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LAW'S SEMANTIC SELF-PORTRAIT: DISCERNING DOCTRINE WITH CO-CITATION NETWORKS AND KEYWORDS

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ARTICLES

LAW'S SEMANTIC SELF-PORTRAIT: DISCERNING DOCTRINE WITH CO-CITATION NETWORKS AND KEYWORDS

Joseph Scott Miller*

ABSTRACT

An apex court's body of cases has an internal texture, continually augmented by recent citations to earlier, topically related cases. How can we best describe that texture? The citation network shows a path. Specifically, what past Supreme Court cases do more recent Supreme Court cases tend to cite together, as if a topical pair? Using a web of those oft-cited pairs, what noun phrases appear in a given cluster of cases more often, relative to the rate at which those phrases appear in writings generally? To answer these questions is to map, in detail, a body of decisional law. Using common network-analysis and corpus-linguistics tools, one can derive from a group of cases the key empirical facets of the legal doctrine embodied in that cluster of cases—a semantic self-portrait that the cases paint with their own words and citations. This Article provides a pair of case studies for revealing the latent semantic building blocks of legal doctrine. First, using a new citation dataset, I analyze the co-citation network of a sharply defined group of Supreme Court cases (in this instance, cases on the Warsaw Convention, a treaty that limits liability for loss or injury in international air travel, and other cases related thereto). Second, building on a citation dataset from prior work, I analyze the co-citation network of all the Supreme Court's intellectual property cases from 1947 to 2018, inclusive. With these empirical studies, I show that co-citation analysis complements *both* traditional legal

* Professor, University of Georgia School of Law. My thanks for helpful feedback on an earlier draft to Christina Boyd, Nathan Chapman, Harlan Cohen, Tim Meyer, Christina Mulligan, John Parry, Nicholson Price, Greg Reilly, and Jessica Silbey.

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analysis—by establishing data about legal doctrine, from the bottom up, using large case networks—*and* the attitudinal-model studies from political science—by focusing on the substance of legal doctrine, rather than on judges' votes in split cases placed on a right-left continuum.

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http://lawreview.law.pitt.edu

Table of Contents

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

> Rather than being little more than the characteristic form of legal jargon, the law's practice of using and announcing its authorities—its citation practice—is part and parcel of law's character.
>
> —*Frederick Schauer*[1]

I. INTRODUCTION

Judicial opinions in common-law practice announce outcomes, describe key facts, and link facts to outcomes with reasoned discussion of authoritative texts (e.g., statutes), regulatory purposes, and judicial precedents. "Reasoned justifications, based on relevant factors, are the bread and butter of judicial decision making."[2] And, at least in the case of mature doctrines, precedents are key: "Rare is the opinion that does not justify its outcome in terms of prior precedents."[3]

As bodies of decisional law grow, the need for case synthesis intensifies. Taking cases two or three at a time is no longer sufficient. One must discern doctrine

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[1] Frederick Schauer, *Authority and Authorities*, 94 VA. L. REV. 1931, 1935 (2008); *see also* FREDERICK SCHAUER, THINKING LIKE A LAWYER: A NEW INTRODUCTION TO LEGAL REASONING 84 (2009) ("The boundaries of law are set by the boundaries of legal authority, and law speaks as law through its sources."); Fred R. Shapiro, *Origins of Bibliometrics, Citation Indexing, and Citation Analysis: The Neglected Legal Literature*, 43 J. AM. SOC'Y INFO. SCI. 337, 337 (1992) (observing that "whereas, in science, publications and their interconnections are by–products of the research enterprise, in law, publications and their interconnections are at the very heart of the discipline").

[2] DANIEL A. FARBER & SUZANNA SHERRY, JUDGMENT CALLS: PRINCIPLE AND POLITICS IN CONSTITUTIONAL LAW 43 (2009); *see also* Barry Friedman, *Taking Law Seriously*, 4 PERSP. ON POL. 261, 266 (2006) ("In common law systems, law is found primarily in legal opinions, not divined from the outcomes of cases. . . . At bottom, what law imposes is a requirement of reasoned justification, and reasons are found in the opinion of a court . . . . This requirement of justification is fundamental in common law systems."). This description of judicial practice applies to administrative adjudication as well; giving reasons is a key facet of fair process, helping to prevent arbitrary state action. *See* Cass R. Sunstein & Adrian Vermeule, *The Unbearable Rightness of* Auer, 84 U. CHI. L. REV. 297, 316–17 (2017) (observing that the Administrative Procedure Act's "'arbitrary and capricious' standard . . . serves to promote 'procedural fairness' by requiring agencies to give good reasons for their procedural choices—and, of course, for their interpretations." (quoting Perez v. Mortg. Bankers Ass'n, 135 S. Ct. 1199, 1209 (2015)).

[3] Stefanie A. Lindquist & Frank B. Cross, *Empirically Testing Dworkin's Chain Novel Theory: Studying the Path of Precedent*, 80 N.Y.U. L. REV. 1156, 1166 (2005) (footnotes omitted); *see also* MELVIN ARON EISENBERG, THE NATURE OF THE COMMON LAW 50 (1988) ("Reasoning from precedent is perhaps the most characteristic mode of reasoning in the common law."); FARBER & SHERRY, *supra* note 2, at 63 ("If you open a random page of the *U.S. Reports* and read a constitutional decision, you will be struck by how much of the space is devoted to discussing the Court's previous rulings."); Anthony Niblett & Albert H. Yoon, *Friendly Precedent*, 57 WM. & MARY L. REV. 1789, 1796 (2016) ("Adherence to precedent, or stare decisis, provides the foundation of the common law."). This is just as true of statutory as it is of common-law cases. *See generally* WILLIAM N. ESKRIDGE, INTERPRETING LAW 139–51 (2016).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

from larger aggregations of cases. Our traditional case-synthetic texts for organizing and elaborating legal doctrine—digests and headnotes, treatises, and restatements of the law—are well known to all American lawyers, from still-green 1Ls to weathered lawyers and judges. Each of these synthetic forms has a different history,[4] and each has garnered specific critiques.[5] What unites them all, as they discuss a given case, is that they reflect their authors' interpretive judgments about what a case *holds*—in addition to whatever else it says—and how *broad or narrow* its holding may be.[6] Interpretive approaches vary, of course. "Different readers may come away from the same opinion with quite different versions of its meaning."[7]

