International Political Science Review
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*International Political Science Review* 2010 31: 405 originally published online 12 August 2010
DOI: 10.1177/0192512110371239

The online version of this article can be found at:
http://ips.sagepub.com/content/31/4/405

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On behalf of:
IPSA AISP
International Political Science Association (IPSA)

International Political Science Review
31(4) 405–427

DOI: 10.1177/0192512110371239
ips.sagepub.com

# Comparing Measures of National Power

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## Abstract

This article proposes a new national power concept, using the social network perspective, called 'structural network power,' which is defined as the power of an individual state arising from its location within the networks of international relations. This article primarily aims to compare and contrast the new measure of national power (structural network power index [SNPI]) to the previous measures of national power (focusing on the correlates of war composite index of national capabilities [CINC]), which is the most widely used measure of national power in international relations. A comparison of the two measures is performed using two sets of analyses: confirmatory factor analyses and correlation analyses (Pearson and Spearman). The results clearly show that the two power measures tap into two different aspects of national power – one measured by the attribute-based power concept and the other measured by the relations-based power concept – and that the measurement model of the new national power measure performs far better than that of previous national power measures. Based on these results, scholars are advised to consider different aspects and measures of national power when they study national power and its application to the phenomena in the fields of comparative politics and international relations.



## Keywords

confirmatory factor analysis, correlation analysis, international relations, national power, social network perspective


## Introduction

This article proposes a new power concept, using the social network perspective, called 'structural network power,' which is defined as the power of an individual state arising from its location within the networks of international relations.[1] A state does not maintain its power in isolation from other states nor from the system structure; rather, it has power as a consequence of its interactive relations with other states in the system and its structural positions in the networks of relations. A structural network power concept views an individual state's power as arising from its positions in different interaction networks of international relations: if it is well-positioned, or

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occupies relatively advantageous positions in networks, it will be powerful. As most social network theorists emphasize, there is a consensus among social network analysts that a positive relationship exists between an actor's centrality (i.e. holding an advantageous position compared with other actors) and its power within a network. Actors occupying central positions in the network are essentially seen to be powerful due to their greater access to and possible control over the relevant resources. Social network theorists argue that a state with a high centrality (i.e. with an advantageous position) holds a powerful and prominent position in the network (Freeman, 1978/1979; Knoke and Kuklinski, 1982; Freeman et al., 1991; Wasserman and Faust, 1994; Borgatti and Everett, 1999; Degenne and Forsé, 1999; Scott, 2000; Hanneman and Riddle, 2001; Borgatti et al., 2002; Brandes and Erlebach, 2005; Carrington et al, 2005). A state with most visibility and centrality is the point where there is most activity in the network and gains influence as a result (Wasserman and Faust, 1994).

This way of conceptualizing a state's power concurs with the work of social network theorists who believe that the characteristics of social units arise out of structural or relational processes played out among all the units within the network. The measures of structural network powers in this article are derived by utilizing six types of international interaction data sets relating to communication patterns and resource flows:

1. diplomatic exchanges from Singer and Small (1991) and from Bayer (2006);
2. foreign student exchanges from the United Nations Educational, Scientific and Cultural Organization (UNESCO)'s *Statistical Yearbook* (various years);
3. international telecommunications from the International Telecommunication Union (ITU)'s *Yearbook of Statistics* (various years) and *Direction of Traffic* (various years);
4. arms transfers from the Stockholm International Peace Research Institute (SIPRI)'s *Arms Transfers Database*;
5. international exports from Gleditsch (2002, 2004);
6. international assistance from the Organization for Economic Cooperation and Development (OECD)'s *International Development Statistics: Geographical Distribution of Financial Flows to Aid Recipients*.

This article primarily aims to compare and contrast the new measure of national power – namely, the structural network power index (SNPI) – to the previous measures of national power, focusing on the correlates of war (COW) material capability index – namely, the composite index of national capabilities (CINC), which is the most widely used measure of national power in the field of international relations.[2] A comparison of the two measures is performed using two sets of analyses: confirmatory factor analyses (CFA) and correlation analyses (Pearson and Spearman). The first part of this article suggests the theoretical justification for the new power measures. The second provides the results and discussion of the CFA of the measurement models of CINC and SNPI. The CFA evaluates the performance of a particular factor structure through a measurement model that assesses the fit of the structure with the data. In other words, the analysis is used to examine the structure of each national power index (CINC and SNPI) by comparing its models with the data, allowing for measurement errors in the indicator variables. The analysis provides insight into which index of national power provides the better fit in its measurement model. The third part of this article provides the results and discussion of the Pearson and Spearman correlation analyses for the two power measures. The analyses indicate the strength and direction of a relationship between the two measures over time.

## Theoretical Justification for the New Power Measures

The social network approach to national power is responsive to the criticism that the concept of an individual state's national power such as the CINC is an isolated concept; isolated both from other system members and from international system structure. First, because it conceptualizes a state's national power on the basis of what it possesses, it is isolated from other states in the system: what state A possesses does not take account of what any other system members possess. The perspective that power is by definition a relative concept is not new. Many scholars have emphasized that the definition of power is essentially based upon relations, and should be conceptualized as relational. For example, Dahl (1961, 1966) defines power as the ability to get others to do what they otherwise would not do; Morgenthau's classical realism posits that power should be understood as 'control' over actors (Morgenthau, 1948: 29–36, 124–165). Baldwin (1985: 18–24) identifies several principles of power analysis and emphasizes that 'power is a relational concept' and that 'it refers to a relationship between two or more people, not to a property of any one of them.' Lasswell and Kaplan (1950) define power relationally, not as a simple property. Pruitt (1964) posits that international theorists have placed too much emphasis on the resources of nations as the basis of their power. As Baldwin (1985) and others correctly point out, international theorists have long been criticized for their failure to define power in relational terms (Sprout and Sprout, 1962; Sullivan, 1963; Holsti, 1964; Pruitt, 1964; McCleland, 1966). For example, during the Cold War era, some viewed power as a zero-sum concept, so that any power increase by the Soviet Union translated to a power decrease of the United States. However, this relative power concept by realists has been treated only as a measurement issue rather than a conceptual one (e.g. the power-balance variable in dyadic conflict studies, measured by the difference of state A's power–state B's power). Even worse, this approach used in dyadic studies ignored information from outside the dyad: behavior in a dyad is studied as if it were a closed system, when of course each dyad is embedded in a network of other international relations. A social network view of power is closer to the relational power concept of 'the ability to get people to do what I want' (as in Dahl, Morgenthau or others) than to the one that is based on a state's attributes.

Second, the conception of national power is also disconnected from international system structure. Neorealists, such as Waltz (1979), posit that the international system is affected by the distribution of power among major powers. However, the causal arrows could go in both directions: units (or characteristics of units such as their power) affect international system structure and international structure affects units (and their characteristics). Waltz (1979, 2003) himself emphasizes that causation runs not only from international structure to interacting units, but from units to structure. However, the existing method of conceptualizing national power has been unable to incorporate the influence of international system structure and its characteristics over the power of its member states. A network view of power implies that an individual state's power derives not from what it possesses, but rather from how it is connected to or interacts with other system members in the networks of relations. Cartwright (1965: 4) posits, 'When an agent, O, performs an act resulting in some change in another agent, P, we say that O influences P. If O has the capacity of influencing P, we say that O has power over P.' In other words, he argues that power is specific to each dyadic relationship. The main difference between the concepts is in how one conceptualizes this influencing capacity. In the attribute power concept, the capacity comes from the properties of a state's own resources (i.e. its control over internal, domestic resources). In the network power concept, this capacity comes from how a state interacts with other system members (i.e. its control over external interactions). Oppenheim (1981) distinguishes power as property versus power as relation. Hart

(1976) and Schmidt (2005) discuss power as control over resources versus power as control over actors. In other words, the two approaches provide different ways of looking at the influencing capacity and, as a result, they tap two different aspects of national power. In brief, this understanding of the 'relational' aspect of national power, focused on control over actors, is not new in the field of international relations.

