a Structural Theory of Action* (New York: Academic Press, 1982), p. 12.

transition from the perspective of complex networks.

Second, applying previously defined concepts and theories, we analyze various trade data from the US and China with a network analysis tool to evaluate the progress of the hegemonic transition between the two superpowers. Unlike approaches that simply utilize indicators such as GDP, our approach allows us to assess the hegemonic relationship between these states and their influence as hegemonic leaders in networked international relations.

We argue that: (1) the US still maintains hegemony in the military, political, and cultural domains; (2) in the economic domain, a hegemonic transition and competition are in progress, and one indicator characteristically shows that China is already ahead; (3) although one indicator at the micro level shows China's dominance, indicators at the meso and macro levels indicate that the US is still ahead. In other words, in the economic realm, hegemony has shifted from the US to China at the micro level, but the US still retains hegemony at the meso and macro-levels of complex networks. In summary, China may have achieved hegemony at the micro level of the economy, but the US continues to maintain dominance at the meso and macro-economic levels and at all levels of the military, politics, and culture.

2. Network analysis of hegemonic transitions

Before conducting a network analysis of the hegemonic transition between the US and China, the following important conceptual and theoretical discussions should be offered: (1) a conceptual discussion of hegemonic transition, which is the main focus of this study, and (2) a practical discussion of whether the concepts and theories of complex networks are applicable to the study of international relations. Consideration should also be given to how to interpret and apply various indicators of network centrality to measure hegemony in international relations research.

2. 1. Conceptual discussion of hegemonic transitions

Dictionary definitions of hegemony include "control by one country, organization, etc. over other countries,"[21] "the social, cultural, ideological, or economic influence exerted by a dominant group,"[22] and "the predominance of one state or social group over others".[23] Summarizing these dictionary definitions, we define hegemony as the social, economic, and cultural predominance of one state or organization and the resulting

[21] *Oxford Learner's Dictionary*, s.v. "Hegemony," accessed September 9, 2019, https://www.oxfordlearnersdictionaries.com/definition/english/hegemony?q=hegemony.
[22] *Merriam-Webster Dictionary*, s.v. "Hegemony," accessed September 9, 2019, https://www.merriam-webster.com/dictionary/hegemony.
[23] *The American Heritage Dictionary*, s.v. "Hegemony," accessed September 9, 2019, https://www.ahdictionary.com/word/search.html?q=hegemony&submit.x=22&submit.y=22.

influence on others.

Hegemony has been variously defined in studies of international relations. The term 'hegemony' was originally used by Marxists like Stalin and Lenin to refer to political leadership.[24] Gramsci, an Italian Marxist, coined the term 'cultural hegemony' to incorporate both cultural and political leadership,[25] which led to the formation of the current concept of hegemony.

John J. Mearsheimer defined hegemony as the domination of the entire world,[26] and David Wilkinson referred to hegemony as "a highly unequal political or politico-military influence relationship" and "a unipolar structure of capability matched by a unipolar structure of influence".[27] Donald J. Puchala described hegemony as "a state of international affairs, a condition or situation which arises when a single state attains preponderant power and elects to use its power to manage the international system in international relations".[28] According to John A. Agnew, hegemony is not simply the exercise of raw military, economic, and political power, but it is also the enrollment of others in the exercise of your power by cajoling and coercing them, convincing them that they should want what you want. It also represents "the binding together of people, objects, and institutions around cultural norms and standards that emanate over time and

[24] Thomas R. Bates, "Gramsci and the Theory of Hegemony," *Journal of the History of Ideas*, Vol. 36, No. 2 (1975), p. 352.
[25] Thiven Reddy, *Hegemony and Resistance: Contesting Identities in South Africa* (New York: Routledge, 2018), p. 3.
[26] John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York: W.W. Norton Company, 2014), p. 40.
[27] David Wilkinson, "Unipolarity without Hegemony," *International Studies Review,* Vol. 1, No. 2 (1999), p. 142.
[28] Donald J. Puchala, "World Hegemony and the United Nations," *International Studies Review*, Vol. 7, No. 4 (2005), p. 572.

space from seats of power occupied by authoritative actors."[29] Putting all these concepts and explanations together, we state that hegemony in international relations refers to the power of a state actor with an overwhelming ability to form an international system and order in the fields of economy, politics, the military, and culture through coercive or non-coercive means and ways.

We intend to use the term 'hegemonic transition' separately from the term 'power transition', which is the main theory in the domain of international relations. Power transition theory was proposed by Organski, who emphasized the sharing of power, not the balance of power, and explained the causes of war and the conditions of peace via power transition theory.[30] However, we refrain from analyzing international phenomena based on this theory in this study. Instead, we use the term 'hegemonic transition' to analyze the phenomenon in which hegemony is being transferred from one superpower to another.

A few other researchers used the term 'hegemonic transition' as well. Barry K. Gills described hegemonic transition as "hegemonic reorganization entailing shifts in the locus of accumulation in the world economy";[31] he also provided an historical analysis of changes in hegemonic power in East Asia.[32] Mark Beeson used the concept of hegemonic

[29] John A. Agnew, *Hegemony: The New Shape of Global Power* (Philadelphia: Temple University Press, 2005), pp. 1-2.
[30] A. F. K. Organski, *World Politics* (New York: Alfred A. Knopf, 1968), pp. 363-376; Ronald L. Tammen, "The Organski Legacy: A Fifty-Year Research Program," *International Interactions*, Vol. 32 (2008), pp. 315-318.
[31] Barry K. Gills, "Hegemonic Transitions in the World System," in Andre Gunder Frank and Barry K. Gills, eds., *The World System* (New York: Routledge, 1999), p. 115.
[32] Barry K. Gills, "The Hegemonic Transition in East Asia: A Historical Perspective," in Stephen Gill, ed., *Gramsci, Historical Materialism and International Relations* (New York: Cambridge University Press, 1994), pp. 186-187.

transition in his research to analyze the competition between the US and China in East Asia.[33] Gunitsky used the term 'hegemonic transition' in discussing structural changes in international relations, which contributed to the formation of democracy in the 20th century.[34]

In this study, based on the conceptual discussion provided above, we define the concept of 'hegemonic transition' as follows: hegemonic transition is the process in which unrivaled power and overwhelming ability in the fields of economy, politics, military, and culture is transferred from an existing superpower to an emerging superpower to form an international system and order.

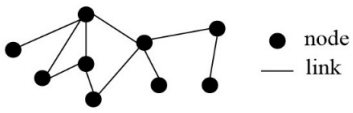
2. 2. Complex networks for IR research

In analyzing ties and mutual influence of states in international relations, network analysis provides a useful perspective and method. As shown in Figure 2, a network is a collection of linked nodes, and network analysis is a technique used to map relationships between nodes.[35] Applying the concepts of node and link to international relations, we see that one node represents one state actor, and links represent various relationships such

[33] Mark Beeson, "Hegemonic Transition in East Asia? The Dynamics of Chinese and American Power," *Review of International Studies*, Vol. 35 (2009), pp. 95-98.
[34] Seva Gunitsky, "From Shocks to Waves: Hegemonic Transitions and Democratization in the Twentieth Century," *International Organization*, Vol. 68, No. 3 (2014), pp. 564-566.
[35] Jay Llebowitz, *Social Networking: The Essence of Innovation* (Lanham: Scarecrow press, 2007), p. 4.

as trade or diplomacy between states,[36] channeling information, resources, or other forms of influence.[37]

Figure 2. Key concepts of network analysis



Network analysis may be divided into three categories, which can be applied to the study of international relations. Nodes are analyzed at the macro, meso, and micro levels, and they can also be described as follows with the focus on nodes: at the node level, at the level of grouped nodes, and at the overall structure level where all nodes are connected.[38] These perspectives can be applied to international relations research as follows. At the macro level, we measure the extent to which a state plays a central role in the structure of the relations among all states. At the meso level, we determine the number of adjacent influential states with which a state interacts. Finally, at the micro level, we measure how influential a state is in networked international relations.