The common-law case-synthesis process has not changed materially in the last several decades, nor is it likely to do so in the years ahead. The primary inputs are case texts and synthesist's judgments. There are, however, new ways to aggregate and analyze case text to establish another semantic layer between multiple cases and the skilled synthesist's interpretive judgments about the contours of legal doctrine. This new semantic layer results from applying the tools of citation-network analysis and corpus linguistics to a body of judicial opinions, the tools of citation-network analysis and corpus linguistics. The Article in hand describes and applies these tools to two illustrative networks of United States Supreme Court case citations. One

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[4] On digests and treatises, see generally EDWIN C. SURRENCY, A HISTORY OF AMERICAN LAW PUBLISHING 121–27, 141–56 (1990); and Patti Ogden, *"Mastering the Lawless Science of Our Law": A Story of Legal Citation Indexes*, 85 LAW LIB. J. 1 (1993). On the American Law Institute's restatement projects, see generally Nathan M. Crystal, *Codification and the Rise of the Restatement Movement*, 54 WASH. L. REV. 239 (1979); and G. Edward White, *The American Law Institute and the Triumph of Modernist Jurisprudence*, 15 LAW & HIST. REV. 1 (1997).

[5] *See generally* Kristen David Adams, *Blaming the Mirror: The Restatements and the Common Law*, 40 IND. L. REV. 205 (2007) (canvassing critiques of the ALI restatements); Ann Bartow, *The Hegemony of the Copyright Treatise*, 73 U. CIN. L. REV. 581 (2004) (critiquing undue reliance on a dominant treatise). Computer databases of court opinions have rendered the digests far less important, though finding aids originating in the digests—such as West headnotes and the key number system—remain useful in the databases. Sabrina Sondhi, *Should We Care If the Case Digest Disappears? A Retrospective Analysis and the Future of Legal Research Instruction*, 27 LEG. REF. SRVS. Q. 263, 266, 277 (2008).

[6] *See* BRYAN A. GARNER ET AL., THE LAW OF JUDICIAL PRECEDENT 2 (2016) ("When lawyers and judges analyze a precedent, they're usually trying to determine just what its holding is. They're also trying to gauge how broadly or narrowly the holding sweeps. . . ."). There is also, it must be said, disagreement over the dividing line between holding and dicta. *Id.* at 44–45.

[7] *Id.* at 3 (footnotes omitted). The "may" matters here. As Hart observed of English precedent—and he could just as well have been speaking of United States precedent—although "there is no single method of determining the rule for which a given authoritative precedent is an authority," it is also true that "in the vast majority of decided cases there is very little doubt. The head-note is usually correct enough." H.L.A. HART, THE CONCEPT OF LAW 134 (3d ed. 2012).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

network centers on disputes about the Warsaw Convention,[8] a treaty that "govern[ed] air carrier liability for injuries to passengers and damages to baggage and cargo during international carriage."[9] The Supreme Court's eight Warsaw Convention cases[10] make for a readily identifiable starting point with a sharply defined outer boundary. The other network—building on data from prior work—contains the Supreme Court's citations to its earlier cases, from all the Court's intellectual property law decisions from 1947 to 2018.[11] The latter network's membership is more open to debate, but usefully involves many more source cases decided over a longer span of time.

The co-citation and keyword analysis techniques I use in this work, though novel in law, are well established in their home fields of bibliometrics[12] and corpus linguistics.[13] Two papers, twenty-five years ago, urged the benefits of analyzing the co-citation networks within case law.[14] But the legal literature, to date, lacks any co-

[8] "Warsaw Convention" is the common name for the Convention for the Unification of Certain Rules Relating to International Transportation by Air, Oct. 12, 1929, 49 Stat. 3000. *See generally* Andreas F. Lowenfeld & Allan I. Mendelsohn, *The United States and the Warsaw Convention*, 80 HARV. L. REV. 497 (1967) (describing the early years of United States' adherence to the treaty).

[9] Philip Weissman, *The Warsaw and Montreal Conventions: Ending the Complete Preemption Debate*, 30 AIR & SPACE L., no. 3, 2017, at 1. The Warsaw Convention was replaced, in 2003 in the United States, by the Montreal Convention, *id.*, more formally the Convention for the Unification of Certain Rules for International Carriage by Air, May 28, 1999, T.I.A.S. No. 13,038 (2000).

[10] *See infra* notes 95–102 and accompanying text.

[11] *See generally* Joseph Scott Miller, *Charting Supreme Court Patent Law, Near and Far*, 17 CHI.-KENT J. INTELL. PROP. 377 (2018).

[12] *See generally* ROBERTO TODESCHINI & ALBERTO BACCINI, HANDBOOK OF BIBLIOMETRIC INDICATORS: QUANTITATIVE TOOLS FOR STUDYING AND EVALUATING RESEARCH 39–42 (2016) (describing citation and co-citation network analysis).