In this article, I focus on several different dimensions of structural network power that arise from a state's position in different types of interaction networks of the international system. These dimensions are based on five different types of interaction data (i.e. degree, betweenness, flow-betweenness, coreness and ego network brokerage) (Freeman, 1978/1979; Knoke and Kuklinski, 1982; Freeman et al., 1991; Wasserman and Faust, 1994; Borgatti and Everett, 1999; Degenne and Forsé, 1999; Scott, 2000; Hanneman and Riddle, 2001; Borgatti et al., 2002; Brandes and Erlebach, 2005; Carrington et al, 2005). There is a consensus among social network analysts that there is a positive relationship between an actor's centrality and its power within a network. Actors occupying central positions are viewed as powerful due to their greater access to and possible control over relevant resources. Each of the five different centralities that have been developed by social network theorists emphasizes different aspects of structural network power, and I argue that we should consider all five when we conceptualize a state's national power.

## *Structural Network Power Based on Degree Centrality*

Viewing a state's structural network power as arising from its degree centrality treats each state's structural power as deriving from its total number of direct connections to other states in the network. A state with a high level of degree centrality (i.e. many direct ties to other states) holds a powerful (or influential), prestigious (or prominent) or advantaged position in the network (Wasserman and Faust, 1994; Degenne and Forsé, 1999; Scott, 2000; Hanneman and Riddle, 2001; Brandes and Erlebach, 2005; Carrington et al, 2005). It is the most visible actor in the network, and therefore it is 'where the action is' in the network (Wasserman and Faust, 1994). Compared with the state that holds a less powerful or prestigious position in the network (with its limited number of direct ties to other network members), a highly degree-central state: (1) is less dependent on other states because it has many alternative ways to get what it needs; (2) has more access to the resources of the network since it has more ties to other states; and (3) usually holds and benefits from a third-party or deal-maker position in exchanges among other states in the network because it has many ties to other states (Hanneman and Riddle, 2001). For example, the Cold War matrices of arms transfers show that the Soviet Union had a higher level of degree centrality in the arms transfer network than Bulgaria. The structural position of the Soviet Union enabled it to: (1) be less dependent on other states for its export and import needs; (2) have more access to the arms resources available within the network; and (3) benefit from advantageous third-party positions in the exchanges of arms.

Network power and other forms of power, such as material power, might be correlated, but, in general, one does not theoretically cause the other. However, we should be able to find such cases in which states can increase their power by exploiting and enhancing their network positions. For example, returning to our Cold War example, the network position of the Soviet Union enabled it to hold a more powerful position compared with other East European countries. If one of the Eastern European countries, Bulgaria for example, decided not to import arms from the Soviet Union, the Soviet Union had many other places to which to export their arms. However, if the Soviet Union decided not to export arms to Bulgaria, Bulgaria (with its limited number of arms sources) might have been unable to find other alternatives from which to import their arms. Also, if the Soviet Union wanted to interact with Albania, for instance, it was simply able to do so. However, if Bulgaria wanted to interact with Albania, it could do so only by way of the Soviet Union. The Soviet Union (as a leader of the Council for Mutual Economic Assistance [COMECON]) might have discouraged such a bilateral agreement between Bulgaria and Albania with the purpose of dictating their relationship and of exploiting its network position to enhance its power (in its relationships with the two countries specifically and in the region of Eastern Europe in general). This example demonstrates the way states might increase their power by exploiting and/or enhancing their network positions.

### *Structural Network Power Based on Betweenness Centrality*

An approach to structural network power focused on betweenness centrality treats each state's structural power as arising from its position on the geodesics (minimal length paths) that connect to other nodes in the network. A state with a high betweenness centrality (standing on many geodesics) holds a powerful or prestigious position in the network (Bavelas, 1948; Shimbel, 1953; Shaw, 1954; Cohn and Marriott, 1958). Many other states depend on it to make connections to other states in the system. The betweenness centrality conceptualizes the degree to which a state plays the role of a 'broker' or 'gatekeeper,' with a potential for control over other states in the network (Scott, 2000). Centrality is also interpreted as the extent to which a state controls communication between other pairs of states in the system (Brandes and Erlebach, 2005: 30). For example, the Cold War matrices of arms transfers show that Italy (ITA) played an important intermediary role among the three sets (or blocs) of states centered around the Soviet Union, the United States and the UK; the same role was played by Indonesia in the international arms transfer network of 1960. During the Cold War, the data show that the Soviet Union had a higher betweenness centrality in the arms transfer network than Bulgaria. The Soviet Union was standing on the geodesic paths connecting many pairs of communist states (as a leader of the COMECON), while there were no direct connections between Bulgaria and many other communist states. Thus, if the Soviet Union wanted to interact with, say, Albania, it was able to do so. However, if Bulgaria wanted to interact with Albania, it could do so only by way of the Soviet Union.

### *Structural Network Power Based on Flow-Betweenness Centrality*

Treating structural network power as arising from flow-betweenness centrality implies measuring each state's structural power based on its position on both the direct and indirect paths that connect two other states in the network (Wasserman and Faust, 1994; Degenne and Forsé, 1999; Scott, 2000; Hanneman and Riddle, 2001; Brandes and Erlebach, 2005; Carrington et al, 2005). As a modification of Freeman's original conceptualization of betweenness, flow-betweenness is focused on the notion that the actors will use all paths available to them to connect to other actors (not only the shortest geodesic paths); as Stephenson and Zelen (1989) point out, there is no reason to believe that interactions between a pair of states occur only on the shortest path. This approach assumes that states use each pathway that connects them in proportion to the length of that pathway, and that states that are 'between' other states are able to translate their broker roles to power (Hanneman and Riddle, 2001). A state with high flow-betweenness centrality (standing on many direct and indirect paths) holds a powerful or prestigious position in the network because it can affect so many interaction channels. Flow-betweenness centrality enriches the conceptualization of betweenness centrality. Suppose, for example, that two states, South Korea and North Korea, want to exchange arms transfers, and that the direct geodesic path between them is blocked by China (say, to maximize its arms transfers by its separate connections to South Korea and to North Korea by blocking the direct connection between the two Koreas). If there is another pathway to connect them, such as through Russia, they will be likely to use it, in spite of the fact that it is longer and also subject to disruption. States interact with other network members using both direct and indirect pathways, and, from a social network perspective, a state that holds a more advantageous position (standing on many direct and indirect paths among network members) holds more structural social network power (in terms of flow-betweenness centrality).

### *Structural Network Power Based on Core Centrality*

Viewing a state's structural network power as arising from its core centrality treats each state's structural power on the basis of its degree of coreness compared with the other states in the network (Borgatti and Everett, 1999). Based on the concepts of a core–periphery structure (i.e. a dense and cohesive core and a sparse and unconnected periphery), and of a core–periphery relationship (the former exploiting the latter), this conceptualization of core centrality is an extension of Wallerstein's (1974, 1979) dichotomous (core-periphery) or trichotomous (core-semiperiphery-periphery) typology that has been used in many studies of world-system theory. It measures 'coreness' as a continuous variable (a high score on coreness represents a highly core state; a low score on coreness represents a highly peripheral state). World-system theorists claim that a state's degree of coreness is strongly related to its power. With this approach, we can now not only partition states into different groups (core, semiperiphery and periphery), but also differentiate the within-group members (who is the most/least powerful within each group).

