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Network Analysis and the Law: Measuring the Legal Importance of Precedents at the U.S. Supreme Court

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We construct the complete network of 26,681 majority opinions written by the U.S. Supreme Court and the cases that cite them from 1791 to 2005. We describe a method for using the patterns in citations within and across cases to create *importance scores* that identify the most legally relevant precedents in the network of Supreme Court law at any given point in time. Our measures are superior to existing network-based alternatives and, for example, offer information regarding case importance not evident in simple citation

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counts. We also demonstrate the validity of our measures by showing that they are strongly correlated with the future citation behavior of state courts, the U.S. Courts of Appeals, and the U.S. Supreme Court. In so doing, we show that network analysis is a viable way of measuring how central a case is to law at the Court and suggest that it can be used to measure other legal concepts.

1 Introduction

Most judges and scholars would suggest that the law develops while clinging to history (see, e.g., Holmes 1991 [1881]). History, in this context, is precedent—the decisions made by earlier courts in similar cases. Precedent plays a central role in the judiciary by providing information to judges and other decision makers about the relevance or weight of particular facts for a legal issue and by defining legal consequences or tests that pertain to those facts (Schauer 1987; Aldisert 1990, 606; Richards and Kritzer 2002). Not all court opinions are equally positioned to serve as a precedent for a given dispute, and the norm of respecting stare decisis instructs judges to rely on the most legally relevant and authoritative cases applicable to a given legal question (see Schauer 1987; Powell 1990; Wald 1995). In this sense, the legal relevance of a case (to which we refer synonymously as case importance or case centrality)—the degree to which the information in a given case remains germane for deciding contemporary legal disputes—lies at the heart of law and legal development.

If the relevance of a case is a notable legal concept, an obvious question is the following: how can we identify the most legally central cases at the U.S. Supreme Court at a given point in time in an empirically rigorous, reliable, and valid manner? We address this measurement need by drawing on a technique used in many disciplines, but most notably in computer science (e.g., Kleinberg 1999) and sociology (e.g., Bonacich 1972, 1987)—network analysis—to create a measure of case centrality based on citation patterns among U.S. Supreme Court precedents. At its core, network analysis maps and measures relationships, between, for example, people, groups, computers, or information. To understand these relationships analysts focus on two concepts: "nodes" (i.e., the people, information, etc., within a given setting) and "links" (i.e., the relationships between nodes). These scholars then utilize the relationships among the nodes to develop quantitative indicators of interest regarding, for instance, the centrality or prestige of the nodes within a network.

For our purposes, we consider Supreme Court opinions as nodes in a legal network.[1] These case nodes are linked to other case nodes through citations to existing precedent. The links between cases may take one of two forms: an "outward citation" or an "inward citation". We refer to all the precedents a case cites as outward citations while all subsequent opinions that cite that case are inward citations. The combination of nodes and links (both outward and inward) create a precedent network of any number of cases—for example, within an issue area or among all existing cases.

A citation analysis is an ideal way to tap "case importance", which we here define as the legal relevance of a case for the network of law at the Supreme Court.[2] One can think of

[1] We are not the first to examine the citation of precedent (or other legal authorities) as a means to understand the importance of courts, opinions, or judges (see, e.g., Merryman 1954, 1977; Landes and Posner 1976; Friedman et al. 1981; Caldeira 1985; Kosma 1998; Landes, Lessig, and Solimine 1998; Sirico 2000; Klein 2002; Chandler 2005; McIntosh et al. 2005; Cross, Smith, and Tomarchio 2006). We thus follow in a long tradition of examining legal citations, but we show that recent advances in the methodology of network analysis lead to more nuanced and precise measures of the relevance of a case for the network of law.

[2] A network approach can be used to derive a variety of measures of different elements of the law. We begin with a focus on legal centrality because it is a prominent element of the law discussed by scholars (Levi 1949; Johnson 1987; Schauer 1987; Maltz 1988; Hansford and Spriggs 2006) and judges (Douglas 1979 [1949]; Powell 1990).

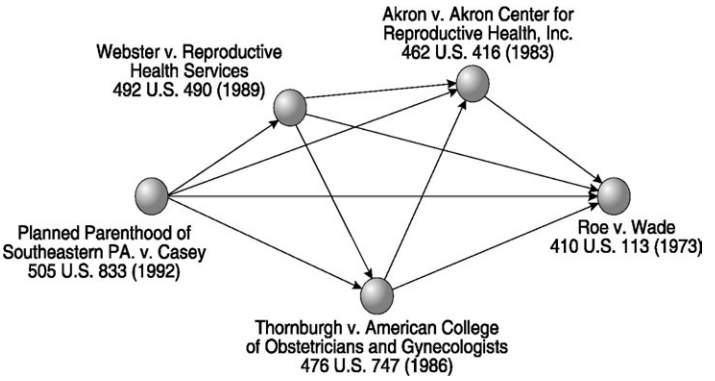

Fig. 1 Network of selected landmark abortion decisions. Node size proportional to inward relevance score within this 83-case network. Each arrow indicates a citation.

a citation to a precedent as a latent judgment by a judge regarding the relevance of the case for helping to resolve a legal dispute. The set of connections among cases can thus reveal much about law and legal development. As Post and Eisen (2000, 545) put it, ". . . one could plausibly suggest that the web of citations from one case to another is a critical component of the network of rules that comprise 'the law' in any area . . .." A network analytic approach also comports with how scholars generally think of law as an interconnected set of legal rules resulting from the repeated use and interpretation of those rules in different cases over time (see Landes and Posner 1976, 250; Dworkin 1986; Lindquist and Cross 2005). It therefore seems reasonable to determine how relevant a particular opinion is by considering how it is embedded in the broader network of opinions comprising the law.

To illustrate, consider the precedent network of five landmark abortion decisions.[3] In Fig. 1, each abortion case is a node, and the arrows represent citations (links) and point from the citing case to the cited case. Notice that each decision references *Roe v. Wade*, 410 U.S. 113 (1973), but that *Roe* does not cite any other cases shown. This means that *Roe* has four inward citations and zero outward citations. In contrast, *Planned Parenthood of Southeastern Pennsylvania v. Casey*, 505 U.S. 833 (1992), cites all the other cases shown, but is not cited by the others since it is the last of the five cases to be decided. Thus, *Casey* has zero inward citations and four outward citations.

Using this technique, we seek to create the network of citations among all majority opinions released by the U.S. Supreme Court between 1791 and 2005. The remainder of the article proceeds as follows. The next section describes how we build the complete network of citations to and from the 26,681 Supreme Court majority opinions released during this time period. We then describe the procedure by which we measure the legal centrality of each precedent at the Court in each year of its existence. Finally, we test the validity of these network measures by using them to predict the citation of precedents by the Supreme Court itself, U.S. Courts of Appeals, and state supreme courts in each ensuing year beginning with the year in which a case was decided and ending in 2005. We believe the general network approach will allow scholars to better measure various attributes of law and thus move forward our attempts to model law and legal development.[4]

[3]Although these cases cite and are cited by many other decisions not shown here, we limit our focus to these five cases for purposes of illustration.

[4]For efforts to model the development of law and legal change, see, for example, Wahlbeck (1998), Klein (2002), and Hansford and Spriggs (2006).

2 Developing a Measure of Case Centrality

Before describing our network measures for legal centrality, we outline the procedure by which we constructed the complete network of citations to Supreme Court majority opinions. First, we compiled a list of every signed or per curiam opinion decided by the U.S. Supreme Court and published in the *United States Reports* between 1791 and 2005.[5] We began with the list of all per curiam, signed, and in-chambers' opinions published in the *United States Reports* provided on the U.S. Supreme Court's Web site through its "Case Citation Finder" link.[6] We then identified all in-chambers' decisions—an opinion released by a single justice in his or her capacity as a circuit justice on an application to the Court—and eliminated them from our list.[7] We also removed nonorally argued per curiam opinions from our final list of precedents.[8] Additionally, we did extensive work to correct any mistakes in the list provided by the Court.[9] This procedure resulted in 26,681 signed or per curiam majority opinions decided over the Court's existence.[10]

[5]Per curiam opinions mean literally "by the Court." Unlike signed opinions, these opinions do not credit a single justice with authorship. Our list also includes early decisions from the Court that were decided seriatim or labeled as "by the Court."