[13] *See generally* Jane Evison, *What Are the Basics of Analyzing a Corpus?*, *in* THE ROUTLEDGE HANDBOOK OF CORPUS LINGUISTICS 122, 127–28 (Anne O'Keefe & Michael McCarthy eds., 2010) (describing keyword analysis).

[14] Ogden, *supra* note 4, at 47 (footnotes omitted) ("Co-citation analysis . . . measures the strength of the relationship between two cases based on how many times later cases cited both of them together. . . . Co-citation patterns among groups of citations have been used in scientific literature to model the intellectual structure of specific discipline areas. Shifts in co-citation patterns among a group of legal cases could, over a period of years, help scholars detect the emergence, or chart the development, of certain specialized areas of the law. . . . These techniques of combining citations and measuring the strength of relationship between cases offer hope for new dimensions in information retrieval, and there is no reason this breakthrough should not apply to law."); Fred R. Shapiro, *The Most-Cited Articles from the Yale Law Journal*, 100 YALE L.J. 1449, 1457 (1991) (footnotes omitted) ("Co-citation analysis offers intriguing possibilities for mapping legal scholarship or case law. . . . The historical development of areas of legal

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

citation analysis of a network of judicial opinions' citations to precedent.[15] This gap is part of a larger deficiency in existing legal research: "Citation to precedent in judicial opinions is a seriously understudied phenomenon."[16] Whatever accounts for the delay in deploying network-analysis tools to explore new ways to synthesize legal doctrine, the case studies I report here show that the network analysis of case-law co-citations truly "is a versatile, rigorous, practical—and, increasingly, an inexpensive—tool of empirical research."[17]

The plan of this Article is straightforward. After reviewing the development of co-citation network analysis within bibliometrics, I describe the methods used for collecting and analyzing the citation networks examined here. Next, I report the results, showing that network analysis reveals facets of doctrine that traditional legal analysis cannot. Others, I hope, will take up the methods proved here.

II. CO-CITATION NETWORK ANALYSIS

In a critically important 2007 study, *The Web of Law*, Professor Thomas Smith demonstrates that "[t]he legal citation network"—which he "call[s] the 'Web of Law'"—has an "overall topology, or mathematical structure . . . [that] closely

thought could be charted by means of network diagrams showing citation connections between more recent and older writings, or time series of co-citation maps.").

[15] There is one study of co-citations to "books, book chapters, monographs, journal articles and published proceedings" that appeared in the "2001 and 2002 issues of scholarly journals that routinely publish research articles in media law." Yorgo Pasadeos et al., *Influences on the Media Law Literature: A Divergence of Mass Communication Scholars and Legal Scholars?*, 11 COMM. L. & POL'Y 179, 190–91 (2006). "Citations to court cases," among other cited materials, "were excluded." *Id.* at 191. There is also one study of co-citations to Internal Revenue Code sections in United States Tax Court decisions from 1990 to 2008. Michael J. Bommarito et al., *An Empirical Survey of the Population of U.S. Tax Court Written Decisions*, 30 VA. TAX REV. 523, 540–44 (2011). Neither study, however, examines a body of judicial opinions to determine which precedents tend to be cited together in subsequent opinions, and at what rate. For a review of the empirical literature on judicial citations to precedent and the network analysis thereof, see generally Joseph Scott Miller, *Which Supreme Court Cases Influenced Recent Supreme Court IP Decisions? A Case Study*, 21 UCLA J.L. & TECH., no. 2, 2017, at 1, 5–15.

[16] David G. Post & Michael B. Eisen, *How Long Is the Coastline of the Law? Thoughts on the Fractal Nature of Legal Systems*, 29 J. LEGAL STUD. 545, 545 (2000). "Studied" in this context means examined both systematically and quantitatively. *See generally id.*

[17] Richard A. Posner, *An Economic Analysis of the Use of Citations in the Law*, 2 AM. L. & ECON. REV. 381, 402 (2000) (making this surmise of citation analysis more broadly). Quantitative study of large case-law citation networks is still quite new. Indeed, "until recently, large-scale analyses of citation practices were impractical; data were difficulty to acquire, analyses methods were rudimentary, and computational power was insufficient." Ryan Whalen et al., *Common Law Evolution and Judicial Impact in the Age of Information*, 9 ELON L. REV. 115, 120 (2017). Happily, "[i]n the last decade, all three of the barriers to large-scale empirical citation analysis have been greatly reduced." *Id.*

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

resembles that of the World Wide Web,"[18] in which "a few nodes have many links, while most nodes have only a few."[19] Using *Shepard*'s citation-index data to aggregate case-specific inward and outward citations[20] and examine large cohorts (e.g., all state cases, or all federal cases),[21] Smith finds that "[i]n each jurisdiction there are relatively very few cases that are cited very frequently, and a large majority of rarely or never cited cases."[22] With respect to the Supreme Court, in particular, Smith shows that "[c]ases receiving one hundred citing references or more comprise only 9.7% of all cited cases," whereas "[a]lmost 68% of cited opinions are cited ten or fewer times."[23] In effect, "[i]f cases that receive more citing references are thought of as more authoritative, we can see that authority is concentrated in a relatively few opinions, and that most opinions have relatively little authority."[24]

Smith also surmises that, because other networks with this Web-like citation topology "tend to be organized in clusters," the network of judicial opinions may cluster as well—in "clusters of cases which are relatively tightly linked within themselves, but more sparsely linked to each other," and which "probably correlate highly with underlying legal semantics."[25] In other words, "cases in the same legal cluster are likely to be related to each other in terms of meaning and subject matter."[26] One can see why this would be so, considered from the perspective of authoring judges across a run of cases:

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[18] Thomas A. Smith, *The Web of Law*, 44 SAN DIEGO L. REV. 309, 310–11 (2007) (footnotes omitted).