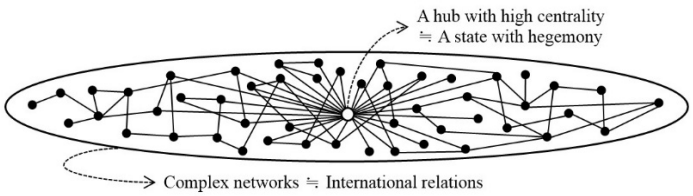
Each level has its own measurement indicators and characteristics. Betweenness

[36] Emilie M. Hafner-Burton, Miles Kahler, and Alexander H. Montgomery, "Network Analysis for International Relations," *International Organization*, Vol. 63, Issue 3 (July 2009), p. 562.
[37] Henry Farrell and Abraham L. Newman, p. 50.
[38] On the level of networks, see Jeanne H. Ballantine, Keith A. Roberts, Kathleen Odell Korgen, *Our Social World: Introduction to Sociology* (SAGE Publications. 2018), pp. 121-122; Christina Prell, *Social Network Analysis: History, Theory and Methodology* (SAGE Publications, 2012), pp. 93-174; Chad Whelan, p. 117.

centrality, an indicator at the macro level, shows how central a node is in the overall structure. Eigenvector centrality at the meso level indicates how much a node interacts with adjacent important nodes, and weighted out-degree centrality at the micro level shows how influential a given node is. In other words, these levels and indicators of networks can be used to assess whether a state actor is a hegemon, influential in the overall structure of international relations, or whether it has some influence over many other states, but not the whole structure.

We conduct a network analysis on the hegemonic transition between the US and China based on these aforementioned basic concepts and levels. First, however, we provide a discussion on the applicability of the network perspective and its concepts to the study of international relations. Accordingly, we examine several key elements of complex networks and their application to international relations, thereby establishing a conceptual and theoretical basis for the analysis. We begin by matching hegemony with centrality of a network, as shown in Figure 3.

Figure 3. Matching of two constructs: complex networks and international relations



The following intrinsic features of complex networks can be adapted and applied to the study of international relations. First, network theory assumes holism, which represents wholes rather than their parts and is the opposite of reductionism.[39] Researchers pursuing reductionism attempt to explain phenomena from the perspective of smaller entities, and then analyze them in small pieces and understand the whole based on them.[40] In contrast, researchers seeking holism, such as those using complex network theory, attempt to understand the whole itself and its structure, informed by actors' interactions.[41]

This complex network viewpoint coincides with one main view among theories of international relations analyzing the whole structure: the neo-realism proposed by Kenneth Waltz. A representative international politics theory, neo-realism is a holistic theory of the global system of power and power structures.[42] World systems theory also explains the role of structures in international relations in the view of structuralism.[43] These views of complex networks based on holism and a holistic view of international

[39] See Geoff Mulgan, "Connexity Revisited," in Helen McCarthy, Paul Miller, and Paul Skidmore, eds., *Network Logic: Who Governs in an Interconnected World?* (London: Demos, 2004), p. 54; Valerie A. Haines, "Social Network Analysis, Structuration Theory and the Holism-Individualism Debate," *Social Networks* (1988), pp. 159-162; Michael J. Radzicki, "System Dynamics and Its Contribution to Economics and Economic Modeling," in Robert A. Meyer, ed., *Complex Systems in Finance and Econometrics* (Springer Science & Business Media, 2011) p. 36.

[40] Ricahrd H. Jones, *Reductionism: Analysis and the Fullness of Reality* (London: Associated University Press, 2000), pp. 162-169.

[41] Jose M. Sallan and Oriol Lordan, *Air Route Networks Through Complex Networks Theory* (Amsterdam: Elsevier, 2019), pp. 45-46; Hua-Wei Shen, *Community Structure of Complex Networks* (New York: Springer, 2013), pp. 2-3.

[42] See Kenneth N. Walts, *Theory of International Politics* (Long Grove: Waveland Press, 2010), pp. 18-101; Chris Farrands, Imad El-Anis, Roy Smith, and Lloyd Pettiford, *A New A-Z of International Relations Theory* (London and New York: I.B.Tauris, 2015), p. 142; John Baylis, Steve Smith, and Patricia Owens, *The Globalization of World Politics: An Introduction to International Relations* (Oxford: Oxford University Press, 2011), p. 155; R. J. Barry Jones, *Globalisation and Interdependence in the International Political Economy: Rhetoric and Reality* (London, New York: Bloomsbury, 2013), pp. 9-10.

[43] See Immanuel Maurice Wallerstein, *World Systems Analysis: An Introduction* (Durham and London: Duke University Press, 2004), pp. 1-40; Alexander E. Wendt, "The Agent-structure Problem in International Relations Theory," *International Organization*, Vol. 41, No. 3 (Summer 1987), pp. 344-349.

relations are intrinsically linked.

Second, research in this area analyzes phenomena from a nonlinear point of view.[44] A linear relationship inherently entails cause-and-effect; this is the most common theoretical point of view in most disciplines.[45] By contrast, the viewpoint of complex systems emphasizes that an effect can be formed by the interactions of components or actors and have multiple causes.[46] In other words, the interactions of components or actors in networks cause nonlinearity, which increases complexity.[47]

This nonlinear perspective is useful in international relations research, where the interactions of various actors have multiple effects.[48] Complex network research is basically the study of relationships,[49] and international relations research is the study of the relationships and interactions of state actors.[50] Nonlinearity is inherent in networked

[44] See Andrey Dmitriev, Victor Dmitriev, Olga Tsukanova, and Svetlana Maltseva, "A Nonlinear Dynamical Approach to the Interpretation of Microblogging Network Complexity," in Chantal Cherifi, Hocine Cherifi, Márton Karsai, Mirco Musolesi, eds., *Complex Network & Their Applications VI: Proceeding of Complex Network 2017* (Cham: Springer International Publishing, 2017), pp. 390-392; Xiao Fan Wang, "Complex Networks: Topology, Dynamics and Synchronization," *International Journal of Bifurcation and Chaos*, Vol. 12, No. 5 (2002), pp. 886-887; Adilson E. Motter, Manuel A. Mat´ıas, J. Kurths, and Edward Ott, "Dynamics on Complex Networks and Applications," *Physica D*, 224 (2006), pp. 1-3; Aura Reggiani and Peter Nijkamp, "Simplicity in Complex Spatial Systems," Aura Reggiani and Peter Nijkamp, eds., *Complexity and Spatial Networks: In Search of Simplicity* (New York: Springer Science & Business Media, 2009), pp. 1-3.

[45] See John T Luhman and Ann L Cunliffe, *Key Concepts in Organization Theory* (Sage, 2012), pp. 24-25; Cliff Hooker, "Introduction to Philosophy of Complex Systems: B," in Cliff Hooker, ed., *Philosophy of Complex Systems* (Oxford: Elservier, 2011), p. 874; Francis Heylighen, Paul Cilliers, and Carlos Gershenson, "Philosophy and Complexity", in Jan Bogg and Robert Geyer, eds., *Complexity, Science and Society* (Oxford, New York: Radcliffe Publishing, 2007), pp. 118-119; Diana Richards, "Nonlinear Modeling: All Things Suffer Change," in Diana Eva-Ann Richards and Diana Richards Doyle, eds., *Political Complexity: Nonlinear Models of Politics* (University of Michigan Press, 2000), p. 1.