[6]http://www.supremecourtus.gov/opinions/casefinder.html. The Court's list includes all "front-of-the-book" decisions published in the *United States Reports*. Early volumes of the *United States Reports* include opinions from Pennsylvania courts, such as the Pennsylvania Supreme Court and the Court of Common Pleas of Philadelphia. We eliminated all opinions not released by the U.S. Supreme Court from our final list of Court opinions.

[7]We excluded the 412 in-chambers' opinions published in the *U.S. Reports* because they are not a decision on the merits, but rather have to do with such matters as extensions of time, injunctions, and stays. As one can see by the small number of in-chambers' opinions, most decisions on applications are not accompanied by a published opinion. We located in-chambers' opinions published through the 1998 term by relying on the exhaustive list complied by Rapp (2004). In recent years, the docket number for all applications begins with the letter "A," and we therefore eliminated opinions for the 1999–2004 terms if the docket number started with an "A."

[8]The list of opinions available through the Court's Case Citation Finder link includes only "front-of-the-book" decisions, and most nonorally argued per curiam decisions (also known as memorandum decisions) are released as "back-of-the-book" decisions in the *United States Reports*. There is one exception to this general rule, however. From October 1957 through May 1970, all final dispositions (except most denials of certiorari and dismissals due to stipulation) were printed in the front of the *United States Reports* (Hellman 1983, 808; Wasby et al. 1992, 32). As a result, from 1957 through 1970 significantly more nonorally argued per curiam opinions appear in the front of the book (and are thus on the Court's list of cases available on its Case Citation Finder link) than during any other time period. If we included nonorally argued per curiam opinions on our list of Court precedents, then we would introduce bias in that we would include a disproportionate share of memorandum decisions released from 1957 through 1970. We therefore chose to remove the 2480 nonorally argued per curiam decisions from our final list of cases (77% of these decisions were released between 1957 and 1970).

[9]We did so by first comparing the Court's list with the one we compiled through a series of Lexis-Nexis searches using the U.S. Supreme Court Cases library. We created a list of all Court opinions in which the "opinion by" segment either identified a majority opinion as authored by a particular justice or authored as a per curiam. We then merged this set of cases with the Court's list to locate discrepancies between the two, and we corrected any omissions, incorrect inclusions, or typographical errors in the Court's list of cases. Second, we compared the list of cases from the Court's Case Citation Finder link with the Court's list of early decisions labeled "Dates of Supreme Court Decisions and Arguments: United States Reports Volumes 2-107 (1792–1882)" (hereafter "Dates of Decisions"), located at http://www.supremecourtus.gov/opinions/datesofdecisions.pdf, and we corrected any errors.

[10]During the 1800s, the Court occasionally published an order at the end of an opinion and labeled it as a "Note" (e.g., *U.S. v. Smith*, 92 U.S. 654n. (1876)). We located 116 of these orders (released between 1823 and 1883) and eliminated each of these from our final list of Court precedents. Most of these decisions are not located on the list available through the Court's Case Citation Finder link, but they are located in the Court's "Dates of Decisions" document. We should point out that Lexis does not treat these orders as opinions and thus one cannot locate them with a Lexis search using case name or case citation.

Second, using *Shepard's Citations*, we identified each instance in which one of the Court's majority opinions referenced a previously decided Court majority opinion.[11] To make the collection of such an immense amount of data feasible, we devised a computer-based search-and-retrieval strategy that automated the process of "Shepardizing" each of these 26,681 cases. The file for each case was saved and then later analyzed by a program, written in R, designed to locate the unique code for each citing case in the file. We then compiled these citations in a file that specifies the citing case, the cited case, and the *Shepard's* category for each citation.[12]

2.1 *The Network Method*

To apply network theory to our data, we note that each Court opinion can be thought of as a node and each citation to a case a link, where there exists a link from case *i* to case *j* if and only if case *i* cites case *j* in its majority opinion. A link from case *i* to case *j* represents an *outward citation* for case *i* and an *inward citation* for case *j*. The total number of links leading to and from each node is the "degree", where the *in degree* is the total number of inward citations and the *out degree* is the total number of outward citations. To further illustrate these relationships, Fig. 2 extends the example from the introduction into a more complete network of abortion cases.

Generally, each judicial citation in an opinion represents a latent judgment by the Court about which cases are most relevant for addressing a legal question. When a citing opinion references another case, it indicates that the decision has a connection to the present legal dispute and signals its continuing legal relevance. Social network theory suggests a number of ways to use these citations to determine which cases are most central or relevant in a network. The two most commonly employed measures are known as degree centrality and eigenvector centrality (Wasserman and Faust 1994, 198–210). In addition to discussing

[11] *Shepard's* is a legal citation service that provides a list of all cases cited by each published state and federal court case decided since the beginning of the U.S. legal system. Importantly, *Shepard's* offers data that are both reliable and valid for the purpose for which we are using them. A quantitative study of *Shepard's* indicates that it reliably lists all cases cited by an opinion and also provides detailed and replicable coding protocols for its coding of case-based information (Spriggs and Hansford 2000; Hansford and Spriggs 2006). Although *Shepard's* always notes whether a citation occurred in a dissenting opinion, only in recent years has it begun to record whether a citation was located in a concurring opinion. *Shepard's*, however, always records the first page on which a citation occurs in an opinion, and we used these page numbers to determine whether a citation was in the majority opinion or a concurring opinion.

[12] *Shepard's* differentiates between a string citation (in which the citing case has no substantive discussion of a cited case) and the legal treatment of a precedent (e.g., a citing case follows or distinguishes a cited case), but we do not do so in this article for several reasons. First, the concept we care about in this article is the legal relevance of a case, which we think is best captured by *whether* a case was cited rather than *how* it was cited. In this sense, we are distinguishing conceptually between case relevance (which we think is largely based on whether a case is cited) and the legal vitality or authoritativeness of a case (which is based on, e.g., whether a case is distinguished rather than followed). This approach is consistent with work by Hansford and Spriggs (2006), who measure legal relevance as the number of times a case was previously interpreted by the Court (whether positively or negatively) and measure legal vitality as the difference in the prior number of positive and negative interpretations. Some might suggest that the negative treatment of a precedent (e.g., distinguishing) decreases the case's future relevance, but we think this is generally not true because negative treatments still indicate that a case continues to have currency for legal debates. In short, we do not want to assume that the negative interpretation of precedent necessarily decreases case relevance. Second, there is an empirical reason that we do not differentiate between negative treatments and other forms of citation when measuring case relevance. The positive or negative interpretation of precedent is a rare event as compared to the string citation of precedent. The average case receives approximately nine cites over its life, but only one of these is a substantive legal interpretation (i.e., positive or negative treatment). To incorporate legal treatments as a separate category in our measure would require that we weigh them more heavily than citations, else they would contribute little to the measure. At present, we are more comfortable assuming that citations and treatments contribute to legal relevance in a roughly equivalent manner.