[19] *Id.* at 318; *see also id.* at 321 fig.4 (footnotes omitted). The pattern should be intuitively familiar to legal scholars: "Forty-three percent of articles are not cited at all, and about 79% get ten or fewer citations." *Id.* at 336; *see also id.* at 335 fig.12 (cross-plotting law review citation count against item count).

[20] *Id.* at 312 nn.12, 324–25 (footnotes omitted).

[21] *Id.* at 325–28.

[22] *Id.* at 314 (footnotes omitted).

[23] *Id.* at 330–31 (footnotes omitted). For the cross-plot of citation count by number of cases with that count, see *id.* at 329 fig.8.

[24] *Id.* at 330; *see also id.* at 339 (footnotes omitted) ("A relatively few important decisions exercise the majority of legal influence and authority, and determine the direction of law, just as a few important scientific papers determine the direction and progress of physics (and probably other sciences as well)."); SCHAUER, *supra* note 1, at 80 ("Far more commonly . . . the status of an authority *as* an authority is the product of an informal and evolving process by which some sources become progressively more authoritative as they are increasingly used and accepted.").

[25] Smith, *supra* note 18, at 345.

[26] *Id.* (footnotes omitted).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

> Judges cite the cases that they think are the most relevant to the case they are deciding. When two judges deciding different cases cite some of the same authorities, it is also a signal that those cases are relevant to each other. In this way, the millions of decisions regarding what to cite organize the Web of Law into what network scientists call clusters or communities. In other real networks, these clusters form not just structures in link topology, but structures in semantic topology as well.[27]

Smith's topical-clustering hypothesis foregrounds the promising prospects from identifying and semantically characterizing those clusters: "If common law systems organize themselves into [citation-driven] clusters in this way, then they would have an organic structure that would be discoverable through network analysis."[28] The tools of network analysis are now, a decade on, readily available for use with large networks of case-law citations.[29] Moreover, the most fruitful bibliometric approach—co-citation analysis—is the very one that Smith's conjectures commend: "different cases cit[ing] some of the same authorities . . . [is] a signal that those cases are relevant to each other."[30]

A co-citation network is simply "a network where the vertices represent papers and the edges represent co-citation of pairs of papers," and co-citation analysis "studies the relationship among co-cited papers."[31] The edge connecting a pair of nodes in such a network can vary in weight, representing the number of times that that pair of items has been cited together in each of the other items in the group under study.[32] The edge weight, or "co-citation strength," is a measure of how similar the authors of the citing papers judged the cited items to be, i.e., "the degree of relationship or association between papers as perceived by . . . citing authors."[33] By aggregating these authors' judgments, one can "measure the intellectual relationship

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[27] *Id.* at 341.

[28] *Id.* at 315; *see also id.* at 345 (suggesting that "clustering analysis may reveal a mode of [semantic] organization that is naturalistic, that is, an organization that is found in the legal system, rather than imposed upon it").

[29] *See* Miller, *supra* note 15, at 10–15, 29–35.

[30] *Id.* at 341.

[31] TODESCHINI & BACCINI, *supra* note 12, at 40, 77.

[32] *See id.* at 40–41; Henry Small, *Co-citation in the Scientific Literature: A New Measure of the Relationship Between Two Documents*, 24 J. AM. SOC'Y FOR INFO. SCI. 265, 265 (1973).

[33] TODESCHINI & BACCINI, *supra* note 12, at 41 (citing generally Small, *supra* note 32).

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http://lawreview.law.pitt.edu

among papers."[34] For example, Chief Justice Roberts' opinion for the Court in *Riley v. California*,[35] the 2014 cellphone search case, cites both *Boyd v. United States*[36] and *Kentucky v. King*.[37] A later court thus linked *Boyd* and *King*. The Chief Justice's more recent opinion for the Court in *Carpenter v. United States*,[38] the 2018 cell tower search case, also cites both *Boyd* and *King*. The two cases have been linked once again. And so on.

To illustrate the phenomenon more generally, consider a group of eight judicial opinions. The first two in time, O1 and O2, do not cite any other cases. The subsequent opinions, O3 to O8, cite O1 or O2. Specifically, cases O3 to O6 cite O1, and cases O4 to O8 cite O2. Cases O4 to O6 thus co-cite cases O1 and O2. Treating cases O3 to O8 as citation sources and cases O1 and O2 as citation targets, we list the citations in a table. The table in Figure 1 does so.

source	target
O3	O1
O4	O1
O5	O1
O6	O1
O4	O2
O5	O2
O6	O2
O7	O2
O8	O2

We can also map the network of citations to visualize the nodes and edges listed in the table. Figure 2 presents an example map of the simple citation network. All the edges are the same weight, because they reflect a single, directed citation out from a source node and into a target node. Importantly, we can further map the co-citation network, shown in Figure 3.[39] In our example, because only two of the nodes (O1 and O2) are co-cited by subsequent cases, only those nodes appear in the map. The edge between them has a weight indicating the pair's co-citation strength in the simple network; the "3" on the edge states that co-citation strength.

[34] *Id.* at 77.

[35] Riley v. California, 573 U.S. 373, 382, 403 (2014).

[36] Boyd v. United States, 116 U.S. 616 (1886).

[37] Kentucky v. King, 563 U.S. 452 (2011).