### *Structural Network Power Based on Ego Network Brokerage Centrality*

Defining structural network power in terms of ego network (or egonet) brokerage centrality involves measuring each state's structural power based on its possibilities for brokerage among the states within its own ego network. This treatment involves two separate network concepts. First, the concept of brokerage has been defined as a process 'by which intermediary actors facilitate transactions between other actors lacking access to or trust in one another' (Marsden, 1982: 202). Burt (1976) and Galaskiewicz and Krohn (1984) define brokers as 'actors who simultaneously send and receive resources from different parts of the network in which they are embedded' (Gould and Fernandez, 1989: 18). This concept of brokerage has been studied in both theoretical and empirical social network research (Pruitt, 1964; Blok, 1974; Boissevain, 1974; Knoke and Laumann, 1982); this research emphasizes linking the ability to broker negotiation or resource flows to perceived power or influence. Gould and Fernandez (1989) identify five qualitatively different roles of the broker: (1) as a local broker or coordinator (e.g. the Federal Reserve Bank as a clearinghouse for all the private banks in a major city); (2) as a cosmopolitan or itinerant broker (e.g. a stockbroker as a mediator among clients, buyers and sellers); (3) as a gatekeeper or representative (e.g. the broker as a gatekeeper for his or her political party can decide whether to grant other party members access to an outsider in a rival party; (4) as a representative for other party members who can decide whether to establish contact with an outsider in a rival party [Rogers and Rogers, 1976]); and (5) as a liaison to link distinct groups (e.g. agents in the publishing or entertainment industries).

To illustrate the brokerage concept, suppose that South Korea has a tie to the United States, and that the United States has a tie to Afghanistan, but that South Korea has no direct tie to Afghanistan.

In this triad of relationships (the United States, South Korea and Afghanistan), the United States (as a local broker or coordinator, as a cosmopolitan or itinerant broker, as a gatekeeper, as a representative, or as a liaison in the relationship between South Korea and Afghanistan) can play a brokerage role in case South Korea needs to reach Afghanistan. If we extend this brokerage role of the United States to all the member states within the United States' ego network, we can depict the United States' structural network power in terms of egonet brokerage centrality. Assume that, during the Cold War era, there were two large ego networks (one led by the United States and the other by the Soviet Union) and a small number of groups whose members did not belong to either. The ego in each of the two ego networks might have played a number of roles as a broker: coordinating and mediating transactions among states within the egonet (e.g. the United States coordinating or mediating the foreign policies among the Organization of American States [OAS] members); deciding, as a gatekeeper, whom to invite as its egonet member(s) or whether to grant its member state(s) access to an outsider (e.g. during the Cold War era, the United States deciding who can belong to the OAS or granting its egonet member[s] permission, in an implicit or explicit way, to interact with the Soviet egonet member[s]); establishing, as a representative, a relationship with an outsider (e.g. the United States establishing, as a representative of its egonet members, a relationship with outside states such as China); working as an agent to mediate transactions between two outside groups (e.g. the United States mediating among the members of different non-aligned groups, such as the Non-Aligned Movement [NAM] groups during the Cold War era). From the social network perspective, this egonet brokerage represents a more localized structural network power compared with other types of structural network power that use all the interactions within the whole network.

## Confirmatory Factor Analysis Measurement Models

Figure 1 represents the CFA measurement model of the CINC 1950–2000[3] (CINC, National Material Capabilities v3.02; Singer et al., 1972; Singer, 1987).[4] The index utilizes the following six variables along three dimensions (i.e. demographic, industrial and military): (1) total population (TPOP); (2) urban population (UPOP); (3) energy consumption (ENERGY); (4) iron and steel consumption (IRST); (5) military expenditure (MILEX); and (6) military personnel (MILPER). The single-headed arrow from the construct toward each of the six indicators represents the direct causal effect (also called factor loading or pattern coefficient) of the latent variable on the observed measures; the single-headed arrow from the indicator to its measurement error term represents all variance not explained by the indicator's underlying factor (such as random or systemic error). Meanwhile, Figure 2 presents the CFA measurement model of the SNPI 1950–2000,[5] the newly proposed measure of national power. The index utilizes the following six variables along two dimensions (communication and resource flows): (1) diplomatic exchange (DEX); (2) foreign student exchange (FSEX); (3) international telecommunication (TELE); (4) arms transfers (ARMS); (5) international trade (TRADE); and (6) international assistance (ASSIST). In addition, Table 1 presents the estimates of coefficients and model fit indices for the CFA measurement model for CINC, Table 2 presents the estimates of coefficients and model fit indices for the CFA measurement model for SNPI.[6]

### *Comparing the Standardized Coefficients of Indicators*

The standardized estimates for the six indicators for the CINC measurement model range from 0.453 to 0.943 (all statistically significant at $p = 0.001$), with the expected positive signs; the

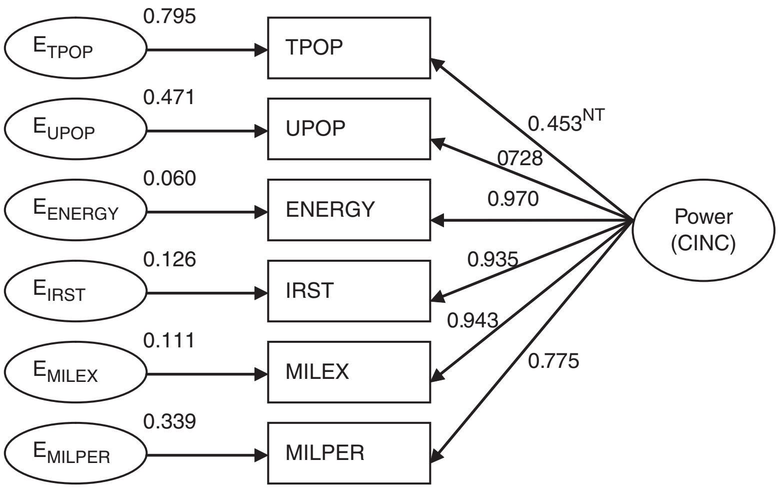



**Figure 1.** Confirmatory Factor Analysis of Six Components of National Power, CINC
*Note*: NT = not tested; the parameter is constrained to 1 for the scaling.

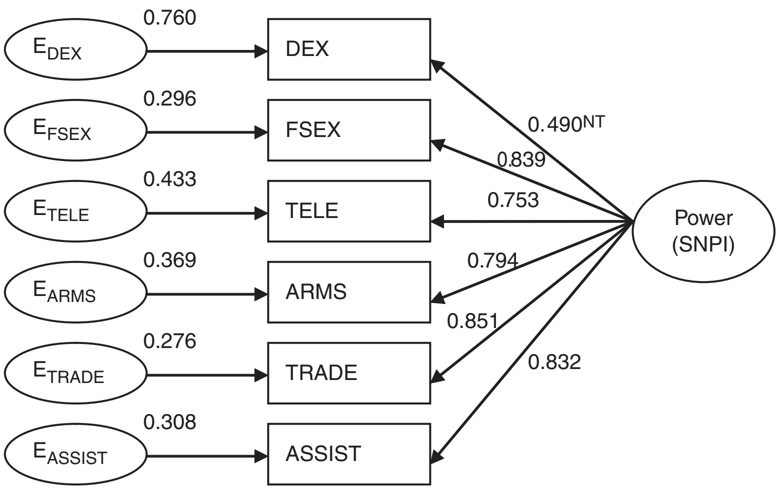



**Figure 2.** Confirmatory Factor Analysis of Six Components of National Power, SNPI

estimates represent how much each indicator changes per one-unit of change of the construct. For example, the coefficient 0.453 for TPOP indicates that, for a one-unit change in the factor POWER (CINC), TPOP changes 0.453 units. According to the results, in general, the set of indicators representing a state's population, such as TPOP, UPOP and MILPER, show relatively low factor loadings – 0.453, 0.728 and 0.775 (respectively) – on CNIC (i.e. relatively low direct causal effects of CNIC on the indicators) compared with the remaining indicators representing a state's consumption or spending (ENERGY, IRST and MILEX), which have relatively high factor loadings of 0.970, 0.935 and 0.943, respectively, on CINC. The standardized estimates for the six indicators in the SNPI measurement model range from 0.490 to 0.851 (all statistically significant at $p = 0.001$), with