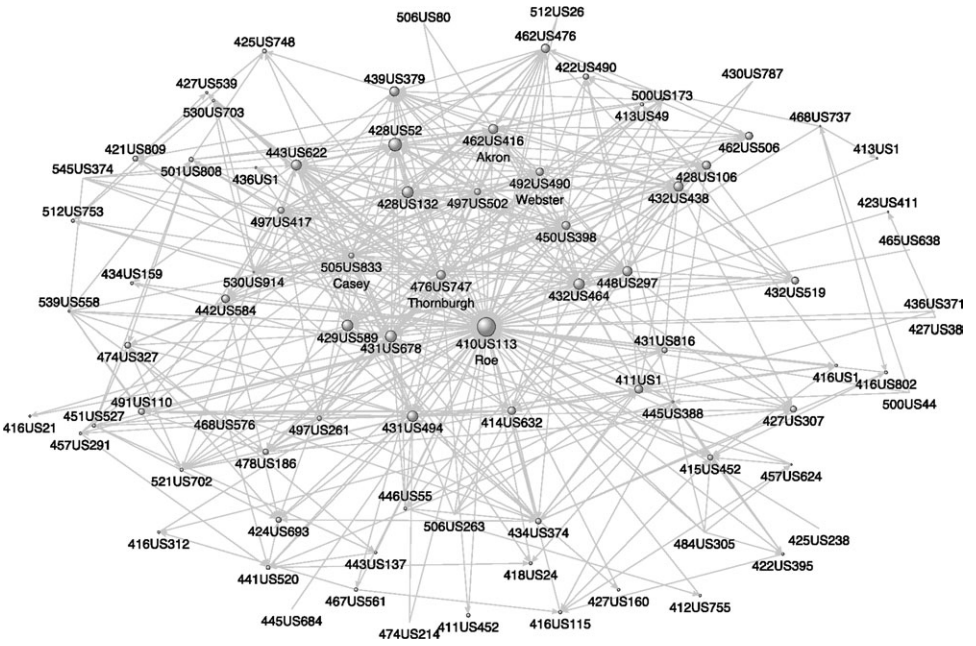

Fig. 2 Extended network of abortion decisions.

these techniques, we also discuss a new interdependent set of measures based on a theory recently developed in computer science (see Kleinberg 1999), which we suggest is a better measure of case relevance.

2.2 *Degree centrality*

At the most basic level the number of citations from other cases (inward citations) can be used to measure the importance of a given court decision. Social network theorists call this measure *degree centrality* (Proctor and Loomis 1951; Freeman 1979). For example, *Roe* is the most relevant case in Figures 1 and 2 because it has the most inward citations. Prior studies using network data often rely on degree centrality as a way to measure the continuing relevance or importance of a given case or judge (see Landes and Posner 1976; Kosma 1998; Hansford and Spriggs 2006).

A shortcoming of degree centrality is that it does not fully use information in the precedent network because it treats all inward citations in exactly the same way. Ideally, we should be able to use information about the importance of citing cases to improve our estimate of the importance of the cases that they, in turn, cite. For example, suppose decision *i* is cited by a case that is considered to be central to the law and decision *j* is cited by a case that is not. This suggests that decision *i* may itself be more important than decision *j*.

2.3 *Eigenvector centrality*

Another way to use network measures to our advantage would be to estimate simultaneously the importance of all cases in the network. To do so we could employ a measure called *eigenvector centrality* (Bonacich 1972). Suppose A is an $n \times n$ adjacency matrix representing all the citations in a network such that $a_{ij} = 1$ if the ith case cites the jth case

and 0 otherwise. Self-citation is not permitted, so the main diagonal contains all zeros. Let x be a vector of importance measures so that each case's importance x_i is the sum of the importance of the cases that cite it: $x_i = a_{1i}x_1 + a_{2i}x_2 + \cdots + a_{ni}x_n$. This yields n equations (i.e., one for each precedent), which we can represent in matrix format as $x = A^T x$. It is unlikely that these equations have a nonzero solution, so Bonacich (1972) suggests an important modification. Suppose the legal centrality of a case is *proportional* to instead of *equal* to the centrality of the cases that cite it. Then $\lambda x_i = a_{1i}x_1 + a_{2i}x_2 + \cdots + a_{ni}x_n$, which can be represented as $\lambda x = A^T x$. The vector of importance scores x can now be computed since it is an eigenvector of the eigenvalue λ.[13]

There are technical and substantive reasons, however, that suggest we may not want to use eigenvector centrality to measure the iterated centrality of each Supreme Court case. Technically, there is a problem in the citation network because many Court cases have not themselves been cited. This means their importance scores are 0 and they add nothing to the importance of the cases that they cite. Since citation is a time-dependent process (current cases usually do not cite future cases) this feature of the measurement inherently biases downward the legal relevance of recent cases.

Substantively, the eigenvector centrality approach to identifying relevant cases assumes that only inward citations contain information about importance. However, outward citations may provide a clue to importance as well. Some cases cite only the most relevant precedents, whereas others cast a wider net, relying on less well-known decisions. If we know how well grounded a case is in relevant precedents, we can use this information to distinguish between relevant and less relevant cases. For example, suppose decision i is cited by a case that is considered to be well grounded in precedent and decision j is cited by a case that is not. This suggests that decision i may itself be more important for the network of law than decision j.

2.4 *A new measure of centrality*

A recent advance in Internet search theory (Kleinberg 1999) allows us to draw on both inward and outward citations to assess case centrality. In particular, this procedure relies conceptually on two different kinds of legally important cases simultaneously—*outwardly relevant cases* and *inwardly relevant cases*. An outwardly relevant case is one that cites many other relevant decisions, thereby helping to define which decisions are pertinent to a given legal question. Such cases can also be seen as resolving a larger number of legal questions (Post and Eisen 2000, 570) or at least engaging in a greater effort to ground a policy choice in prior rulings. An inwardly relevant case is one that is widely cited by other prestigious decisions, meaning that judges see it as an integral part of the law. Cases can act as both inwardly and outwardly relevant opinions, and the degree to which cases fulfill these roles is mutually reinforcing within the precedent network. That is, a case that is *outwardly relevant* cites many *inwardly relevant* opinions, and a case that is inwardly relevant is cited by many outwardly relevant opinions.

Kleinberg's (1999) technique allows us to determine the extent to which each case fulfills these roles. Suppose x is a vector of *inward relevance* scores, y is a vector of *outward relevance* scores, and these vectors are normalized so their squares sum to 1. Let each case's inward relevance score x_i be proportional to the sum of the outward relevance scores of the cases that cite it: $x_i = a_{1i}y_1 + a_{2i}y_2 + \cdots + a_{ni}y_n$, and let each

[13] Although there are n nonzero solutions to this set of equations, in practice the eigenvector corresponding to the principal eigenvalue is used.

case's outward relevance be the sum of the inward relevance scores that it cites: $y_i = a_{i1}x_1 + a_{i2}x_2 + \cdots + a_{in}x_n$. This yields $2n$ equations which we can represent in matrix format as $x = A^T y$ and $y = Ax$. Kleinberg (1999) shows that the solution to these equations converges to $\lambda x^* = A^T A x^*$ and $\lambda y^* = AA^T y^*$, where λ is the principal eigenvalue and x^* and y^* are the principal eigenvectors of the symmetric positive definite matrices $A^T A$ and AA^T, respectively. The resulting outward and inward relevance scores help us identify key precedents in the network—those that are *influential* (inwardly relevant) and those that are *well founded in law* (outwardly relevant).

To better illustrate how we generate the importance scores, consider, once again, the pattern of inward and outward citations for the five landmark abortion cases shown in Fig. 1. This network generates two equations for each case—one for the inward relevance score (x) and one for the outward relevance score (y)—for a total of 10 equations:

$$\begin{aligned}
\lambda x_{Roe} &= y_{Casey} + y_{Webster} + y_{Thornburgh} + y_{Akron} & \lambda y_{Roe} &= 0 \\
\lambda x_{Akron} &= y_{Casey} + y_{Webster} + y_{Thornburgh} & \lambda y_{Akron} &= x_{Roe} \\
\lambda x_{Thornburgh} &= y_{Casey} + y_{Webster} & \lambda y_{Thornburgh} &= x_{Roe} + x_{Akron} \\
\lambda x_{Webster} &= y_{Casey} & \lambda y_{Webster} &= x_{Roe} + x_{Akron} + x_{Thornburgh} \\
\lambda x_{Casey} &= 0 & \lambda y_{Casey} &= x_{Roe} + x_{Akron} + x_{Thornburgh} + x_{Webster}
\end{aligned} \quad . \quad (1)$$