[38] Carpenter v. United States, 138 S. Ct. 2206, 2214, 2222–23 (2018).

[39] I have adapted this example from one described in TODESCHINI & BACCINI, *supra* note 12, at 40–41.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

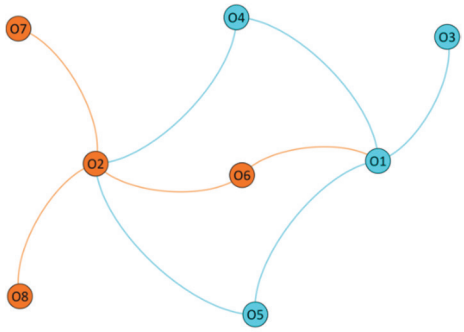

Figure 2: Simple citation network

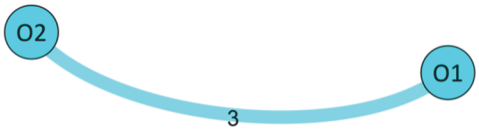

Figure 3: Co-citation network

Henry Small, who helped establish and develop co-citation analysis, did so as a way to map the relationships among papers in a scientific research field, with special attention to the way those relationships *change over time* as new subfields emerge within (and ultimately separate from) existing fields.[40] As Small explains, "[i]n measuring co-citation strength, we measure the degree of relationship or association between papers as perceived by the population of citing authors."[41] One can also map the citation relationships graphically, in a manner that reports co-citation strength and thus highlights key idea-clusters that help define a field.[42] If "frequently cited papers represent the key concepts, methods, or experiments in a field, then co-citation patterns can be used to map out in great detail the relationships between these key ideas."[43] Critically, co-citation strength is *dynamic*, changing as a

[40] Small, *supra* note 32, at 265.

[41] *Id.*

[42] *Id.* at 266–67 fig.1, tbl.1.

[43] *Id.* at 265–66 (footnotes omitted). As De Bellis puts it in her comprehensive history of bibliometric methods, "[a]bove a certain threshold, structural affinities between the co-cited documents are likely to emerge for the simple reason that, by agreeing on what constitutes the previous significant sources, scientists define, to a certain extent, the intellectual boundaries of their research field." NICOLA DE BELLIS, BIBLIOMETRICS AND CITATION ANALYSIS 158 (2009).

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http://lawreview.law.pitt.edu

literature grows: "[B]ecause of th[e] dependence on the citing authors, these patterns can change over time, just as vocabulary co-occurrences can change as subject fields evolve . . . . Co-citation patterns change as the interests and intellectual patterns of the field change."[44] In the years since Small pioneered the co-citation network analysis and mapping, others have used the techniques to discern relationships among key ideas in varied research fields (and subfields) from the physical and social sciences.[45] Given that scholarly papers push hard into novel territory, in contrast to decisional law's preference for stable gradualism, it seems likely that the change rate in co-citation patterns is considerably higher in a set of published research papers than in a set of judicial cases.

Co-citation analysis frequently deals with many thousands of citations in hundreds or thousands of research articles. For example, Kieran Healy's co-citation network of the philosophy literature draws on more than 2,200 articles published between 1993 and 2013 in four leading general-interest philosophy journals.[46] One

[44] Small, *supra* note 32, at 265; *see also id.* at 266 ("Changes in the co-citation patterns, when viewed over a period of years, may provide clues to understanding the mechanism of specialty development."), 268 ("The pattern of linkages among key papers establishes a structure or map for the specialty which may then be observed to change through time. Through the study of these changing structures, co-citation provides a tool for monitoring the development of scientific fields, and for assessing the degree of interrelationship among specialties."). The dynamic character does hit a limit, given that the most recent papers in a field have not themselves garnered citations (and thus co-citations) from others. *See* Kevin W. Boyack & Richard Klavans, *Co-Citation Analysis, Bibliographic Coupling, and Direct Citation: Which Citation Approach Represents the Research Front Most Accurately?*, 61 J. AM. SOC'Y FOR INFO. SCI. & TECH. 2389, 2391 (2010) (observing that co-citation "cannot cluster the most recent papers that have not yet been cited").

[45] *See, e.g.*, EUGENE GARFIELD, CITATION INDEXING—ITS THEORY AND APPLICATION IN SCIENCE, TECHNOLOGY, AND HUMANITIES 98–147 (1979) (providing a detailed review of the first few years of co-citation studies, conducted by Small and others); Debra L. Casey & G. Steven McMillan, *Identifying the "Invisible Colleges" of the* Industrial & Labor Relations Review*: A Bibliometric Approach*, 62 INDUS. & LAB. REL. REV. 126 (2008); Ella Desmedt & Martin Valcke, *Mapping the Learning Styles "Jungle": An Overview of the Literature Based on Citation Analysis*, 24 EDUC. PSYCHOL. 445 (2004); Katherine Gundolf & Matthias Filser, *Management Research and Religion: A Citation Analysis*, 112 J. BUS. ETHICS 177 (2013); Pasadeos et al., *supra* note 15; Antonio-Rafael Ramos-Rodríguez & José Ruíz-Navarro, *Changes in the Intellectual Structure of Strategic Management Research: A Bibliometric Study of the* Strategic Management Journal*, 1980–2000*, at 25 STRATEGIC MGMT. J. 981 (2004); Kai-Yu Tang et al., *A Co-Citation Network of Young Children's Learning with Technology*, 19 EDUC. TECH. & SOC'Y 294 (2016); Malcolm Tight, *Higher Education Research as Tribe, Territory and/or Community: A Co-Citation Analysis*, 55 HIGHER EDUC. 593 (2008); Howard D. White & Katherine W. McCain, *Visualizing a Discipline: An Author Co-Citation Analysis of Information Science, 1972–1995*, at 49 J. AM. SOC'Y FOR INFO. SCI. 327 (1998); Kieran Healy, *A Co-Citation Network for Philosophy*, KIERANHEALY.ORG (June 18, 2013), https://kieranhealy.org/blog/archives/2013/06/18/a-co-citation-network-for-philosophy/.