[46] See José Fonseca, *Complexity and Innovation in Organizations* (London and New York: Routledge, 2002), pp. 69-75; Göktuğ Morçöl, *A Complexity Theory for Public Policy* (New York and London: Routledge, 2012), p. 36.

[47] On correlation of interactions, nonlinearity, and complexity, see Péter Érdi, *Complexity Explained* (Berlin: Springer Science & Business, 2008), pp. 5-55.

[48] On international relations studies applying the concept of nonlinearity, see Emilian Kavalski, "Complexity IR: Disturbing the Deep Newtonian Slumber," in Emilian Kavalski, ed., *World Politics at the Edge of Chaos: Reflections on Complexity and Global Life* (New York: SUNY Press), p. 256; Sean T. Lawson, *Nonlinear Science and Warfare: Chaos, Complexity and the U.S. Military in Information Age* (London and New York: Routledge, 2014), pp. 107-113; Antoine Bousquet and Simon Curtis, "Beyond Models and Metaphors: Complexity Theory, Systems Thinking and International Relations," *Cambridge Review of International Affairs*, Vol. 24, No. 1 (March 2011), pp. 47-51.

[49] Kurths, Jürgen, Jobst Heitzig, and Norbert Marwan, "Approaching Cooperation via Complexity," in Dirk Messner and Silke Weinlich, eds., *Global Cooperation and the Human Factor in International Relations* (London and New York: Routledge, 2016), p. 161.

[50] Rosa Gomez Dierks, *Introduction to Globalization: Political and Economic Perspectives for the New Century* (Chicago: Burnham Inc., 2001), pp. 30-31.

international relations where the interactions of state actors, non-state actors, and various other actors take place.[51] Thus, complex networks and international relations have a common intrinsic characteristic of nonlinearity, to which various analytical tools of complex networks can be applied. In this study, we utilize these tools to analyze the complexities of international relations.

Finally, complex networks also have hubs, that is, important and influential nodes within the network; preferential attachment is the key mechanism for creating hubs. In a complex network, a small number of nodes (components or actors) is linked with a much larger number of nodes.[52] These hubs are authorities among nodes because they are in the important position of connecting many nodes.[53] In addition, they have a higher centrality index than other nodes, indicating their own importance and influence, which means that they are dominant in their network structures. Transformation of common nodes into hubs is affected by the preferential attachment mechanism, in which new nodes prefer to be connected to influential nodes that are already connected to many other nodes.[54]

Hubs are prominent in international relations as well. A hub is generally identified as

[51] Effie Charalampaki, "Conceptualising European Security Post-Brexit: Turbulence, Complexity and Interdependence," in Cornelia-Adriana Baciu and John Doyle, eds., *Peace, Security and Defence Cooperation in Post-Brexit Europe: Risks and Opportunities* (Cham: Springer, 2019), p. 213.
[52] Mitchell, Melanie, "Complex systems: Network thinking," *Artificial Intelligence*, 170 (2006), p. 1198.
[53] M. E. J. Newman, *Networks: An Introduction* (New York: Oxford University Press, 2010), p. 75.
[54] Albert-László Barabási, *Linked: How Everything is Connected to Everything Else and What It Means for Business, Science, and Everyday Life* (New York: Basic Books, 2014), pp. 63-65; pp. 86-88.

a great power, or hegemon, with overwhelming influence in the international network.[55] The concept of preferential attachment can be applied to explain the emergence of such a great power or hegemon in international relations. The bandwagon effect, one of the main concepts in international relations theories, is similar to preferential attachment. It is as follows: a state (hub) allows connections from other states, and together they eventually form a coalition; non-hub states can accordingly join a large coalition by attaching themselves to the hub.[56]

2. 3. Hegemony and network centrality

Among various network analysis methodologies, centrality analysis is suitable for assessing states' power and analyzing hegemonic transitions between powerful states. Two guiding principles of network analysis are that networks are more likely to be linked through a central node, and that nodes that are more central in networks or structures are more likely to be influential or powerful.[57] Accordingly, network centrality means power, prestige, popularity, dominance, and prominence.[58] A general centrality measure

[55] G. John Ikenberry, "The Liberal Sources of American Unipolarity," in G. John Ikenberry, Michael Mastanduno, William C. Wohlforth, eds., *International Relations Theory and the Consequences of Unipolarity* (Cambridge University Press, 2011), pp. 223-224; Ehsan M. Ahrari, *The Great Powers versus the Hegemon* (Springer, 2011) pp. 2-4.
[56] Song Yang, Franziska B. Keller, and Lu Zheng, *Social Network Analysis: Methods and Examples* (SAGE, 2017), p. 195.
[57] Robert A. Hanneman and Mark Riddle, "Concepts and Measure for Basic Network Analysis," in John Scott and Peter J. Carrington, eds., *The SAGE Handbook of Social Network Analysis* (London: SAGE, 2011), p. 363.
[58] Peter J. Carrington, p. 54.

represents how predominant a node is and to how many nodes it is connected.[59] High centrality generally means that the node is connected to a relatively large number of nodes, whereas low centrality means that it is interconnected with a small number of nodes. Applying these concepts of network centrality to international relations, we can empirically and structurally analyze state influence and use the analysis results to evaluate hegemonic transitions between superpowers.

Although there are various types of network centrality analysis, we focus on three types of centrality applicable to international relations, as shown in Table 2. As mentioned briefly above, centrality depends on levels within networks. In this study, two types of centrality, betweenness centrality and eigenvector centrality, are measured from the macroscopic and mesoscopic perspectives, respectively. A third type, weighted out-degree centrality, is a microscopic measure focused on a given node rather than being viewed at the macroscopic level. Though these three types of centrality differ in certain respects, all are based on the same premise: they are all affected by network structures and systems.

[59] Stanley Wasserman and Katherine Faust, pp. 172–173.

Table 2. Three types of network centrality

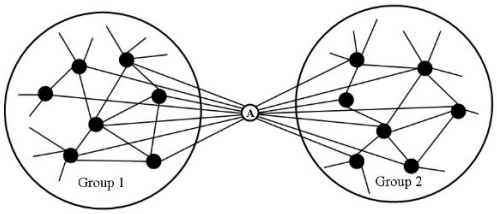
Level of complex networks	Network centrality	Interpretation in international relations research	Meaning
Macro level	Betweenness centrality	Bridgeness between grouped states	Connections with grouped states of a state in a central position
Meso level	Eigenvector centrality	Connectivity with important states	Connections with important states of a given state
Micro level	Weighted out-degree centrality	Weighted unidirectional connectivity affecting all connected states	Extent of influence of a given state

2. 3. 1. Betweenness centrality: Bridgeness between grouped states

First, we use betweenness centrality to assess connections between grouped states and a state in a central position. Betweenness centrality differs from the other two types of centrality. It measures the extent to which a node falls between other nodes in a network and its importance as a link in the chains of contacts among nodes.[60] As shown in Figure 4, node A lies on a bridge joining two groups of other nodes. Nodes in each group must pass through node A to be linked to other nodes in other groups. In this case, the betweenness centrality of node A is higher than that of other nodes.

[60] M, E. J. Newman, p. 7.36; Peter J. Carrington, p. 55; Wouter de Nooy, Andrej Mrvar, and Vladimir Batagelj, p. 150.