These equations indicate that because *Thornburgh v. American College*, 476 U.S. 747 (1986), is cited by *Planned Parenthood v. Casey* (1992) and *Webster v. Reproductive Health Services*, 492 U.S. 490 (1989), *Thornburgh*'s inward relevance score must be proportional to the sum of the outward relevance scores for *Casey* and *Webster*. Further, *Thornburgh* cites *Roe* and *Akron*, so *Thornburgh*'s outward relevance score must be proportional to the sum of the inward relevance scores of *Roe* and *Akron*. The λ's on the left-hand side permit us to find a constant proportion across all equations that generates a solution for this set of equations. In technical terms, these are the *eigenvalues*. In this example, we obtain the following legal relevance values:

$$\begin{aligned}
x_{Roe} &= 0.66 & y_{Roe} &= 0 \\
x_{Akron} &= 0.58 & y_{Akron} &= 0.23 \\
x_{Thornburgh} &= 0.43 & y_{Thornburgh} &= 0.43 \\
x_{Webster} &= 0.23 & y_{Webster} &= 0.58 \\
x_{Casey} &= 0 & y_{Casey} &= 0.66
\end{aligned} , \quad (2)$$

$$\lambda = 2.88.$$

One should recognize that the scale of these numbers is inherently arbitrary; because we are using proportions, we could multiply all the values by any constant to find another set of values that would solve these equations. Moreover, the distance between these values is arbitrary as well. One usually generates eigenvectors via an iterative process and, to keep the values in a manageable range, computational methods can be used to rescale values at each iteration so the sum of their squares is equal to 1 (in our example: $0.66^2 + 0.58^2 + 0.43^2 + 0.23^2 + 0^2 = 1$). As a result, the only invariant information in the raw scores is their *ranks*, not their values, and the rank order of each case represents the most meaningful way to measure its importance. We thus base our measure of inward and outward

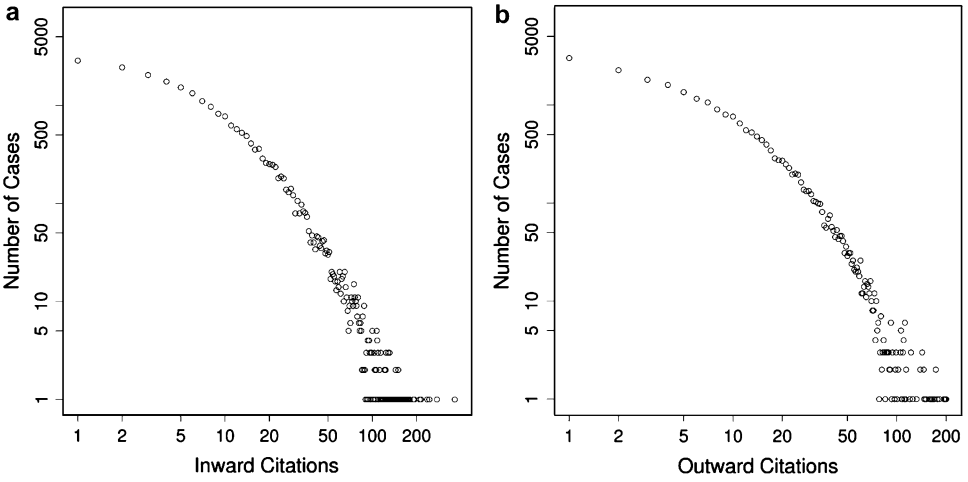

Fig. 3 Distribution of inward and outward citations in the Supreme Court network, 1791–2005. We refer to all the precedents a case cites as "outward citations" while we label all subsequent opinions that cite a case as "inward citations."

relevance on the rank order of each case in each year, as determined by the raw relevance scores. However, because the number of precedents in the network increases over time, our final measure of inward and outward relevance is the *percentile rank* of each case, which equals the rank order of each case in each year divided by the total number of Supreme Court cases in the network in that year.

Overall, there are several ways of measuring the centrality of precedent with the network of law. As we have discussed, we think the final measure—based simultaneously on inward and outward importance scores—corresponds best with our conception of legal centrality. The next section provides descriptive statistics regarding the Supreme Court citation network and illustrates the derivation and meaning of the centrality measures. The final section demonstrates the construct validity of these measures (Carmines and Zeller 1979).

3 Empirical Properties of the Supreme Court Citation Network

The average majority opinion for the Court received 9.1 inward citations from other majority opinions of the Court over its life, with an SD of 13.8 citations. The number of inward cites varies from 0 to 355 and has a lower quartile of 2, a median of 5, and an upper quartile of 11. Note that the Supreme Court network is square, which means the aggregate number of inward citations equals the aggregate number of outward citations, and thus, their respective mean, though not their distribution, is equivalent. Figure 3 portrays variation in the total number of inward and outward citations to these precedents (what network analysts refer to as the degree distribution of a network). As is evident, the vast majority of opinions are cited by only a few cases while a few opinions garner a significant number of citations.[14]

The citation of precedent also clearly manifests time-dependent characteristics. Figure 4a shows the average number of outward citations as a function of the year in which citing

[14]Figure 3 exhibits an exponential tail distribution, which is a feature common to many large-scale networks (Albert and Barbasi 2002), including scientific citation networks (Redner 1998).

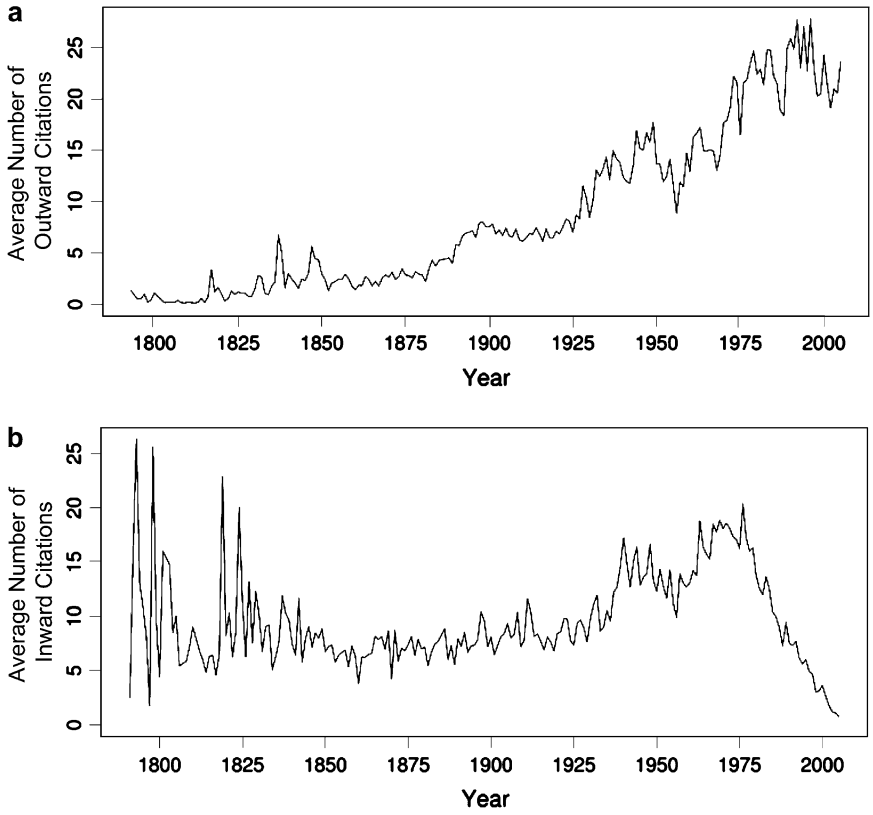

Fig. 4 (a) Average outward citations in the Supreme Court network, 1791–2005. (b) Average inward citations in the Supreme Court network, 1791–2005.

cases were decided. That is, it portrays the mean number of citations to Supreme Court opinions contained within opinions released in a given year (i.e., outward citations). One obvious feature of the citation of precedent is that, over time, the Supreme Court has become more inclined to cite a greater number of prior Court decisions. Figure 4b documents the average number of citations to precedents decided in a given year. This number remains fairly constant over time.[15]

To illustrate the network context of the legal centrality of precedent more precisely, Table 1 provides the inward relevance and outward relevance measures, measured as percentile ranks, for the five landmark abortion decisions from Fig. 1 based on three different network assumptions. The first set of values assumes that these five cases are the only ones in the network, the second set assumes they are embedded in the network of 83 abortion decisions that cite *Roe* (Fig. 2), and the third set assumes they are part of the complete network of 26,681 cases. Notice that in the network of five cases the number of inward citations directly implies the inward relevance score, and the number of outward citations directly imply the outward relevance score. Outward relevance follows the same pattern in the 83-case network, but inward relevance does not—for example, *Webster*

[15]The outliers in a few of the early years in the Court's existence occur because the Court decided only a handful of cases each year—a smoothed average shows about the same rate of citation as in later years. Also, the inward citations decrease at the end of the time period because those cases have not had as much time to be cited as the earlier decided cases.