**Table 1.** Evaluation of a Measurement Model of Composite Index of National Capability (CINC)

| Correlations | TPOP | UPOP | ENERGY | IRST | MILEX | MILPER | $R^2$ | Standardized coefficient |
|---|---|---|---|---|---|---|---|---|
| TPOP | 1.000 | | | | | | 0.205 | 0.453 |
| UPOP | 0.329 | 1.000 | | | | | 0.529 | 0.728 |
| ENERGY | 0.439 | 0.706 | 1.000 | | | | 0.940 | 0.970 |
| IRST | 0.423 | 0.680 | 0.906 | 1.000 | | | 0.874 | 0.935 |
| MILEX | 0.427 | 0.686 | 0.914 | 0.881 | 1.000 | | 0.889 | 0.943 |
| MILPER | 0.351 | 0.564 | 0.752 | 0.725 | 0.731 | 1.000 | 0.601 | 0.775 |

Goodness of fit summary

| | $X^2$ | d.f. | $X^2/df$ | CFI | NFI | IFI | AIC | ECVI | SRMR |
|---|---|---|---|---|---|---|---|---|---|
| 1950–2000 | 22626.208 | 9 | 2514.023 | 0.629 | 0.629 | 0.629 | 22662.208 | 3.175 | 0.593 |
| 1950s | 2905.042 | 9 | 322.782 | 0.659 | 0.659 | 0.659 | 2941.042 | 3.556 | 0.624 |
| 1960s | 4520.527 | 9 | 502.281 | 0.642 | 0.642 | 0.642 | 4556.527 | 3.720 | 0.640 |
| 1970s | 5718.195 | 9 | 635.355 | 0.575 | 0.575 | 0.575 | 5754.195 | 3.944 | 0.659 |
| 1980s | 5900.541 | 9 | 655.616 | 0.570 | 0.570 | 0.570 | 5936.541 | 3.713 | 0.640 |
| 1990s | 7487.214 | 9 | 831.913 | 0.559 | 0.559 | 0.559 | 7523.214 | 3.717 | 0.641 |

**Table 2.** Evaluation of a Measurement Model of Structural Network Power Index (SNPI)

| Correlations | DEX | FSEX | TELE | ARMS | TRADE | ASSIST | $R^2$ | Standardized coefficient |
|---|---|---|---|---|---|---|---|---|
| DEX | 1.000 | | | | | | 0.240 | 0.490 |
| FSEX | 0.411 | 1.000 | | | | | 0.704 | 0.839 |
| TELE | 0.369 | 0.632 | 1.000 | | | | 0.567 | 0.753 |
| ARMS | 0.389 | 0.667 | 0.598 | 1.000 | | | 0.631 | 0.794 |
| TRADE | 0.417 | 0.714 | 0.640 | 0.676 | 1.000 | | 0.724 | 0.851 |
| ASSIST | 0.407 | 0.698 | 0.626 | 0.661 | 0.708 | 1.000 | 0.692 | 0.832 |

Goodness of fit summary

| | $X^2$ | d.f. | $X^2/df$ | CFI | NFI | IFI | AIC | ECVI | SRMR |
|---|---|---|---|---|---|---|---|---|---|
| 1950–2000 | 634.204 | 9 | 70.467 | 0.974 | 0.973 | 0.974 | 670.204 | 0.094 | 0.099 |
| 1950s | 253.162 | 9 | 28.129 | 0.935 | 0.932 | 0.935 | 289.162 | 0.350 | 0.181 |
| 1960s | 271.224 | 9 | 30.136 | 0.947 | 0.945 | 0.947 | 307.224 | 0.251 | 0.154 |
| 1970s | 100.784 | 9 | 11.198 | 0.981 | 0.980 | 0.981 | 136.784 | 0.094 | 0.084 |
| 1980s | 147.882 | 9 | 16.431 | 0.975 | 0.974 | 0.975 | 183.882 | 0.115 | 0.098 |
| 1990s | 190.560 | 9 | 21.173 | 0.972 | 0.970 | 0.972 | 226.560 | 0.112 | 0.100 |

the expected positive signs; one of the indicators (DEX) shows low factor loading (0.490), whereas the other five indicators show relatively high and comparable factor loadings (FSEX with 0.839, TELE with 0.753, ARMS with 0.794, TRADE with 0.851 and ASSIST with 0.832).

## *Comparing the Reliability Coefficients of Indicators*

The reliability coefficient of each indicator shows how well the construct explains the variance in the indicator. The reliability coefficients of the six indicators for the CINC measurement model range from 0.205 to 0.940; thus, the indicator TPOP is the least reliable (only 20.5 percent of its variance is explained by the latent variable) while the indicator ENERGE is the most reliable (94.0 percent of its variance is explained by the latent variable). The reliability coefficients of the six indicators for the SNPI measurement model range from 0.240 to 0.724; in other words, the indicator DEX is the least reliable (only 24.0 percent of its variance is explained by the latent variable) and the other five indicators show comparable reliability coefficients (ranging from 0.567 to 0.724).

The correlations among the six indicators in each measurement model also show a similar pattern. For the indicators of the CINC model, the correlations of TPOP (the least reliable indicator) with the other five indicators are quite low (ranging from 0.329 to 0.439); meanwhile, the remaining correlations between indicators all exceed 0.564. For the indicators of the SNPI model, the correlations of DEX (the least reliable indicator in the model) with the other five indicators are quite low (ranging from 0.369 to 0.417); the remaining correlations between indicators all exceed 0.598.

## *Comparing the Model Fits*

Researchers have used different model fit indices to examine how well the implied model (set by the researchers) portrays the data. Following suggestions by Kline (1998, 2005), Hoyle and Panter (1995) and Hu and Bentler (1999), I used five standard indices to evaluate the overall fit of proposed measurement models (of CINC and SNPI): (1) Bentler's (1990) comparative fit index (CFI); (2) Bentler and Bonett's (1980) normed fit index (NFI); (3) Bollen's (1989) incremental fit index (IFI); (4) the standardized root mean square residual (SRMR); and (5) the Akaike information criterion (AIC) and its parsimony-adjusted index ([ECVI], Browne and Cudeck, 1992).[7] The first three indices (CFI, NFI and IFI) are called comparative or incremental fit indices, which are the most widely used indices in the structural equation model literature (Kline, 2005: 140). The indices assess the relative fit improvement of the implied model (set by the researchers) compared with the null model (or so-called baseline model or independence model), which assumes zero variance among the observed variables. Values for the CFI, NFI and IFI range from 0 to 1, and any fit of 0.95 or better is considered to be excellent, while 0.90 or better is deemed acceptable (Kline, 1998, 2005; Hu and Bentler, 1999). The fourth index (SRMR) is based on covariance residuals – the differences between observed and predicted covariances. It has been suggested that a value greater than 0.10 indicates that the model does not explain the associated correlations very well; conversely, a value less than 0.10 is considered to indicate a 'good' model (Browne and Cudeck, 1992: 239; Kline, 2005: 131). The last two indices (AIC and ECVI) are called predictive fit indices; they assess the model fit in hypothetical replication samples of the same size and randomly drawn from the same population as the researcher's original sample (Kline, 2005: 142). The model with the smallest AIC and ECVI is preferred as it represents the best fit (Baron and Kenny, 1986).