[46] Healy, *supra* note 45.

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http://lawreview.law.pitt.edu

might then group the application of network methods to judicial outputs together with other large-dataset approaches to studying judicial outputs, such as the many political-science studies of ideology as a predictor of judges' votes in a large run of cases.[47] From that perspective, co-citation analysis and political-science studies of judicial behavior are alike in using large datasets, in contrast to the necessarily more selective, anecdotal approaches of both traditional doctrinal scholarship[48] and close narrative studies of court life[49] and judicial biography.[50]

But with respect to the *output* under study, co-citation studies differ from *both* doctrinal exegesis *and* political-science attitudinal-model studies. In traditional legal scholarship, cases matter both for how they describe doctrine and how they apply that doctrine to case-specific facts, reaching a specific outcome. In judicial or curial biography, cases are neither substantive doctrine nor votes to tally so much as they are events that propel narratives. Political scientists studying judicial behavior largely ignore cases' doctrinal discussions, although—like doctrinalists—they care about outcomes; a wag might say that, along with judges' ideologies, votes are all they care about.[51] Co-citation network analysis also contrasts with doctrinal

[47] *See* LEE EPSTEIN ET AL., THE BEHAVIOR OF FEDERAL JUDGES: A THEORETICAL AND EMPIRICAL STUDY OF RATIONAL CHOICE 65–99 (2013) (reviewing this empirical literature comprehensively).

[48] "Legal academics understand that the language of judicial opinions represents the law. The classical form of legal scholarship was doctrinal analysis, in which a researcher examined the content of a legal opinion to evaluate whether it was effectively reasoned or to explore its implications for future cases." Emerson H. Tiller & Frank B. Cross, *What is Legal Doctrine?*, 100 NW. U.L. REV. 517, 518 (2006); *see also* Bernard Trujillo, *Patterns in a Complex System: An Empirical Study of Valuation in Business Bankruptcy Cases*, 53 UCLA L. REV. 357, 363 n.18 (2005) ("Often, doctrinal research bases its conclusions on a set of data that is both highly selective and rather small relative to the total amount of available data—for example, by limiting the data set to a few appellate court opinions. . . .").

[49] *See, e.g.*, BOB WOODWARD & SCOTT ARMSTRONG, THE BRETHREN: INSIDE THE SUPREME COURT (1979).

[50] *See, e.g.*, LINDA GREENHOUSE, BECOMING JUSTICE BLACKMUN: HARRY BLACKMUN'S SUPREME COURT JOURNEY (2005); GERALD GUNTHER, LEARNED HAND: THE MAN AND THE JUDGE (1994).

[51] *See* Friedman, *supra* note 2, at 262 ("Yet, reflecting an almost pathological skepticism that law matters, positive scholars of courts and judicial behavior simply fail to take law and legal institutions seriously."). The critique has been made by judicial-behavior adepts as well:

> In stark contrast to legal research, many social scientists have disregarded the significance of doctrine entirely. . . . Since the outcomes of cases could easily be coded on a binary scale (as conservative or liberal, affirmance or reversal, etc.), outcomes analysis became the default tool for quantitative social scientific studies of judicial decisionmaking [sic].

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

scholarship but in the opposite way, ignoring case outcomes but tracking citations to the court's prior cases, which embody legal doctrine as the judges themselves describe it. When we organize approaches to studying apex courts' outputs by whether they focus on legal doctrine or outcome valence, as in Figure 4, the complementary nature of co-citation analysis is apparent.

Studying An Apex Court's Outputs		**Is the vote/outcome important?**	
		Yes	No
Is the doctrinal content important?	Yes	traditional doctrinal analysis	**co-citation analysis**
	No	attitudinal-model studies	*The Brethren*

Figure 4: Output-based approaches to apex courts

There is, moreover, reason to hope this is not simply the vice of filling a much-needed gap in the literature. Lee Epstein, a leading figure in empirical studies of judicial behavior, has approvingly noted that "studies are now moving beyond the vote with the goal of analyzing the many other choices judges make," including "what precedents (and other authority) to cite."[52] Co-citation analysis may thus serve as a bridge joining substantive legal analysis and political-science empirics.[53] Consider, for example, that a core feature of political-science studies of judicial behavior is the use of one or more *ex post* ideology scores for the individual judges studied.[54] A particularly prominent ideology score in these studies, known as the

Tiller & Cross, *supra* note 48, at 522–23 (footnote omitted); *see also id.* at 528 ("Political researchers have too often focused on outcomes and ignored legal doctrine. Legal researchers have studied doctrine as pure legal reasoning, without recognizing its political component.").

[52] Lee Epstein, *Some Thoughts on the Study of Judicial Behavior*, 57 WM. & MARY L. REV. 2017, 2049–50 (2016).

[53] For a similar account of citation analysis from a European-law perspective, *mutatis mutandis*, see Urska Šadl & Henrik Palmer Olsen, *Can Quantitative Methods Complement Doctrinal Legal Studies? Using Citation Network and Corpus Linguistic Analysis to Understand International Courts*, 30 LEIDEN J. INT'L L. 327, 328–30 (2017).