Table 1 Inward and outward relevance of selected landmark abortion decisions

	5-Case network				*83-Case network*				*Complete network*			
Decision	*Inward relevance % rank*	*Outward relevance % rank*	*Inward citations*	*Outward citations*	*Inward relevance % rank*	*Outward relevance % rank*	*Inward citations*	*Outward citations*	*Inward relevance % rank*	*Outward relevance % rank*	*Inward citations*	*Outward citations*
Roe v. Wade, 410 U.S. 113 (1973)	1.00	0.20	4	0	1.00	0.01	82	0	0.9975	0.9995	82	85
Akron v. Akron Center for Reproductive Health, 462 U.S. 416 (1983)	0.80	0.40	3	1	0.87	0.96	10	15	0.9626	0.9873	15	39
Thornburgh v. American College, 476 U.S. 747 (1986)	0.60	0.60	2	2	0.86	0.98	11	18	0.9645	0.9975	13	73
Webster v. Reproductive Health Services, 492 U.S. 490 (1989)	0.40	0.80	1	3	0.77	0.95	6	15	0.9395	0.9966	9	88
Planned Parenthood of Southeastern Pennsylvania v. Casey, 505 U.S. 833 (1992)	0.20	1.00	0	4	0.64	1.00	6	26	0.9752	0.9991	25	106

surpasses *Planned Parenthood* even though both of them have the same number of inward citations.

When we take the whole network into account, *Thornburgh* has fewer outward citations than *Webster* yet maintains a higher outward relevance score. Since cases that are outwardly relevant cite cases that are inwardly relevant, we can deduce from this information that *Thornburgh* cites better inwardly relevant cases than *Webster*. Also, in spite of subtle differences in their scores, all these cases rank quite highly for both inward and outward relevances as we would expect of "landmark" cases.

It is also interesting to note that our measure allows us to determine objectively the most relevant case based on the extent to which justices cite them in later cases. Table 2 lists the raw relevance scores and percentile ranks of the cases with the 20 highest *Inward* and outward relevance scores in the complete network, as of 2005. Two items are notable. First, cases with higher inward relevance tend to be older than those that have greater outward relevance: the median age of the top 20 inwardly relevant cases is 64 years, whereas the median age is 36 years for the top 20 outwardly relevant cases. Further, the majority of these cases involve First Amendment issues, although this would clearly change if we chose to analyze an earlier partition of our entire network. For example, in 19 of the 20 most inwardly relevant cases in 1955, the Commerce Clause was one of the main legal issues.

Additionally, it is important for us to point out that the inward relevance and outward relevance scores contain information that cannot be gleaned from simple citation counts (degree centrality). For example, the number of inward citations can only increase or remain constant, and the number of outward citations is by definition a constant number. By contrast, our two measures can ebb and flow as the direct and indirect linkages between cases develop as a case ages. One gets a sense of the variation in our measures not contained in the citation counts by regressing the former on the latter. The R^2 from a regression of inward relevance on *inward cites* equals 0.226, whereas this statistic equals 0.221 for a similar regression of outward relevance on *outward cites*.

Figure 5 illustrates the dynamic, interdependent nature of our measures. In this set of figures, we graph inward relevance, outward relevance, and inward cites for two cases, *Dennis v. United States*, 341 U.S. 494 (1951), and *Barenblatt v. United States*, 360 U.S. 109 (1959). By comparing the figures, one pattern is immediately evident—the inward relevance and outward relevance scores contain information not available in the citation counts. Both *Dennis* and *Barenblatt* have a significantly larger than average number of inward citations, and we see a steady increase in cites until the late 1970s. When we examine their inward relevance, we do indeed witness an increase in their legal importance as they garner more citations. There is one notable feature of this figure. By about 1973, both these cases began to lose inward relevance. Although the number of citations to these cases stopped increasing at this time, this decrease in inward relevance results in large part because of a drop in the outward relevance of the cases that cite *Dennis* and *Barenblatt*.

We see an even more striking example of how the interdependent network measures contain more information than raw citation counts when we look at the difference in outward relevance and outward cites. For example, the opinion in *Barenblatt* contains 48 citations to previously decided Supreme Court opinions (i.e., outward citations). Although this number remains constant over time, the outward relevance of this case nonetheless manifests considerable change, rising until the mid 1970s and then falling thereafter. This variability in outward relevance is a function of changes to the inward relevance of the cases cited by *Barenblatt*.

Table 2 The 20 most legally important cases as of 2005

Case	*Score (percentile rank)*
Inward relevance	
Cantwell v. Connecticut (1940)	0.1682 (1.0)
Schneider v. State (Town of Irvington) (1939)	0.1427 (0.9999625)
NAACP v. Button (1963)	0.1412 (0.999925)
Thornhill v. Alabama (1940)	0.1352 (0.9998876)
New York Times v. Sullivan (1964)	0.1285 (0.9998501)
NAACP v. Alabama (1958)	0.1261 (0.9998126)
Lovell v. City of Griffin (1938)	0.1114 (0.9997751)
Speiser v. Randall (1958)	0.1110 (0.9997376)
West VA State Bd. of Ed. v. Barnette (1943)	0.1007 (0.9997002)
Hague v. Committee for Industrial Org. (1939)	0.1007 (0.9996627)
Shelton v. Tucker (1960)	0.0995 (0.9996252)
Whitney v. California (1927)	0.0959 (0.9995877)
Chaplinsky v. New Hampshire (1942)	0.0956 (0.9995502)
Near v. Minnesota (1931)	0.0947 (0.9995128)
Roth v. U.S. (1957)	0.0936 (0.9994753)
Ashwander v. TVA (1936)	0.0894 (0.9994378)
Pierce v. Society of Sisters (1925)	0.0885 (0.9994003)
Buckley v. Valeo (1976)	0.0883 (0.9993628)
Thomas v. Collins (1945)	0.0879 (0.9993253)
Stromberg v. California (1931)	0.0871 (0.9992879)
Outward Relevance	
Branzburg v. Hayes (1972)	0.1172 (1.0)
Griswold v. Connecticut (1965)	0.1100 (0.9999625)
Buckley v. Valeo (1976)	0.1036 (0.999925)
Communist Party of U.S. v. Subversive Activities Control Board (1961)	0.1034 (0.9998876)
Paris Adult Theatre I v. Slaton (1973)	0.0967 (0.9998501)
Columbia Broadcasting System v. Democratic National Comm. (1973)	0.0958 (0.9998126)
First National Bank v. Bellotti (1978)	0.0957 (0.9997751)
McGautha v. California (1971)	0.0947 (0.9997376)
Young v. American Mini Theatres Inc. (1976)	0.0945 (0.9997002)
Dennis v. U.S. (1951)	0.0860 (0.9996627)
Oregon v. Mitchell (1970)	0.0845 (0.9996252)
Metromedia v. City of San Diego (1981)	0.0822 (0.9995877)
Poe v. Ullman (1961)	0.0807 (0.9995502)
Roe v. Wade (1973)	0.0783 (0.9995128)
NAACP v. Button (1963)	0.0754 (0.9994753)
California v. LaRue (1972)	0.0745 (0.9994378)
Grayned v. City of Rockford (1972)	0.0731 (0.9994003)
Broadrick v. Oklahoma (1973)	0.0730 (0.9993628)
American Communications Assn. v. Douds (1950)	0.0728 (0.9993253)
VA State Board of Pharmacy v. VA Citizens Consumer Council (1976)	0.0708 (0.9992879)