Table 1 shows the different fit indices of the CINC measurement model. Overall, the model fits fall within a range that is far from acceptable. The first three incremental fit indices are 0.629 (far from the conventional threshold of 0.90) while the SRMR is 0.593 (far from the conventional threshold of 0.10). Sub-sampling the entire population into five decades (the 1950s, 1960s, 1970s, 1980s and 1990s) reveals that the overall model fits get worse over time (e.g. CFI of 0.659 for the 1950s to 0.559 for the 1990s; SRMR of 0.624 for the 1950s to 0.641 for the 1990s).

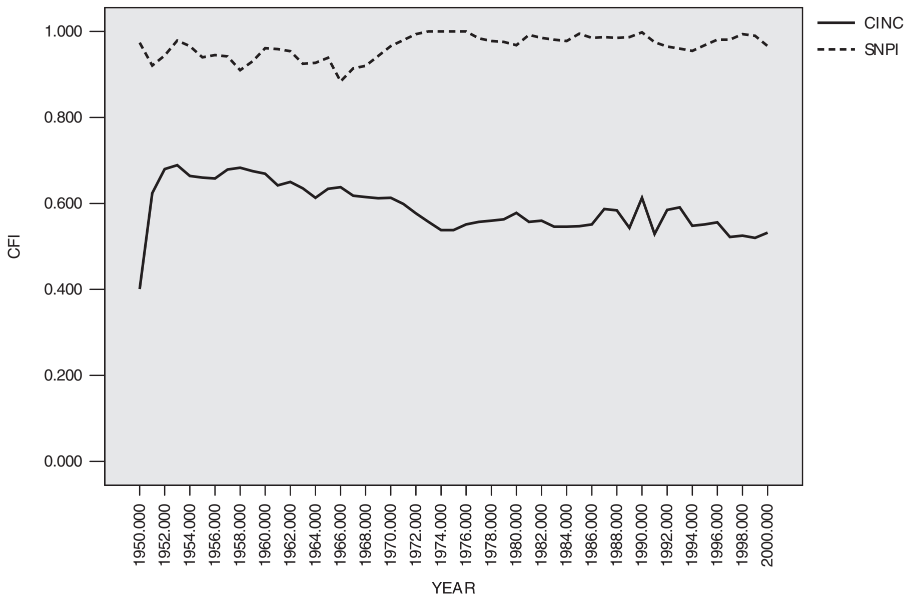
Table 2 shows the different fit indices of the SNPI measurement model. Overall, the model fits are far better than those of the CINC measurement model and are acceptable. The first three incremental fit indices are 0.974 (better than the conventional threshold of 0.90), and the SRMR is 0.099 (better than the conventional threshold of 0.10). In contrast to the results from the CNIC measurement model, sub-sampling the whole population into five decades reveals that the model fits improve over time (e.g. CFI of 0.935 for the 1950s to 0.972 for the 1990s, SRMR of 0.181 for the 1950s to 0.100 for the 1990s). Finally, the predictive fit index (ECVI) for the CINC measurement models is 3.175 for the whole period, worsening over time (3.556 for the 1950s to 3.717 for the 1990s). The SNPI measurement model shows a much better model fit than the CNIC measurement model; the fit index is 0.094 for the whole period, improving over time (0.350 for the 1950s to 0.112 for the 1990s). Three overall patterns are clearly revealed from the comparison of the fit indices of the CINC and SNPI measurement models. First, the fit indices from the CINC measurement model are far from the acceptable range of a 'good' model. In contrast, all the fit indices from the SNPI measurement model are within the range of a 'good' model. Second, all the fit indices from the SNPI model are far better than those from the CINC model, providing the rationale to prefer the SNPI model over the CINC model. Finally, the gap of fit indices between the two models expands over time (i.e. the SNPI model gets better while the CINC model gets worse); in other words, the performance difference between the SNPI model and the CINC model is more apparent over time. Figure 3, comparing the overall model fit indices between the CINC and SNPI measurement models based on yearly statistics (instead of the decade statistics in Tables 1–2) for 1950–2000, also confirms the three patterns indicated herein.

### *Sensitivity Analyses*

I conducted two sensitivity checks on the CFA measurement models of CINC and SNPI.[8] First, I ran a two-factor measurement model of SNPI (for the two dimensions of the SNPI index) and compared the results with those from the proposed single-factor model of SNPI. The overall results indicate that a two-factor model poorly fits the data and that a single-factor model is superior.[9] The various overall fit indices show little difference between the two; for example, the CFI, NFI, IFI, SRMR and ECVI for the two-factor model are 0.975, 0.975, 0.975, 0.101 and 0.088, respectively, whereas for the single-factor model they are 0.974, 0.973, 0.974, 0.099 and 0.094, respectively. However, the $X^2_{\text{difference}}$ statistic (45.791 with one degree of freedom, which is significant at the 0.001 level) of the two hierarchical (nested) models,[10] indicates that the fit of the single-factor model is significantly better than that of the two-factor model. Furthermore, I performed the CFA measurement models for CINC and SNPI, putting all 12 indicators together. Based on the results, the six indicators for CINC load on one factor (with the factor loadings ranging from 0.683 to 0.921), whereas the six indicators for SNPI load on the other factor (with the factor loadings ranging from 0.851 to 0.943).

## Pearson and Spearman Correlation Analyses

Table 3 shows the correlations of CINC with SNPI (different aspects of SNPI and GDP are also compared). Pearson correlations among measures are listed below the main diagonal, and Spearman correlations among measures are listed above the diagonal. I also split the entire sample into two groups – developed states and less-developed states – using the yearly medians of GDP.[11] The purpose for the sub-sample correlations is to examine the argument that 'the commonly used power capability indices do not adequately tap the underlying concept because they work well only among more developed countries (MDCs) but fail among the less developed countries (LDCs)' (Taber, 1989: 29; see also Organski and Kugler, 1980; Tellis et al., 2000).[12] Several overall patterns are clear from the correlation tables. First, the correlation of CINC with SNPI is modest (0.551). Second, the Spearman correlation of CINC with SNPI is higher (0.718) than the Pearson correlations, which indicates that – although the face validity among the measures is acceptable (as evidenced from the Spearman correlations) – the two measures do not completely overlap (as evidenced from the Pearson correlations). Third, providing indirect evidence for the findings by Taber (1989), Tellis et al. (2000) and Organski and Kugler (1980), the Pearson