[54] *See* EPSTEIN ET AL., *supra* note 47, at 70–77 (discussing various *ex ante* and *ex post* judicial ideology scores). *Ex post* here means "based on judicial votes," i.e., shown in behavior *after* the studied persons became judges. *Id.* at 107.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

Martin-Quinn score,[55] is based on a judge's votes in a multi-member court's *split* decisions—its "non-unanimous cases."[56] In other words, the decisions that show *ideology* as political scientists use the term, are the very ones that separate the justices by favored outcome. As Martin and Quinn explain in the central paper developing this score using Supreme Court data, "[w]e exclude *unanimous* cases because they *contribute no information* to the likelihood" of an outcome.[57] The Court, however, decides *many* cases unanimously—about thirty percent, for example, from 1946–2009.[58] Traditional legal analysis does not ignore unanimous cases, for they are equally critical to the shape and direction of legal doctrine as a discursive practice. Co-citation analysis also takes full account of unanimous decisions, along with divided ones, empirically examining the citation facet of that same discursive practice.

How does co-citation analysis play this complementary role, pulling doctrinal analysis beyond selective normative models and pulling attitudinal studies beyond coded judge-vote tallies? Citation networks are a significant step toward a much deeper context.[59] Specifically, co-citation maps and the networks they depict are *semantically* rich. As Small himself noted, a citation to an earlier work is not *only* a

[55] *Id.* at 74–75 (describing the Martin-Quinn score), 106–11 (reporting Martin-Quinn scores for all Supreme Court Justices using voting data from the 1937 to the 2009 terms, inclusive).

[56] *Id.* at 107. This continues the practice of the pioneer of attitudinal studies of judicial behavior, Herman Pritchett. *Id.* at 65–69 (discussing Pritchett's early work). Pritchett, struck by the fact "that Supreme Court Justices were publishing dissenting opinions at [a then-]unprecedented rate," he tallied "the number of non-unanimous decisions in which pairs of Justices voted together" and ordered the Justices on a right-left continuum. *Id.* at 67–68.

[57] Andrew D. Martin & Kevin M. Quinn, *Dynamic Ideal Point Estimation via Markov Chain Monte Carlo for the U.S. Supreme Court, 1953–1999*, at 10 POL. ANALYSIS 134, 137 n.3 (2002) (emphases added).

[58] EPSTEIN ET AL., *supra* note 47, at 124–26 & fig.3.1 (providing unanimity-rate data across all cases). The likelihood of a divided vote on outcome is not the same across all doctrinal areas. "The biggest ideological voting differences between Justices appointed by Presidents of different parties are found in union, civil rights, and due process cases and the smallest differences in judicial power, federalism, privacy, and federal tax cases." *Id.* at 113; *see also id.* at 133 & tbl.3.12. In a sense, then, using metrics that take no account of votes in unanimous cases—which differ predictably by subject matter—is doubly removed from a comprehensive account of judicial behavior.

[59] *Cf.* MATTHEW L. JOCKERS, MACROANALYSIS: DIGITAL METHODS AND LITERARY HISTORY 27 (2013) ("The result of such macroscopic investigation is contextualization on an unprecedented scale. The underlying assumption is that by exploring the literary record writ large, we will better understand the context in which individual texts exist and thereby better understand those individual texts.").

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

pointer, not only a *sign* of the earlier work—though it is that.[60] A citation is also a *symbol* of the concept(s) that the earlier work has come to represent to experienced participants in the field—"the cited document (or its sign) is a symbol for a concept."[61] And the act of citing the earlier work is the very means by which those experienced participant-authors create and confer the symbol's meaning in a shared discourse such as decisional law: "In citing a document an author is creating its meaning, and this . . . is a process of symbol making."[62] A co-citation map is thus a semantic map, as well.

One way to depict a co-citation map is to label the nodes and the cited papers with each of the paper's citation information.[63] That mapping convention is likely quite readable for an expert in the field(s) that the co-citation network charts. For a less expert reader, however, the semantic content of the map is less accessible. Small's research group developed a helpful technique to make the map's semantic content more apparent on its face, harnessing recurring words in the titles of citing papers to describe cited papers. Specifically, Small and Griffith created a "word profile" for each of the 1,832 items that had been cited 10 or more times in the portion of *Science Citation Index* data under review (from the first quarter of 1972).[64] The

[60] Henry G. Small, *Cited Documents as Concept Symbols*, 8 SOC. STUD. SCI. 327, 329 (1978) (noting that, at one level, "the citation as 'author, journal, volume, page and year' is a sign for the physical document itself").

[61] *Id.*; *see also id.* at 328 (stating "that a cited document is formally analogous to a subject heading in an indexing system").

[62] *Id.* at 328; *see also* White & McCain, *supra* note 45, at 328 ("Writers show commonalities in how they judge the subject matter, methodology, and intellectual style of other writers; for example, they often attach the same meanings and significance to precedent works. . . . Call this structure, for which writers are jointly not singly responsible, the consensus on past literature."). Legal historian James Boyd White has made this meaning-making function of decisional law explicit:

> The judicial opinion is a claim of meaning: it describes the case, telling its story in a particular way; it explains or justifies the result; and in the process it connects the case with earlier cases, the particular facts with more general concerns. It translates the experience of the parties, and the languages in which they naturally speak of it, into the language of the law, which connects cases across time and space. . . . The opinion thus engages in the central conversation that is for us the law, a conversation that the opinion itself makes possible.

James Boyd White, *What's an Opinion For?*, 62 U. CHI. L. REV. 1363, 1367–68 (1995).