4 Testing the Validity of Network Measures of the Importance of Precedent

Now that we have established how we measure case importance with network measures, we turn to testing their validity. To do so, we examine the degree to which they explain how often and when American courts cite U.S. Supreme Court precedent. Our dependent

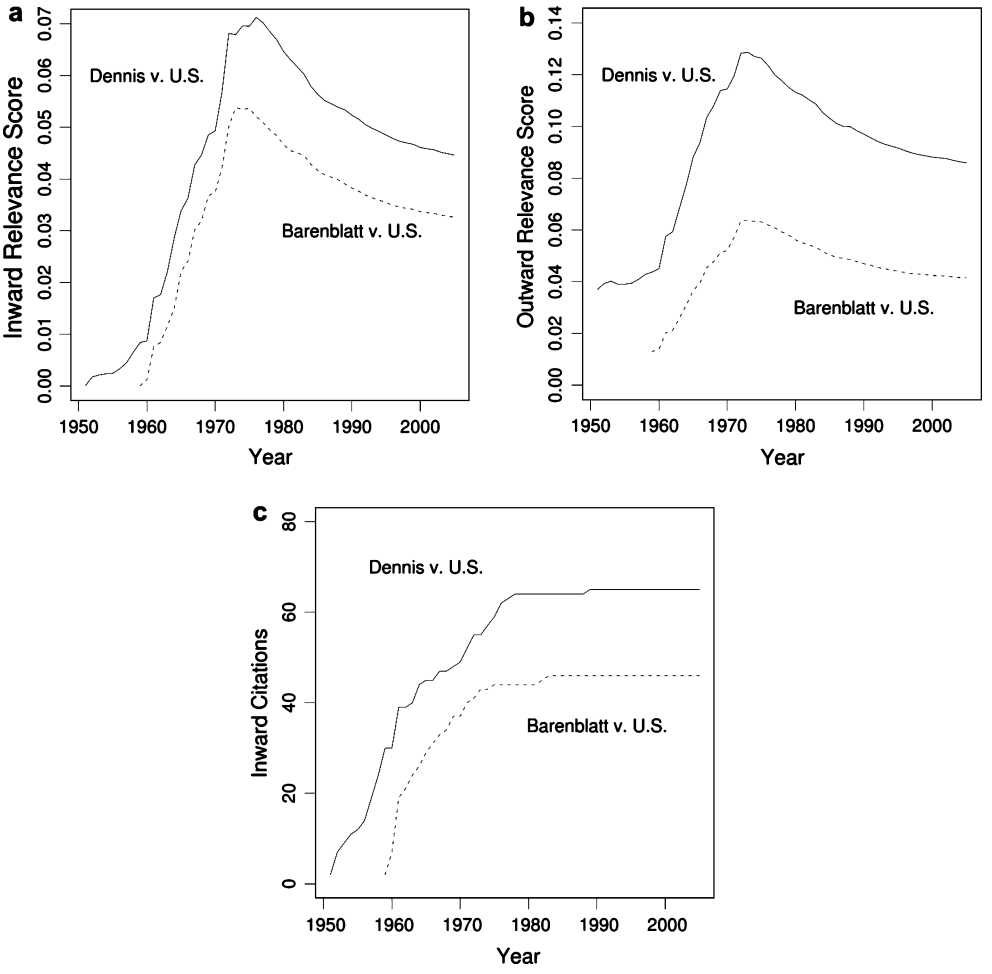

Fig. 5 (a) Inward relevance for *Dennis v. U.S.* and *Barenblatt v. U.S.* (b) Outward relevance for *Dennis v. U.S.* and *Barenblatt v. U.S.* (c) Inward citations to *Dennis v. U.S.* and *Barenblatt v. U.S.* In these figures, we use the raw relevance scores, rather than the percentile ranks.

variables are counts of, respectively, the number of times the U.S. Supreme Court, U.S. Courts of Appeals, and U.S. state courts cite each of the 26,681 Supreme Court precedents in each year, starting with the year each case was decided and ending in 2005.[16] We gathered these data using *Shepard's Citations*. Our unit of analysis is the case-year; therefore, we have an observation for each case in each year, and we aggregate all decisions by a given level of the American judiciary for a given year.

Our main independent variables are 1-year lagged measures based on the above three network measures. First, we examine the two most prominent measures of network centrality, the raw number of citations (inward cites and outward cites) and eigenvector

[16]The mean, median, and SD, respectively, for the U.S. Supreme Court, Courts of Appeals, and state courts, are as follows: 0.10, 0, 0.42; 0.61, 0, 5.56; and 0.70, 0, 9.64. The minimum and maximum values, respectively, for the Supreme Court, Courts of Appeals, and state courts are the following: 0 to 17; 0 to 3518; and 0 to 3246.

centrality (*inward eigenvector centrality* and *outward eigenvector centrality*). We then examine our new measures based on the inward relevance and outward relevance scores, which are computed using the Supreme Court citation network with the technique discussed above. Note that, for purposes of the regression analyses, we converted the raw importance scores into percentiles that indicate, for a given year, how relevant a case is relative to all other existing majority opinions of the Court.[17]

Recall that our network measures relate to one aspect of case importance—the legal relevance of a case for law at the Court. To control for other dimensions of importance, our models include several alternative measures. Two of the variables assess the political salience of a case at the time the Court decided it: amici curiae participation in a case (*Amici Briefs*)[18] and a dichotomous variable denoting presence on the front page of the *New York Times* (*New York Times*).[19] We also include dummy variables for a case's inclusion on two different lists of important Court cases—Congressional Quarterly's *Guide to the United States Supreme Court* (Biskupic and Witt 1997) and the *Oxford Guide to Supreme Court Decisions* (Hall 1999).[20] These latter two variables designate the overall social and legal significance of a case as determined by expert evaluators.

Because our dependent variables are counts, we estimate these quantities of interest using a negative binomial regression model.[21] To control for autocorrelation and systematic changes in the rate of citation over time, we include a lagged value of the dependent variable as a covariate. We also include two variables that control for the age of a precedent, age and age squared.

Let us begin with a comparison of the predictive power of the three different types of network measures. Table 3 reports the results of bivariate negative binominal regressions for the U.S. Supreme Court's, the U.S. Courts of Appeals', and U.S. state courts' citation of U.S. Supreme Court precedents. Each column reports a separate model for each measure of importance. To gain an initial sense of their relative fit with the data, we compare the log pseudolikelihoods for the models with the network measures. A model with a larger likelihood indicates that the particular measure explains more variation in the dependent variable than the alternative measures.[22] Recall that we expected inward relevance and outward relevance to outperform the alternative network measures, for both substantive and technical reasons. Overall, inward relevance fits the data better than the alternatives—it has the best fit with the Supreme Court citation of precedent and it is one of the top two performers at the U.S. Courts of Appeals and state courts. Inward citations also fit the data reasonably well at all levels of the judiciary.

[17]Our models control (at least indirectly) for the opportunity for a case to be cited in a given year. First, the models control for the age of a case, which is correlated with opportunity to cite. Second, we include a 1-year lag of the dependent variable as an independent variable, and it is also correlated with opportunity to cite.

[18]The measure of amicus participation is a term-specific z-score [(no. of briefs in case x − average number of briefs in term y)/SD of briefs in term y]. It thus measures the number of SDs away the number of briefs in a given case is from the average number of briefs filed in cases in that term. We obtained these data, for cases decided between 1946 and 2005, from Gibson (1997) and Hansford and Spriggs (2006).

[19]We obtained these data, for cases decided between 1946 and 2005, from Epstein and Segal (2000) and Hansford and Spriggs (2006).