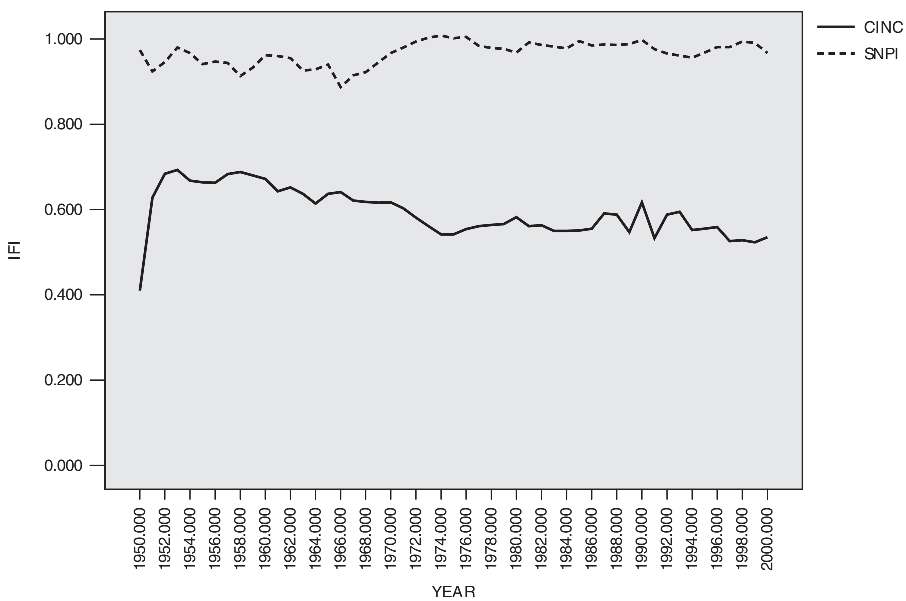



**Figure 3.** *(Continued)*

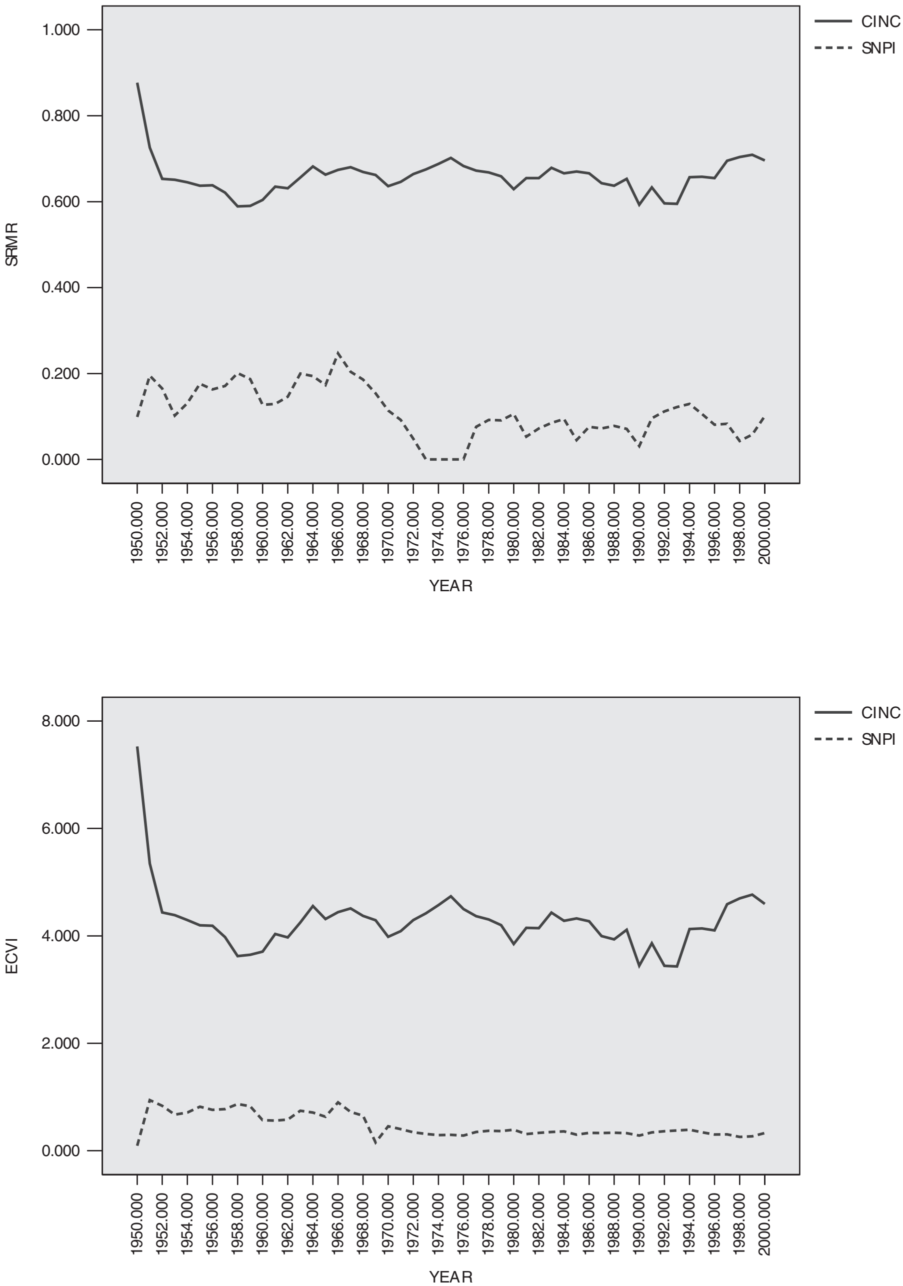



**Figure 3.** Fit Indices of CINC with SNPI

correlations are higher among developed states (0.512) than less-developed states (0.304), whereas the Spearman correlations are compatible for the two groups (0.508 for developed states and 0.503 for less-developed states). The yearly correlation graphs in Figure 4 also confirm these

**Table 3.** Pearson and Spearman Correlations of CINC and GDP with SNPI

| All | CINC | GDP | SNPI |
|---|---|---|---|
| CINC | | 0.823 | 0.718 |
| GDP | 0.550 | | 0.712 |
| SNPI | 0.551 | 0.502 | |
| Underdeveloped | | | |
| CINC | | 0.535 | 0.503 |
| GDP | 0.200 | | 0.401 |
| SNPI | 0.304 | 0.316 | |
| Developed | | | |
| CINC | | 0.603 | 0.508 |
| GDP | 0.523 | | 0.518 |
| SNPI | 0.512 | 0.481 | |

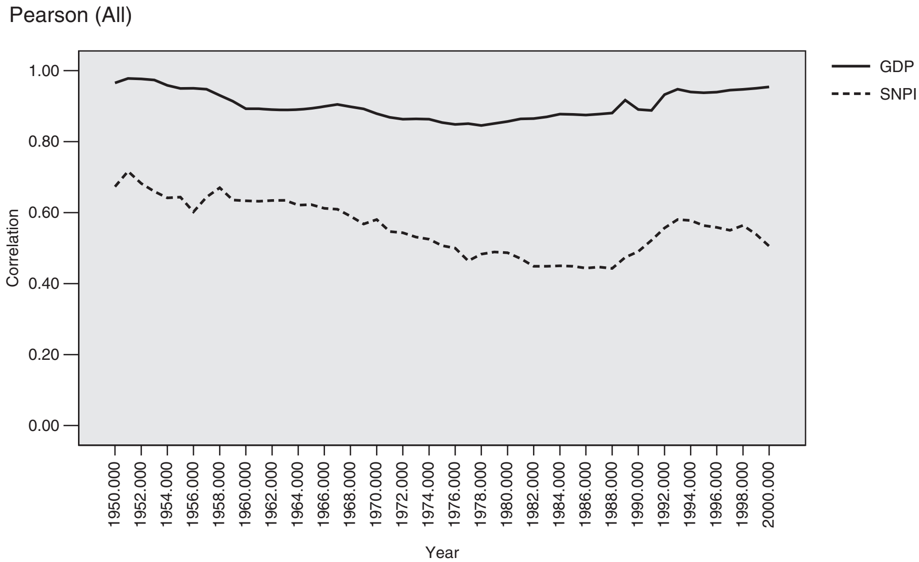
*Note*: The upper, right-hand quadrant represents Spearman correlations among measures. The lower, left-hand quadrant represents Pearson correlation.