Figure 4. Betweenness centrality



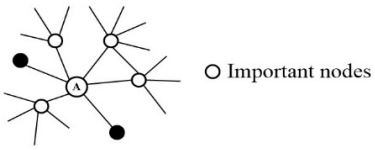
Betweenness centrality is important in evaluating hegemony in international relations; it helps determine the importance of a given state as a bridge between states economically and politically. All states form clustered economic and political groups according to their geopolitical location, culture, and identity. These clustered groups are linked by superpowers that influence them all. Superpowers that are influential around the world play a central role in bridging gaps between these clustered groups, which can be important in evaluating who has hegemony in the world.

Betweenness centrality is also important as a proxy indicator for the influence or hegemony of a state; it is measured at the macro level. As previously mentioned, hegemony may be defined as a strong ability to form international systems and bring order to international relations. A state with hegemony may have considerable influence on international structures and systems. In other words, betweenness centrality is an appropriate mathematical and conceptual indicator of hegemony measuring the importance and influence of a node within the overall network structure.

2. 3. 2. Eigenvector centrality: Connectivity with important states

Second, we use eigenvector centrality to assess whether a state has ties with important states in international relations. According to network theory, a node's importance in a network is increased by having connections to other nodes that are themselves important.[61] In other words, the more a node is linked to important nodes, the more important the node is, and the more influence it can exert.[62] As shown in Figure 5, node A is connected to important nodes which are connected to many other nodes. In this case, node A has higher eigenvector centrality than other nodes.

Figure 5. Eigenvector centrality



This concept of eigenvector centrality can be used to determine the number of important states to which a given state is connected, which in turn represents its influence in international relations. Structure and order in international relations come about due to the influence of strong states such as those belonging to the G2, G7, or G20. Various

[61] M, E. J. Newman, p. 72.
[62] Wouter de Nooy, Andrej Mrvar, and Vladimir Batagelj, *Exploratory Social Network Analysis with Pajek* (New York: Cambridge University Press, 2011), p. 153.

international orders in the areas of economy, environment, and security are established in relations between strong states.[63] Taking this into consideration, one state's influence must be assessed by its interactions with these strong states; a given state must interact with many strong states in order to be considered an important state. Hence, eigenvector centrality is a key indicator of how important and influential a state is in international relations.

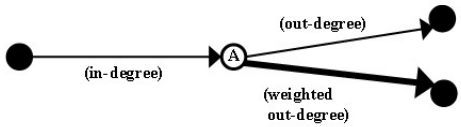
2. 3. 3. Weighted out-degree centrality: Weighted unidirectional connectivity affecting all connected states

Finally, weighted out-degree centrality can be used to analyze the unilateral influence that one state exerts on other states. If degree centrality is directional, out-degree centrality can be defined as a type of centrality that exerts influence in only one direction. For example, in a trade network between states, a state with high out-degree centrality would be a heavy exporter.[64] In Figure 6, one directional link leads to node A and two directional links from node A lead to two other nodes. In-degree centrality is indicated by the link entering node A, and out-degree centrality is represented by the two links flowing out of node A. Figure 6 also shows the two different thicknesses of the two directional

[63] Andrew F. Cooper and Ramesh Thakur, *The Group of Twenty (G20).* (New York: Routledge, 2013), pp. 3–4.
[64] Stanley Wasserman and Katherine Faust, pp. 125–127.

links from node A, indicating that these two links have different weights. Applying this concept to trade relations between states, the weight can be explained as the amount exported by a given state.

Figure 6. Weighted out-degree centrality



Ultimately, to assess the influence of one superpower on other states in international relations, we must analyze how much it affects other states. A state with hegemony is called a dominant state, one that is very important in the international system.[65] To compare and analyze the hegemonic transition between superpowers in this study, we focus on their influence on others in only one direction.

As mentioned earlier, weighted out-degree centrality is measured at the micro level. This type of centrality shows how much influence one single node has on other nodes. Although it is a meaningful indicator in terms of quantity, it is less meaningful than betweenness and eigenvector centrality in terms of quality. Thus, a superpower with relatively high out-degree centrality may not have a significant impact on structures and

[65] Woosang Kim and Scott Gates, "Power Transition Theory and the Rise of China," *International Area Studies Review*, Vol. 18 (2015), p. 220.

systems within international relations, but may have considerable influence on individual states in terms of quantity. To refine our definition, a hegemon should have not only high weighted out-degree centrality, but also high eigenvector centrality at the meso level and high betweenness centrality at the macro level. This is necessary for a state to affect the overall structure of international relations.

3. Research Design

3. 1. Data sources

In this study, we use data from the economic, political, military, and cultural sectors to analyze the hegemonic transition between the US and China. For this analysis, we collected trade data in which the concept of a state's power potential was inherent.[66] As detailed in Table 3, data provided by UN Comtrade, the international trade statistics database, were collected and categorized by code from 1996 to 2018.[67]

[66] Joanne Gowa and Edward D. Mansfield, "Power Politics and International Trade," *American Political Science Review*, Vol. 87, No. 2 (1993), p. 408.
[67] "UN COMTRADE is the pseudonym for United Nations International Trade Statistics Database. Over 170 reporter countries/areas provide the United Nations Statistics Division (UNSD) with their annual international trade statistics data detailed by commodities/service categories and partner countries." "What is UN Comtrade?," *United Nations International Trade Statistics Knowledgebase,* United Nations, https://unstats.un.org/unsd/tradekb/Knowledgebase/50075/What-is-UN-Comtrade.

Table 3. Collected data by sector

Sector	Commodity list	Code number of commodity & description
Economy	All commodities	Total: all commodities
Politics and military	Arms	Code 9306: Bombs, grenades, mines, missiles, ammunition, etc.
Culture	Cultural goods	Code 37: Photographic or cinematographic goods Code 49: Printed books, newspapers, pictures, etc. Code 97: Works of art, collectors' pieces, and antiques

In the economic sector, we use trade data of all commodities between all states as an indicator of centrality. Data from the political, military, and cultural sectors are also used, as described in Table 3. Using these data in our network centrality analysis allows us to determine states' economic influence in international relations; changes in the centrality of certain states can then be traced to analyze hegemonic transitions occurring in the economic sector.

We use arms trade data to analyze the political and military influences of the US and China in international relations. Exporting weapons is not only economically meaningful, but also politically and militarily significant. Supplying weapons to particular states means strengthening the military position of the importing states, which also means strengthening the political friendship between buyer and seller.[68] For this portion of the analysis, we use data with code number 9306 provided by UN Comtrade, which refers to strategic weapons such as bombs and missiles rather than common weapons such as

[68] Ron Smith, Anthony Humm, and Jacques Fontanel, "The Economy of Exporting Army," *Journal of Peace Research*, Vol. 22, No. 3 (1985), p. 243.

ammunition or weapon accessories.

Finally, we use data from the cultural goods trade to measure the cultural influence of the US and China. While data from the areas described above are for measuring the hard power of a state, data on cultural goods trade are for measuring its soft power.[69] Joseph Nye, who coined the term 'soft power', noted the importance of culture as a form of soft power in international relations:

> "Culture is the set of practices that create meaning for a society, and it has many manifestations. It is common to distinguish between high culture such as literature, art, and education, which appeals to elites; and popular culture, which focuses on mass entertainment.[70]"

Soft power means the ability to achieve desired outcomes through attraction rather than coercion.[71] In this study, to represent soft power, we use various data about cultural goods exported from the US and China. By analyzing trade in photographs, books, newspapers, and art, we can assess how much soft power these two states have over other states.[72] We can then compare the results to examine the hegemonic status of the two

[69] Joseph Nye coined the term 'soft power', describing it as "power which occurs when one country gets other countries to want what it wants". Joseph S. Nye, "Soft Power," *Foreign Policy,* No. 80 (1990), p. 166.
[70] Joseph S. Nye, "'Public Diplomacy and Soft Power," *Annals of the American Academy of Political and Social Science*, 616 (March 2008), pp. 96-97.
[71] Robert O. Keohane and Joseph S. Nye, "Power and Interdependence in the Information Age," in Elaine Ciulla Kamarck and Joseph S. Nye, eds., *Democracy.com? : Governance in a Networked World* (Hollis, NH: Hollis Publishing Company, 1999), p. 204.
[72] Cultural productions data used to analyze cultural networks typically include data such as songs, paintings, newspaper articles,

states in terms of culture.