[20]The *CQ list* covers cases decided between 1791 and 1996, whereas the Oxford list includes cases decided between 1791 and 1998.

[21]We use this model rather than the Poisson because the dispersion parameter indicates that the data are overdispersed.

[22]Note that one should not compare the log likelihoods across models with a different numbers of observations, and we thus hold off, for a moment, on comparing the network measures with the measures of alternative aspects of case importance.

Table 3 Relationship between measures of case importance and future citations of U.S. Supreme Court precedent by the U.S. Supreme Court (1791–2005), U.S. Courts of Appeals (1791–2005), and state courts (1791–2005)

Importance measure	*Inward relevance*	*Outward relevance*	*Inward cites*	*Outward cites*	*Inward eigenvector centrality*	*Outward eigenvector centrality*	*New York Times*	*Amici Briefs*	*CQ list*	*Oxford list*
Dependent variable: number of times a U.S. Supreme Court case is cited by the U.S. Supreme Court[a]										
Importance measure	2.862	2.841	0.056	0.032	2.425	2.280	0.589	0.139	1.283	1.684
	(0.021)	(0.047)	(0.001)	(0.001)	(0.026)	(0.045)	(0.026)	(0.009)	(0.024)	(0.041)
Lagged dependent variable	0.423	0.542	0.436	0.631	0.586	0.679	0.442	0.472	0.661	0.718
	(0.008)	(0.012)	(0.006)	(0.014)	(0.007)	(0.012)	(0.007)	(0.007)	(0.008)	(0.008)
Age	−0.058	−0.042	−0.062	−0.043	−0.043	−0.028	−0.045	−0.043	−0.044	−0.045
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(.001)	(0.002)	(0.002)	(0.001)	(0.000)
Age squared	0.0003	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.00004	0.0002	0.0002
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.00004)	(0.0000)	(0.0000)
Constant	−2.735	−3.301	−1.271	−1.652	−2.757	−3.300	−0.752	−0.687	−1.431	−1.339
	(0.019)	(0.034)	(0.010)	(0.014)	(0.021)	(0.040)	(0.015)	(0.015)	(0.010)	(0.009)
Dispersion	1.113	1.091	1.405	1.514	1.252	1.389	0.874	0.925	1.466	1.603
	(0.019)	(0.027)	(0.038)	(0.030)	(0.018)	(0.029)	(0.018)	(0.018)	(0.021)	(0.019)
Log pseudolikelihood	−606,015	−613,020	−609,089	−631,109	−622,439	−631,520	−139,729	−140,467	−630,929	−636,646
Null likelihood	−756,246	−756,246	−756,246	−756,246	−756,246	−756,246	−156,699	−156,699	−752,926	−754,334
N	2,407,926	2,407,926	2,407,926	2,407,926	2,407,926	2,407,926	198,321	198,321	2,405,033	2,406,337
Dependent variable: number of times a U.S. Supreme Court case is cited by the U.S. Court of Appeals[b]										
Importance measure	1.968	1.896	0.056	0.039	2.156	2.258	0.262	0.049	1.009	1.235
	(0.026)	(0.036)	(0.001)	(0.001)	(0.029)	(0.048)	(0.024)	(0.009)	(0.024)	(0.046)

Continued

Table 3 (continued)

Importance measure	*Inward relevance*	*Outward relevance*	*Inward cites*	*Outward cites*	*Inward eigenvector centrality*	*Outward eigenvector centrality*	*New York Times*	*Amici Briefs*	*CQ list*	*Oxford list*
Lagged dependent variable	0.273	0.281	0.250	0.279	0.262	0.278	0.102	0.103	0.327	0.341
	(0.007)	(0.007)	(0.007)	(0.001)	(0.007)	(0.007)	(0.004)	(0.004)	(0.008)	(0.007)
Age	−0.039	−0.027	−0.041	−0.028	−0.029	−0.014	−0.023	−0.022	−0.028	−0.028
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Age squared	0.0001	0.0001	0.0001	0.0001	0.0001	0.00004	−0.0001	−0.0001	0.0001	0.0001
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.00000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Constant	−1.482	−1.848	−0.601	−0.955	−1.785	−2.506	−0.842	0.872	−0.707	−0.657
	(0.018)	(0.026)	(0.017)	(0.017)	(0.018)	(0.041)	(0.029)	(0.029)	(0.017)	(0.018)
Dispersion	2.277	2.279	2.186	2.363	2.206	2.233	1.033	1.041	2.498	2.602
	(0.044)	(0.046)	(0.042)	(0.045)	(0.041)	(0.046)	(0.036)	(0.036)	(0.050)	(0.051)
Log pseudolikelihood	−1,430,193	−1,440,522	−1,419,924	−1,446,710	−1,437,559	−1,442,111	−416,871	−417,328	−1,448,235	−1,460,188
Null likelihood	−1,808,853	−1,808,853	−1,808,853	−1,808,853	−1,808,853	−1,808,853	−483,137	−483,137	−1,790,750	−1,798,080
N	2,407,926	2,407,926	2,407,926	2,407,926	2,407,926	2,407,926	198,321	198,321	2,405,033	2,406,337
Dependent variable: number of times a U.S. Supreme Court case is cited by state courts[c]										
Importance measure	2.492	2.099	0.061	0.059	3.802	3.790	0.398	0.066	1.200	1.510
	(0.039)	(0.054)	(0.001)	(0.001)	(0.057)	(0.210)	(0.032)	(0.011)	(0.070)	(0.110)
Lagged dependent variable	0.196	0.225	0.188	0.270	0.105	0.250	0.098	0.100	0.340	0.350
	(0.011)	(0.012)	(0.011)	(0.010)	(0.007)	(0.010)	(0.007)	(0.007)	(0.010)	(0.010)
Age	−0.034	−0.019	−0.035	−0.020	−0.024	0.001	−0.016	−0.015	−0.020	−0.020
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)

Continued

Table 3 (continued)

Importance measure	*Inward relevance*	*Outward relevance*	*Inward cites*	*Outward cites*	*Inward eigenvector centrality*	*Outward eigenvector centrality*	*New York Times*	*Amici Briefs*	*CQ list*	*Oxford list*
Age squared	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	−0.0001	−0.0001	0.0001	0.0001
	(0.000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0002)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Constant	−1.763	−2.032	−0.613	−1.641	−2.708	−4.290	0.487	0.527	−1.180	−1.050
	(0.021)	(0.034)	(0.025)	(0.046)	(0.021)	(0.021)	(0.049)	(0.050)	(0.038)	(0.051)
Dispersion	2.197	2.373	2.277	3.550	1.565	3.610	1.870	1.895	4.160	4.420
	(0.079)	(0.090)	(0.076)	(0.070)	(0.058)	(0.070)	(0.059)	(0.112)	(0.050)	(0.080)
Log pseudolikelihood	−1,502,241	−1,529,853	−1,510,077	−1,771,413	−1,468,505	−1,743,820	−381,702	−382,420	−1,705,128	−1,747,244
Null likelihood	−1,912,839	−1,912,839	−1,912,839	−1,912,839	−1,912,839	−1,912,839	−439,745	−439,745	−1,918,232	−1,923,021
N	2,407,926	2,407,926	2,407,926	2,407,926	2,407,926	2,407,926	198,321	198,321	2,405,033	2,406,337

Note. Each column shows estimated parameters and SEs in parentheses for a negative binomial regression model that includes a lagged dependent variable, age of the cited case, age squared, and the case centrality measure listed at the top of the column. SEs are corrected for heteroskedasticity (Huber–White) and clustered by cited precedent (Froot–Williams).
[a]Dispersion values greater than 0 indicate significant overdispersion. Null likelihood indicates log pseudolikelihood of the constant-only model for that subset of the data.
[b]Dispersion values greater than 0 indicate significant overdispersion. Null likelihood indicates log pseudolikelihood of the constant-only model for that subset of the data.
[c]Dispersion values greater than 1 indicate significant overdispersion. Null likelihood indicates log pseudolikelihood of the constant-only model for that subset of the data.