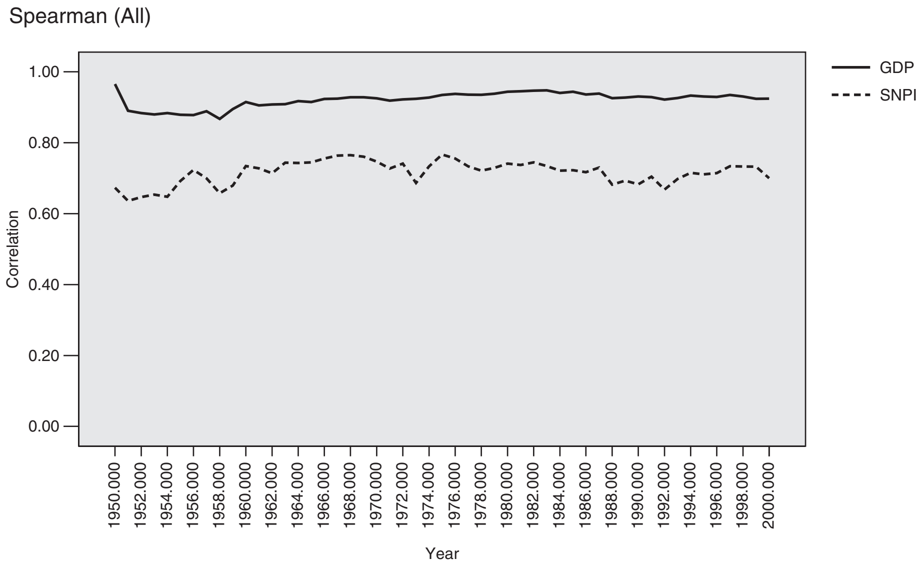
findings and reveal that the yearly correlations of CINC with SNPI show a similar pattern to that of CINC with GDP.[13]

## Conclusion

This article compared the social network measures of national power with the previous measures of power, focusing on the COW material capability index. A comparison of the two sets of measures was performed using two sets of analyses: confirmatory factor analyses and correlation analyses (Pearson and Spearman). The first part of this article provided the results and discussion of the CFA of the measurement models of CINC and SNPI. The analysis was used to examine the structure of each national power index (CINC and SNPI) by comparing its models with the data, allowing for measurement errors in the indicator variables. The analysis provided insight into which index of national power provides the better fit in its measurement model. The second part of this article provided the results and discussion on the Pearson and Spearman correlation analyses for the two power measures. The analyses indicated the strength and direction of a relationship between the two measures over time.

Three overall patterns clearly emerged from the comparison of the fit indices of the CINC and SNPI measurement models. First, the fit indices from the CINC measurement model are far from the acceptable range of a 'good' model. In contrast, all the fit indices from the SNPI measurement model are within the range of a 'good' model. Second, all the fit indices from the SNPI model are far better than those from the CINC model, providing a rationale for choosing the SNPI model over the CINC model. Finally, the gap of fit indices between the two models expanded over time (i.e. the SNPI model got better while the CINC model got worse); in other words, the performance difference between the SNPI model and the CINC model is more apparent over time. Furthermore, three overall patterns became clear from the Pearson and Spearman correlation analyses. First, the correlation of CINC with SNPI is modest. Second, the Spearman correlation of CINC with SNPI is higher than the Pearson correlations. Third, the Pearson correlations are higher among developed states than less-developed states, whereas the Spearman correlations are compatible for the two groups. However, one of the most important limitations of the model of the SNPI is that, in general, it adequately measures national power for the developed world but fails to do so for less-developed countries. As indicated in note 12, this limitation also applies to all previous power measures (such as the COW index and GNP) that have been used in international relations, mostly due to analysts' and data collectors' greater interest in and familiarity with developed countries compared with




*(Continued)*

**Figure 4.** *(Continued)*

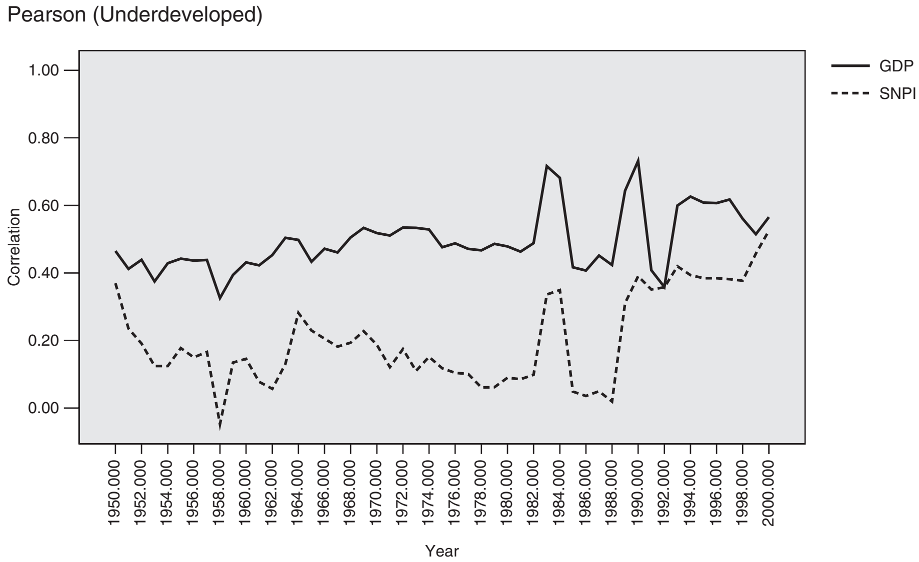
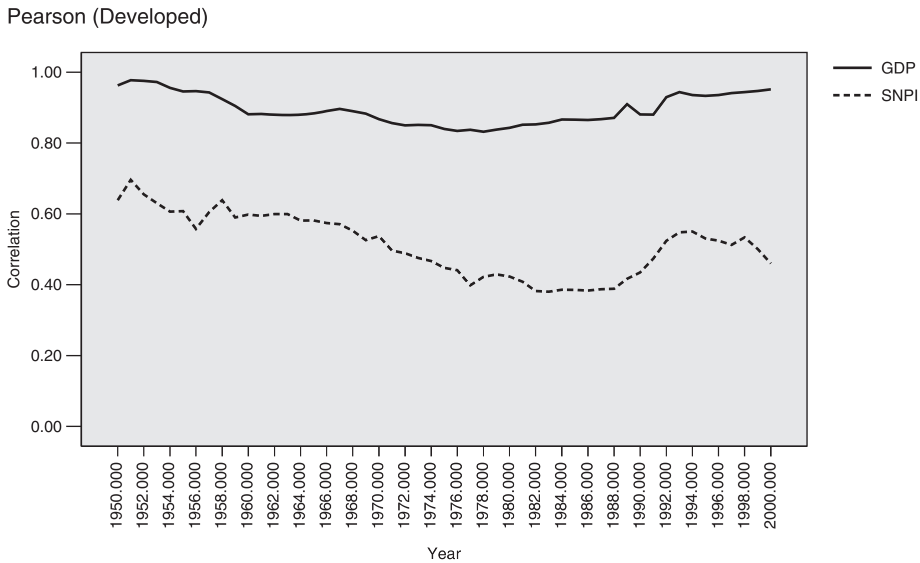