Table 4. Numbers of nodes and links of trade of all commodities by year, 1996–2018

year	nodes	links	year	nodes	links	year	nodes	links
1996	231	8,167	2004	240	21,010	2012	243	22,852
1997	231	11,194	2005	240	21,320	2013	244	23,308
1998	232	13,137	2006	241	21,711	2014	243	22,935
1999	233	14,754	2007	241	22,020	2015	243	22,642
2000	240	18,279	2008	240	22,354	2016	244	22,519
2001	242	18,922	2009	241	22,719	2017	243	21,643
2002	242	19,771	2010	243	23,194	2018	243	20,092
2003	240	20,114	2011	244	23,067			

Collected data are converted into node and link data by year, as shown in Table 4, for the network analysis. This sample table shows the results after converting all commodities trade data of the two states from 1996 to 2018 into node and link data. For example, in 2018, 243 nodes represent 243 states, and 20,092 links mean that 243 states are connected by 20,092 links through mutual trade.

To derive values for weighted out-degree centrality, the link data should be weighted. UN Comtrade not only provides data on trade between states, but also provides values on trades; these values are the amount of trade in dollars. Using this information, we can empirically analyze weighted out-degree centrality, not just out-degree centrality.

meals, sermons, laws, poems, scientific papers, and garments. Paul DiMaggio, "Cultural Networks," in John Scott and Peter J. Carrington, eds., *The SAGE Handbook of Social Network Analysis* (London: SAGE, 2011), p. 287.

3. 2. Network centrality analysis

The network centrality analyses involve use of the following formulas. First, weighted out-degree centrality can be defined as:

$$C_D^W(i) = \sum_j^N w_{i,j},$$

where node j is unidirectionally linked with node i, and wij is the weight given to the link from node i to node j.[73]

Second, eigenvector centrality is expressed by the following equation:

$$C_E(i) = \frac{1}{\lambda} \sum_{j=1}^{n} A_{ij} x_j,$$

where λ is a constant representing the eigenvalue, A_{ij} is the connection of node i and node j in an adjacent matrix A, which is 1 if these nodes are connected and 0 if not. x_j is the centrality value of node j adjacent to node i.[74]

Finally, the equation for betweenness centrality is defined by this equation:

[73] See Tore Opsahl, Filip Agneessens, and John Skvoretz, "Node Centrality in Weighted Networks: Generalizing Degree and Shortest Paths," *Social Networks*, 32 (2010), p. 246; Yang Fan, Suting Ren, Hongbo Cai, and Xuefeng Cui, "The State's Role and Position in International Trade: A Complex Network Perspective," *Economic Modelling*, 39 (2014), p. 74; Bokwon Lee, Kyu-min Lee, Jae-suk Yang, "Network Structure Reveals Patterns of Legal Complexity in Human Society: The Case of the Constitutional Legal Network," *PLoS One* (January 2019), p. 5.

[74] M. E. J. Newman, "Mathematics of networks," L. E. Blume and S. N. Durlauf, eds., *The New Palgrave Encyclopedia of Economics* (Basingstoke: Palgrave Macmillan, 2008), pp. 1-12.

$$C_B(i) = \sum_{j \neq i \neq k} \frac{g_{jk(i)}}{g_{jk}} ,$$

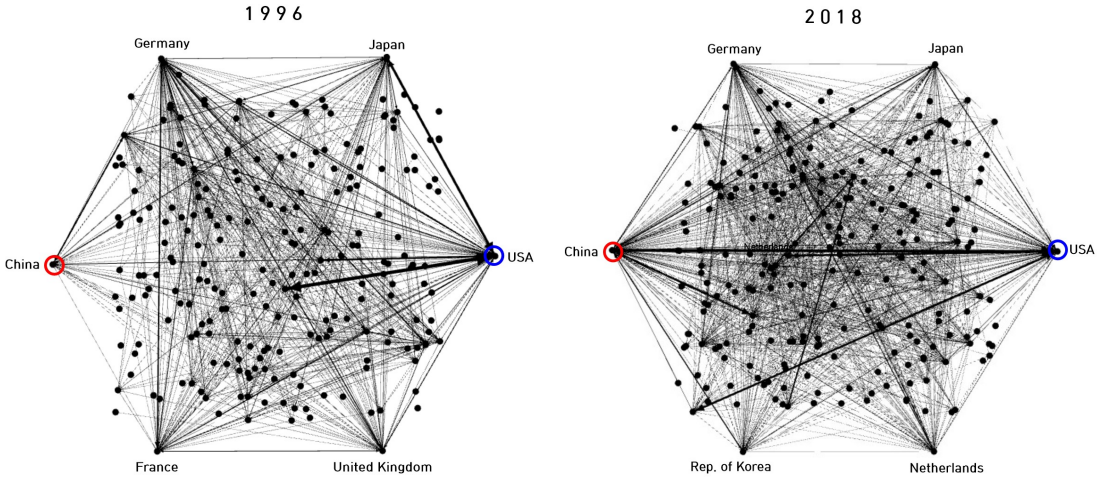
where g_{jk} is the number of binary shortest paths between two nodes, and $g_{jk(i)}$ is the number of those paths that go through node i.[75]

4. Results and Discussion

4. 1. Results of network centrality analysis by sector

4. 1. 1. Economic sector

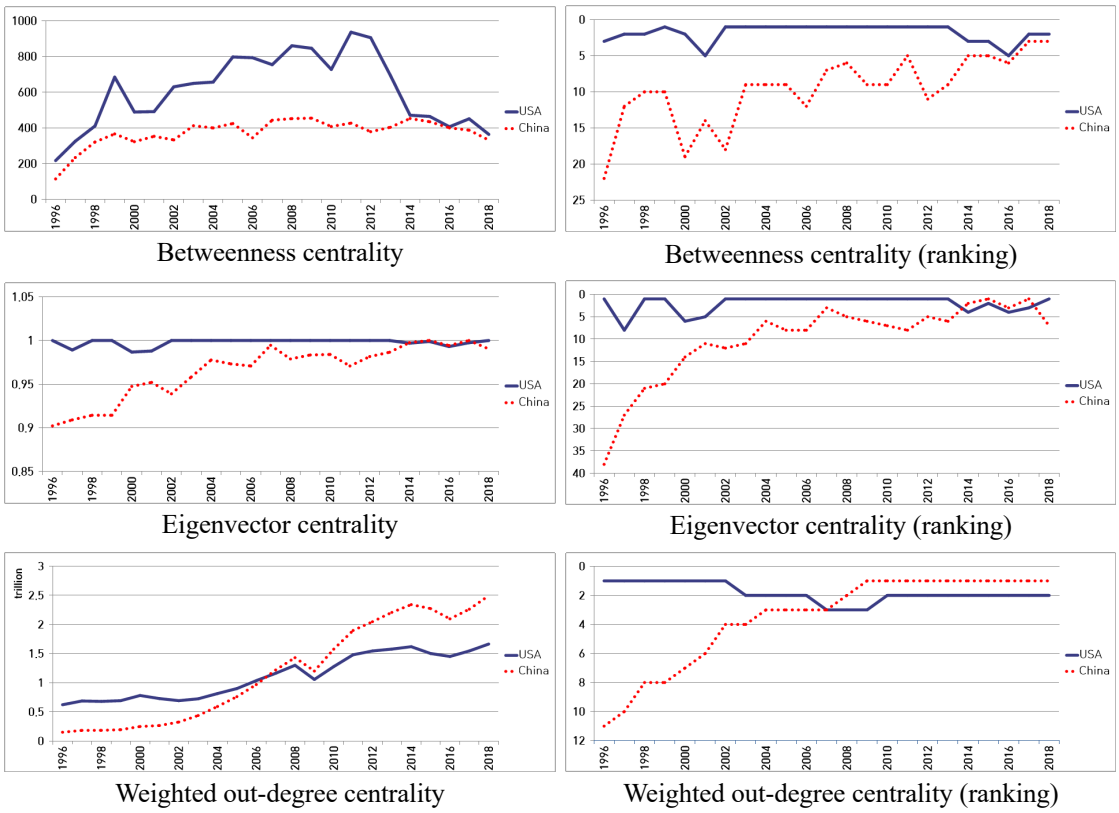
Figure 7. Network topologies of all commodities trade configured with weighted out-degree centrality, 1996 and 2018