Table 4 Comparison of alternative measures of case importance for predicting future citations to U.S. Supreme Court precedent, 1791–2005

Alternative importance measure	*Inward cites*	*Outward cites*	*Inward eigenvector centrality*	*Outward eigenvector centrality*	*New York Times*	*Amici Briefs*	*CQ list*	*Oxford list*
Effect size: percent increase in probability a U.S. Supreme Court case is cited by the U.S. Supreme Court in the following year given a 1-SD change in the importance measure								
Inward relevance	51.4	76.1	62.3	77.7	43.3	45.3	71.2	73.5
Outward relevance	44.3	42.7	45.3	51.9	54.4	56.2	47.8	50.4
Alternative importance measure	32.3	9.5	28.9	3.8	9.8	7.7	12.1	11.1
Effect size: percent increase in probability a U.S. Supreme Court case is cited by the U.S. Courts of Appeals in the following year given a 1-SD change in the importance measure								
Inward relevance	24.6	50.4	38.1	57.3	27.9	27.9	48.4	49.7
Outward relevance	23.9	15.3	27.2	0.0	24.2	24.3	28.5	30.7
Alternative importance measure	39.9	20.6	33.0	58.3	0.0	0.0	8.9	6.5
Effect size: percent increase in probability a U.S. Supreme Court case is cited by the state courts in the following year given a 1-SD change in the importance measure								
Inward relevance	64.4	76.5	49.6	77.0	50.7	51.0	74.1	74.4
Outward relevance	23.9	21.6	26.6	32.1	61.1	61.4	27.0	29.1
Alternative importance measure	32.6	10.7	79.6	0.0	0.0	0.0	10.6	9.1

Note. Each column shows estimated effect size from a negative binomial regression model that includes a lagged dependent variable, age of the cited case, age squared, the alternative importance measure listed at the top of the column, and inward relevance and outward relevance. SEs (not shown) corrected for heteroskedasticity (Huber–White) and clustered by cited precedent (Froot–Williams) were negligible, ranging between 0.0 and 4.4 for all effect sizes.

To probe further the explanatory capacity of the network measures and to compare them with the nonnetwork-based measures of importance, we examine how each of these variables affects the predicted probability that a case will be cited in the future. Table 4 reports effect sizes for each of the alternative measures, where effect size refers to the change in the probability a given case will be cited in a particular year based on a 1-SD increase in the value of the variable of interest. To make the effect sizes of inward and outward relevance comparable to each of the alternative measures, we analyzed a separate model for each of the alternatives. That is, each model (represented by each column in Table 4) includes the inward relevance and outward relevance variables, a lagged dependent variable, age and age squared, as well as one of the alternative measures of case importance.

We turn first to the top of Table 4 and the Supreme Court's citation of its own precedents. Most notably, inward relevance and outward relevance dominate all the other measures of case importance; that is, they lead to significantly larger changes in the predicted probability of the Court citing a case than the other measures do. For example, the best performing alternative measure, by far, is inward cites, and a 1-SD increase in its value leads to a 32.3% increase in the probability of a case being cited in a given year. Raising inward relevance by 1 SD, by contrast, increases the probability of a case being cited in a year by 51.4%. This value would be even higher without the inward citation

covariate, since inward relevance contains information about both the *quantity* of inward citations and the *quality* of the network. This difference is even more stark when we examine the model with outward cites as the alternative importance measure. A 1-SD change in outward relevance increases the probability of a citation by 42.7% while a similar change in outward cites increases this probability by only 9.5%. Another way to think about this is that we are getting a considerable amount of information out of the indirect network relationships, after controlling for the simple direct relationships that appear in the citation counts.

We see an even more dramatic difference in effect sizes if we compare inward relevance and outward relevance with the nonnetwork importance measures. For instance, if a case appears on the *CQ list* or on the front page of the *New York Times* the probability of the case being cited by the Supreme Court increases by 73.6% and 30.2%, respectively.[23] A case with the maximum value of inward relevance increases this probability by, respectively, 558.6% and 249.1% when we examine the models with the *CQ list* and *New York Times* as the alternative importance measures. For this particular comparison, we use the maximum value of inward relevance, rather than the SD change in Table 4, because the *CQ list* and *New York Times* predictions are based on the maximum value of those variables. Likewise, the effect sizes of *Amici Briefs* and the *Oxford List* are smaller than inward relevance and outward relevance.

The results for the U.S. Courts of Appeals' (middle panel of Table 4) and state courts' (bottom panel of Table 4) citation of Supreme Court precedent are in reasonable accord with the Supreme Court results. With the exception of *Inward Citations* in the Courts of Appeals model and inward eigenvector centrality in the state court model, inward relevance packs more punch than any other network measure of case importance.[24] Even the models that control for inward citations show that both importance measures exhibit a strong relationship with future citations, suggesting that there is valuable information in these scores that cannot be captured by a simple citation count.

5 Conclusion

In this article we offer a study of how a new methodological technique—network analysis—can help scholars measure how legally central a case is at the Supreme Court. Scholars often note the importance of analyzing a case within the context of related cases, and using citations to define this context allows us to rely on the opinions of the judges themselves in determining which cases are legally relevant for the network of law at the Court. The whole network of these citations contains a rich array of information not only about the cited cases but also about the citing cases as well. We describe methods for quantifying this network information. A simple analysis of the full network of majority opinions demonstrates quantitatively that the number of cases cited by the average opinion has gradually increased over time, whereas the number of times a case is cited by later courts has remained relatively stable. The distribution of these citations also looks strikingly similar to scientific citation networks, as most cases are rarely cited while a handful of highly cited cases dominate the network.

[23]These numbers are not the same as those reported in Table 4. In Table 4, the effect size is based on a SD change in the value of a variable. Since *New York Times* and *CQ list* are dichotomous variables a SD is not really the apt metric to use. The numbers in the text are thus based on the value of these two variables equaling one.

[24]We note that the effect size of inward relevance is also approximately equal to that of outward eigenvector centrality in the state court model.

We then demonstrate a method that is based on the theory that influential cases are more likely to be cited by cases that are considered to be well-grounded in the law and well-grounded cases are more likely to cite influential cases. This method yields two measures, an inward relevance measure that identifies influential cases and an outward relevance measure that identifies cases that are well grounded in the law. In most of our tests these network measures outperform conventional measures that have been used to define case importance, and in all our tests, we show that there is additional information in the network (beyond simple citation counts) that can be utilized to predict which cases will be cited in the future. That is, the network method allows us to determine the extent to which cases become more or less relevant over time, in comparison to other cases in the network, in a more valid way than extant measures.

We hope that the methods described in this article will motivate future study on a number of important questions relating to law and legal development. For example, one could use network techniques to probe the extent to which judges are influenced by precedent when they decide which cases to cite, when to overrule past decisions, and the like. One could also attempt to understand the development of the norm of stare decisis in American law. Despite the acknowledged importance of this norm, no scholarly study to date has explained when or why it originated and developed in the United States. Indeed, although legal historians generally agree that the idea that past cases are binding did not exist prior to the late 18th century, there is no consensus concerning when this norm became institutionalized (e.g., Kempin 1959; Allen 1964; Jones 1975). One could use the data discussed above—especially the patterns in the citation and following of precedent—to determine when the norm originated and developed in the American judiciary and to test an explanation for its institutionalization.

Finally, we are interested more broadly in the question of how the Supreme Court's citation network relates to other citation networks and other kinds of networks found in human society and in nature. A quickly growing literature has shown that many real-world networks, such as cellular networks, legislative networks, the World Wide Web, and scientific citation and coauthorship networks, are alike in fundamental ways (Albert and Barabasi 2002; Fowler 2006). In particular, the exponential tail in the degree distribution of inward and outward citations in the precedent network suggests that there is something systematic about the evolution of law that mimics the evolution of other network phenomena. A fruitful investigation of these similarities might not only yield a better understanding of Supreme Court decision making—it could also help us to understand the general properties of all networks. There is much work to be done.

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