**Figure 4.** *(Continued)*



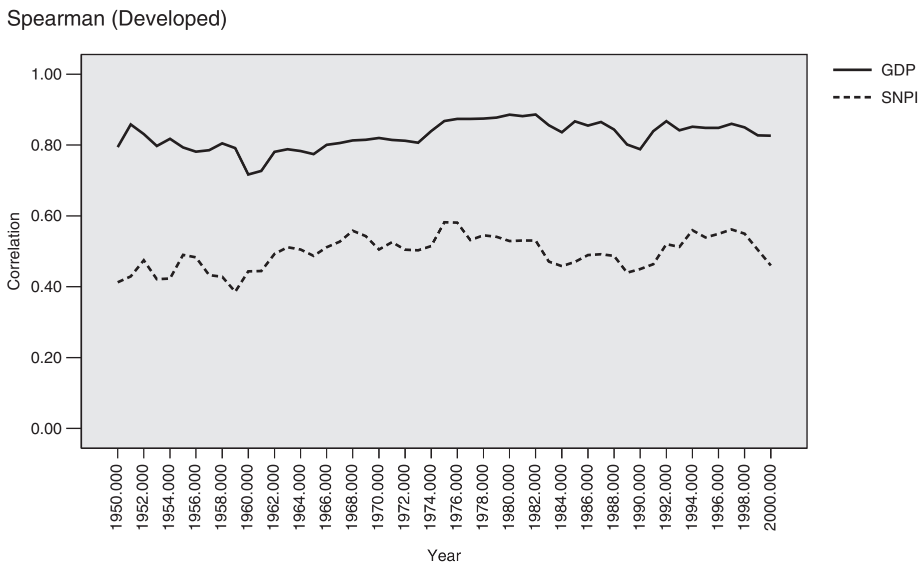




**Figure 4.** Pearson and Spearman Correlations of CINC and GDP with SNPI

lesser developed countries (Organski and Kugler, 1980; Tellis et al., 2000). For the purpose of collecting reliable data with which to measure national power, we surely need more expertise regarding less-developed as well as developed countries.

## Acknowledgments

I would like to thank Timothy J. McKeown, Mark J.C. Crescenzi, Thomas Oatley, Marco R. Steenbergen, Stephen E. Gent, and anonymous reviewers for their invaluable comments and suggestions.

## Notes

1. For more detailed conceptual and measurement discussions on the new power concept and its application to empirical phenomena in the field of international relations, please see Kim (2007).
2. For a discussion of the utility of a network perspective for international relations, see Hafner-Burton et al. (2009). For its theoretical and empirical applications in international relations, see Arquilla and Ronfeldt (2001), Brams et al. (2006), Dorussen and Ward (2008), Hafner-Burton and Montgomery (2006, 2008, 2009), Kahler (2009), Maoz (2001, 2006, 2009), Maoz et al. (2005, 2006, 2007a, 2007b), Montgomery (2005, 2008) and Sageman (2004). See also Brams (1966, 1968, 1969), Deutsch (1954), Nemeth and Smith (1985), Rossem (1996), Singer and Small (1966), Smith and White (1992) and Snyder and Kick (1979).
3. Following the conventions of standard CFA models (see Kline, 2005: 165–169), two assumptions are held. First, each indicator ($X_i$, per notation conventions of Jöreskog [1978], or $Y_i$, per conventions of Bollen [1980]) is a continuous variable represented as having two causes: a single underlying factor ($\xi_i$ or $\eta_i$) that the indicator is supposed to measure and all other unique sources of causation that are represented by the error term ($\delta_i$ or $\varepsilon_i$). Second, the measurement errors are independent of each other and of the factor.
4. Singer and his colleagues (Singer et al., 1972; Singer, 1987) have developed the most widely used national material power capability index (from their Correlates of War Project). They use three dimensions of power capabilities: (1) demographic capabilities (using the data on total population and urban population); (2) industrial capabilities (using the data on energy consumption and iron/steel production); and (3) military capabilities (using the data on total military expenditures and size of the armed forces). This CINC has been updated several times since its launch; the current version of the data set (National Material Capabilities v.3.02) runs from 1816 to 2001.
5. For more details on the new power index and its complete data for 1950–2000, please see Kim (2007).
6. All of the CFA measurement models examined in this article pass the two necessary conditions (i.e. the number of free parameters is less than or equal to the number of observations and every latent variable has a scale) and one sufficient condition (i.e. at least three indicators are used for a single-factor model) for model identification (Kline, 2005: 169–175).
7. The formal definitions of each of the fit indices used are as follows: (1) CFI = 1 – $d$ (proposed model) / $d$ (null model), where $d = X^2 - df$, where $df$ indicates the degrees of freedom of the model; (2) NFI = 1 – $X^2$ (proposed model) / $X^2$ (null model); (3) IFI = (1 – $X^2$ (proposed model) / $X^2$ (null model) – ($df$ / ($N$ – 1)); (4) SRMR is the standardized difference between the observed covariance and predicted covariance; and (5) AIC = $X^2$ (proposed model) + $k(k - 1) - 2df$ where $k$ is the number of variables in the model and ECVI = ($X^2$ (proposed model) + $k(k - 1) - 2df$ ) / ($N$ – 1) where $N$ is the sample size in the model. I have also examined other overall model fit indices; the results are in line with those presented in the article. However, I decided not to use one of the other most widely used fit indices, the $X^2$ index, because – as Kline (1998: 128) astutely pointed out – the index is very sensitive to sample size; if the sample size is large (as is the case for all the models examined in this article), the statistic is usually significant even

though differences between observed and model-implied covariances are slight. Bollen and Long (1993) and Tanaka (1993) also demonstrated that large sample size can supply sufficient statistical power to reject the null hypothesis (indicating the model is significantly different from the data), regardless of the adequacy of model fit.

8. In addition to the two main sets, several additional sets of sensitivity checks on the CFA measurement models were performed; the results also supported the main findings.
9. Similar results were found with a three-factor measurement model of CINC (for the three dimensions of the CINC index) compared with the results with those from the proposed single-factor model of CINC.
10. As Kline (1998: 215) pointed out, the two models are nested because the single-factor model is a constrained version of the two-factor model. If the correlation between the two factors in the two-factor model is fixed at 1.0, then the two factors are identical, which is the same as replacing the two factors with just one factor (as in a single-factor model).
11. Using the yearly medians of GDPs as the cutoff points (e.g. US$3.724 million in 1950 and US$23.309 million in 2000), the countries of the sample in each year were split into two groups, with the countries above the yearly median point being categorized as developed and those below as less developed.
12. Tellis et al. (2000: 3) argue that most power measures such as GNP and the COW index adequately measure national power for the developed world, but fail to do so for the developing world, largely due to 'analysts' greater interest in and familiarity with the great power as opposed to the underdeveloped countries.' Organski and Kugler (1980: 66) argue that 'although [power measures such as GNP and the COW index] in the case of developed countries can generate some fairly reliable estimates of national capabilities, the same measures, applied to other systems, lead to substantial errors'; as a result, 'such measures fail mainly in cases in which a developing and a developed nation, or two developing nations, go to war with each other' (1980: 68).
13. The congruence between the two measures was also assessed using ordinary least squares (OLS). Regressing CINC on SNPI, the results indicated that (1) the SNPI only accounts for 30.3 percent of the variance in CINC, (2) the variance in CINC explained by SNPI is larger for developed states (26.2 percent) than for less-developed states (9.2 percent) and declines over time (43.1 percent for the 1950s to 29.8 percent for the 1990s), and (3) similar patterns are also found for the regressions of CINC on GDP.

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