[75] Tore Opsahl, Filip Agneessens, and John Skvoretz, p. 247.

Figure 7 shows network topologies in 1996 and 2018, derived from the network analysis on the data of all commodities trade. As this figure shows, China had no significant economic impact on other states in 1996. At that time, traditional powers such as the US, Germany, Japan, France, and the United Kingdom had a great economic impact on the international community. By contrast, the topology of 2018 shows that China had as much economic impact as the US in that year, which means that China has emerged as a G2 in the global economy.

Figure 8. Results of centrality analysis of all commodities trade, 1996–2018



In Figure 8, we see that China has been emerging as a potential hegemon in the

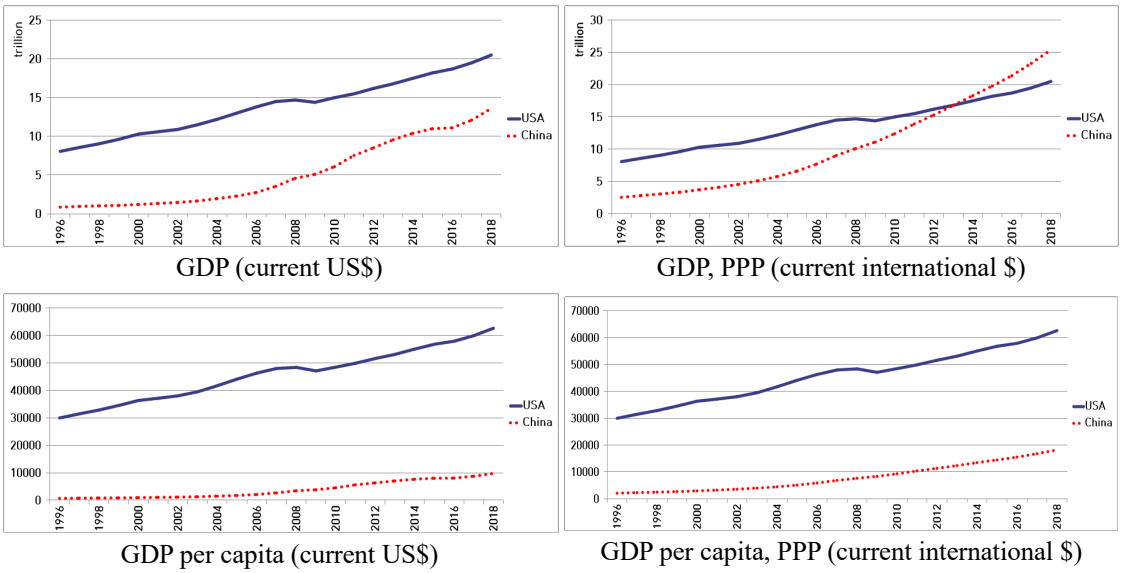
economic domain over time. As the graph of betweenness centrality shows, the gap in centrality between the US and China was very close in 2018, but the US still continued to play the most important bridging role compared to China in the economic domain. The results for eigenvector centrality show that China was linked to more important states than the US from 2014 to 2017. The indicator of weighted out-degree centrality also shows that China has surpassed the US since 2007, when China began to be called G2.[76]

Considering the results reported above, we note that China has been emerging as a new superpower in the economic domain since 1996, and that hegemony is being transferred from the US to China in economic terms. However, the indicators of betweenness centrality and eigenvector centrality at the macro and meso levels show that the US is still ahead, but that of weighted out-degree centrality at the micro level shows that China has moved ahead. Thus, China now has the greatest influence in terms of quantity, while the US still has the greatest influence in terms of quality in international relations.[77] The results also indicate that China has achieved hegemony at the micro level, but the US still maintains hegemony at the meso and macro levels, which affects the structure and systems of international relations.

[76] The term "group of two (G2)" was originally used by C. Fred Bergstenin in 2005 and has subsequently been used to refer to these two great powers in terms of economics and politics. C. Fred Bergsten, *The United States and the World Economy: Foreign Economic Policy for the Next Decade* (Washington, D.C.: Columbia University Press, 2005), pp. 51-53.

[77] Weighted out-degree centrality can be seen as a relatively quantitative measure because it indicates how much influence a node has on how many other nodes. On the other hand, since eigenvector centrality is a measure of a state's relationship with important nodes and betweenness centrality is a measure of the bridge role between nodes, these two types of centrality can be seen as relatively qualitative measures in the context of network analysis. See Phillip Bonacich, "Some Unique Properties of Eigenvector Centrality," *Social Networks*, Vol. 29, Issue 4 (2007), pp. 555-564; Emilie M. Hafner-Burton, Miles Kahler, and Alexander H. Montgomery, pp. 564-565; Yang Fan, Suting Ren, Hongbo Cai, and Xuefeng Cui, p. 75.

Figure 9. Existing indicators for analyzing the hegemonic transition between the US and China



Source: The World Bank Databank

Figure 9 shows graphs of various indicators, such as GDP and GDP per capita, which have historically been used to analyze the hegemonic transition between the US and China. The results for these existing indicators, excluding that of GDP (PPP), show that the US remains economically ahead and that no transition is in progress in economic terms. By contrast, the data for GDP (PPP) shows that China has surpassed the US since 2013 and that a hegemonic transition from the US to China has been in progress. As this figure shows, there is a difference between the results using existing indicators and those of the centrality indicators presented in this study.

4. 1. 2. Military and political sectors

Figure 10. Network topologies of arms trade configured with weighted out-degree centrality, 1996 and 2018

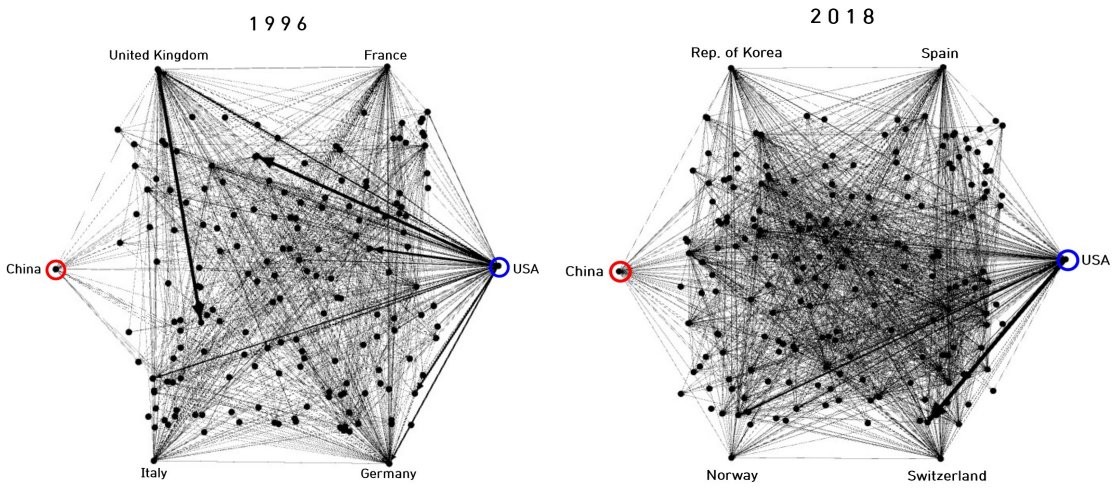
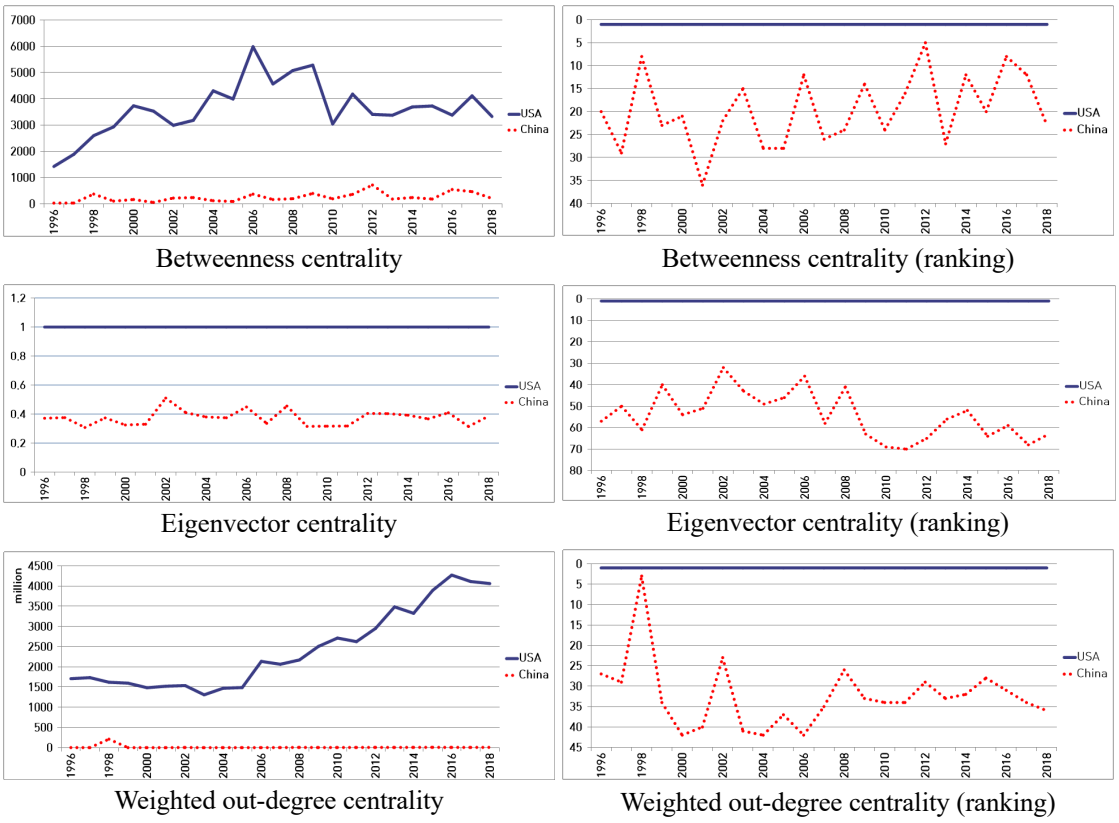


Figure 10 shows the network topologies configured after analyzing weighted out-degree centrality based on arms trade data in 1996 and 2018. As discussed above, the arms trade entails not only military influence, but also political influence. As shown in the 1996 topology, the US, United Kingdom, France, Italy, and Germany had the greatest military and political influence on other states in international relations, while China had little influence. Unlike in the economic sector, the topology of 2018 shows that China was not linked with many other states, which means that China has not emerged as a hegemon in military and political affairs.

As shown in Figure 11, the US has maintained first place in each sector for all three measures of betweenness, eigenvector, and weighted out-degree centrality. In particular,

as shown in the indicator of weighted out-degree centrality, the influence of the US has been increasing in networked international relations. While the influencing power of the US has continued to grow, that of China has remained largely unchanged.

Figure 11. Results of centrality analysis of arms trade (code 9306), 1996–2018



The betweenness centrality indicator shows that China almost did not make it into the top 10 and has no chance of overcoming other strong states. The index ranking of eigenvector centrality for China ranges from 30th to 70th; since 1996, it remained between the 20th and 40th places (except for in 1998) in the index ranking of weighted out-degree centrality. Hence, the results of our centrality analysis of the arms trade

indicate that in the military and political fields, the US has been the only hegemon in international relations at all levels.

4. 1. 3. Cultural sector

Figure 12. Network topologies of cultural goods trade configured with weighted out-degree centrality (code 49: printed books, newspapers, pictures, etc.), 1996 and 2018

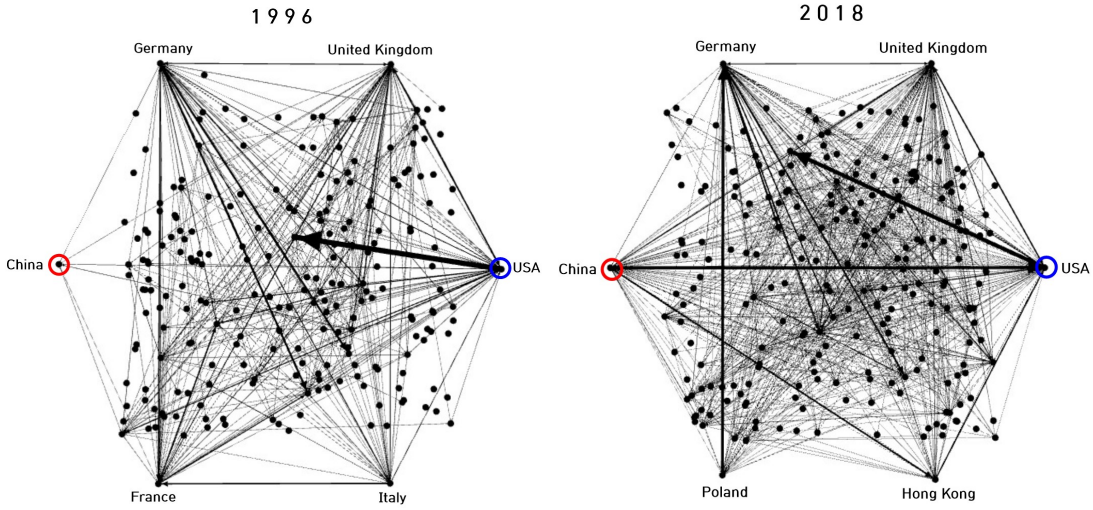
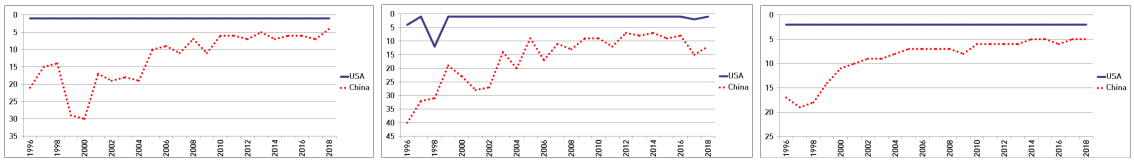


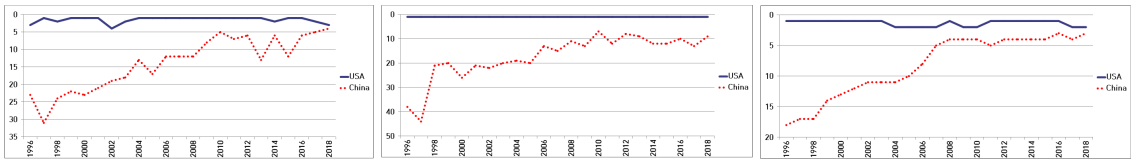
Figure 12 shows the network topologies of the cultural goods trade (printed books, newspapers, pictures, etc.) that represent soft power indicators. In 1996, the US, Germany, United Kingdom, France, and Italy had cultural influence in international relations, whereas China could not be considered to have a significant cultural influence at that time. Although China's cultural influence increased in 2018, it did not surpass that of the US and other powerful states. In other words, although China's cultural influence has increased to some extent, it has not grown enough to dominate or influence other states in international relations.

Figure 13. Results (ranking) of centrality analysis of cultural goods trade, 1996–2018



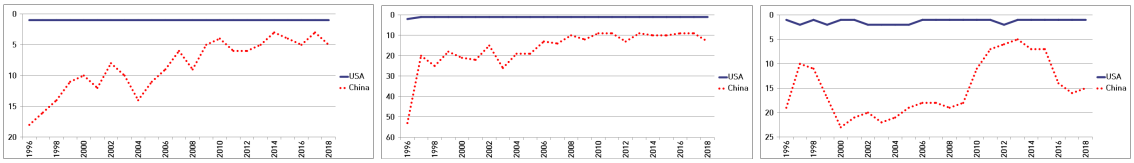
Betweenness centrality | Eigenvector centrality | Weighted out-degree centrality

Code 37, Photographic or cinematographic goods



Betweenness centrality | Eigenvector centrality | Weighted out-degree centrality

Code 49, Printed books, newspapers, pictures etc.



Betweenness centrality | Eigenvector centrality | Weighted out-degree centrality

Code 97, Works of art, collector pieces and antiques

Figure 13 shows the rankings of the two states derived from our network analysis of the trade data of cultural goods. As noted above, China's cultural influence increased over time. However, China's growth stopped at some stage, and it has not surpassed the levels of existing major states such as Germany, the United Kingdom, and the US. By contrast, the US has remained almost at the top, except in the analysis of weighted out-degree centrality for code 37, where Japan has continued to rank first. Therefore, considering the results of the analysis of the cultural goods trade, an indicator of soft power, we observe that the US still exerts cultural influence over many states as a hegemon. Though China's cultural influence has increased, it is relatively weak compared to other major states,

including the US.

4. 2. Discussion

In this study, we have analyzed the hegemonic transition between the US and China using network analysis. Based on the results of this analysis, we argue as summarized in Table 5. First, considering only the economic domain, we conclude that China has achieved hegemony at the micro level, and the results of the centrality analysis indicate that the US and China are very close at the other two levels. This means that the hegemonic transition between the US and China is progressing in the economic sector. However, the US retains hegemony on the meso and macro levels, which means that although China is ahead in terms of quantity, the US is still ahead in terms of quality. In sum, considering its relationships with important states and its role as a bridge in networked international relations, it can be concluded that the US still maintains hegemony.

Table 5. Evaluation of the hegemonic transition between the US and China by sector and level as of 2018

Sector		Progress of hegemonic transition	Hegemon (US or China)		
			Macro level (Betweenness centrality)	Meso level (Eigenvector centrality)	Micro level (Weighted out-degree centrality)
Hard power	Economy	Yes	US	US	China
	Politics and military	No	US		
Soft power	Culture	No	US		

Second, in the political and military sectors, the US has consistently maintained hegemony in international relations at all levels. Trading weapons is different from trading general goods; it indicates military and political influence in addition to economic influence. We analyzed the arms trade network between states, suggesting that the US has been uniquely influential in this network. On the other hand, we found no significant influence of China in this trade domain from the long distant past to 2018. These results indicate that the US is the only hegemon in terms of politics and the military.

Third, analyzing the influence of the two states in terms of soft power rather than hard power, we see that the US exerts a dominant influence over states in international relations at all levels. In the current climate of international relations, economic and military power cannot be regarded as the only power of a given state; soft power that attracts other states by shaping their motives and intentions should be considered as well.[78] As the results of

[78] David W. Kearn, "The Hard Truth about Soft Power," *Journal of Political Power*, Vol. 4, No. 1 (April 2011), p. 68.

our analyses of the cultural goods trade show, China's soft power has expanded considerably compared to 1996. However, it has not yet surpassed that of the US, and China does not have enough soft power to surpass the traditional European powers such as Germany and the United Kingdom.

In sum, we conclude that the US still maintains global hegemony, exerting the greatest influence on other states in networked international relations. It is clear from the results of our analysis that China has gained economic comparability to the US at the micro level, which can be an indication that economic hegemony is shifting from the US to China. However, other indicators in our network analysis at the meso and macro levels show that the US is still ahead of China, continuing to have the greatest impact on the structure of international relations. The influence of a state is not just measured by its economic power; various aspects should be considered in the evaluation. In this study, by analyzing the economic, military, political, and cultural aspects of structured international relations, we demonstrate that the US is still the central state of the world and maintains global hegemony.

5. Conclusion

In this study, we examined the hegemonic transition between the US and China in a network analysis. Indicators of gross output such as GDP, when used in analyzing state power or hegemonic transitions between superpowers, do not accurately reflect state

influence. Hence, these indicators are not suitable for analyzing the power of a state and hegemonic transitions between superpowers.

Unlike these traditional indicators, network centrality is useful for determining which powerful states have hegemony and whether a hegemonic transition is in progress or not. As mentioned earlier, network analysis involves scrutiny of the interactions within the framework and examination of structures and systems, providing an appropriate theoretical foundation for analyzing the actual influence of a given state in international relations. In addition, since the concept of centrality used in network analysis coincides with that of hegemony, it can be applied in empirical analysis of hegemonic transitions between superpowers.

Analyzing the hegemonic transition between the US and China with this useful technique, we argue that the US still maintains hegemony in international relations. Although some indicators in the economic domain of international relations suggest that power has been shifting from the US to China at the micro level, it is obvious that the US still maintains hegemony at all levels in the political, military, and cultural sectors, and that it still dominates other states at the meso and macro levels in the economic sector.

This study has two important implications. First, we present an approach to analyze and evaluate hegemonic transitions in international relations by matching hegemony, a key concept in international relations theory, and centrality, a core concept in network science. This allows us to analyze the phenomena of hegemonic transitions in

international relations empirically and structurally.

Second, we assess the possibility of hegemonic transition between the US and China, which is a current issue in international relations research, through the very suitable method of network analysis. In current international relations research, this transition between the US and China has not been clearly assessed due to a lack of clear indicators for quantitative evaluation. In this study, however, we analyze and evaluate this hegemonic transition empirically and clearly using network analysis.

Further research is required to complement this study. First, 2019 trade data should be collected to track and analyze further the hegemonic transition between the US and China. In this study, we only examine the situation up to 2018 due to the limitations of data availability. Given the fast-changing dynamics of economic networks in 2019, we expect that some interesting results may be found in future studies of the hegemonic transition between states using data from 2019.