[63] *See, e.g.*, Henry Small & Belver C. Griffith, *The Structure of Scientific Literatures I: Identifying and Graphing Specialties*, 4 SCI. STUD. 17, 29–30, fig.1 & fig.2 (1974).

[64] *Id.* at 20, 31.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

word profile for a cited item comprised the four most frequently used words (other than common words such as "the") in the titles of the items citing it.[65] A resulting co-citation map can be redrawn to label nodes with their associated word profiles.[66] "Faddeev L, ZH Eksp Teor, 1960," for example, becomes "Collisions, Particles, Scattering, Approximation."[67]

In a body of interconnected judicial decisions, no less than in a body of scholarly research literature, citations are both signs and symbols. Over time, a case name can come to stand for a complex body of doctrine: arresting officers give suspects *Miranda* warnings;[68] a prosecutor's failure to provide the defendant exculpatory evidence is a *Brady* violation;[69] a criminal defendant's contention that potential jurors were peremptorily struck from the venire on racial grounds is a *Batson* challenge;[70] a civil suit alleging a federal official's violation of the plaintiff's constitutional rights is a *Bivens* action;[71] a pretrial proceeding to test the admissibility of a party's proffered expert testimony is a *Daubert* hearing;[72] a federal court that refrains from enjoining a parallel, pending state criminal case is engaged in *Younger* abstention;[73] and so on. These case-based symbols run through and knit together the

[65] *Id.* at 31 & n.23.

[66] *Id.* at 32–33, fig.3 & fig.4.

[67] *Compare id.* at 29 fig.1, *with id.* at 32 fig.3.

[68] *See, e.g.*, Birchfield v. North Dakota, 136 S. Ct. 2160, 2170 (2016) ("The state trooper arrested Birchfield for driving while impaired, gave the usual *Miranda* warnings, again advised him of his obligation under North Dakota law. . . ."). The term references *Miranda v. Arizona*, 384 U.S. 436 (1966).

[69] *See, e.g.*, Williams v. Pennsylvania, 136 S. Ct. 1899, 1908 (2016) ("The PCRA court determined that the trial prosecutor—Chief Justice Castille's former subordinate in the district attorney's office—had engaged in multiple, intentional *Brady* violations during Williams's prosecution."). The term relies on *Brady v. Maryland*, 373 U.S. 83 (1963).

[70] *See, e.g.*, Foster v. Chatman, 136 S. Ct. 1737, 1743 (2016) ("The State exercised nine of its ten allotted peremptory strikes, removing all four of the remaining black prospective jurors. Foster immediately lodged a *Batson* challenge."). The term references *Batson v. Kentucky*, 476 U.S. 79 (1986).

[71] *See, e.g.*, Minneci v. Pollard, 565 U.S. 118, 120 (2012) ("The question is whether we can imply the existence of an Eighth Amendment-based damages action (a *Bivens* action) against employees of a privately operated federal prison."). The term references *Bivens v. Six Unknown Fed. Narcotics Agents*, 403 U.S. 388 (1971).

[72] *See, e.g.*, United States v. Tingle, 880 F.3d 850, 854 (7th Cir. 2018) ("Although the court never held a *Daubert* hearing, a hearing is unnecessary 'where the reliability of an expert's methods is properly taken for granted.'") (quoting Kumho Tire Co. v. Carmichael, 526 U.S. 137, 152 (1999)). The term references *Daubert v. Merrell Dow Pharmaceuticals*, 509 U.S. 579 (1993).

[73] *See, e.g.*, Sprint Commc'ns, Inc. v. Jacobs, 571 U.S. 69, 72–73 (2013) ("This Court has extended *Younger* abstention to particular state civil proceedings that are akin to criminal prosecutions or that

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

cases that use them. "Citation is not just a pathway to precedent—it is the language the law uses to embody its precedential character."[74] Even so, not every case or body of cases generates a short semantic tag that lawyers can conveniently deploy. And case names, of course, come from the parties' names—they are not composed for the purpose of describing a case's content, in contrast to (most) law-journal articles' titles. As a result, if one wants to develop a semantic tag, or tag set, for a given node or cluster of cases in a case-law co-citation network, one must develop an alternative to the citing-articles'-titles method from Small and Griffiths. The germ of that alternative, however, *is* from Small and Griffiths—namely, frequently used words.

Judicial opinions are texts built of words, written by and for people to communicate. A set of opinions is, in short, a *corpus*, "a collection of texts."[75] We can study a corpus of judicial opinions using the methods and tools of corpus linguistics, "the aim [of which is] the analysis and description of *language use*, *as realised in text(s)*."[76] Today, the focus of corpus linguistics is machine-readable text, analyzing corpora that are "usually of a size which defies analysis by hand and eye alone within any reasonable timeframe."[77] A corpus is valuable in that, at least as to some questions, "it is a more reliable guide to language use than native speaker intuition."[78] Intuition is definitely "a poor guide" in estimating word frequency.[79] One particular form of frequency analysis common to corpus linguistics is keyword analysis, which compares two corpora to determine which words "are significantly

implicate a State's interest in enforcing the orders and judgments of its courts.") (internal citations omitted). The term references *Younger v. Harris*, 401 U.S. 37 (1971).

[74] Schauer, *supra* note 1, at 1955 n.75; *see also* ALEXA Z. CHEW & KATIE R.G. PRYAL, THE COMPLETE LEGAL WRITER 12 (2016) ("Because lawyers use legal citations to support their claims, *legal citations are an integral part of every legal text that you read*. And they are an integral part of legal discourse.").

[75] Elena Tognini Bonelli, *Theoretical Overview of the Evolution of Corpus Linguistics*, *in* THE ROUTLEDGE HANDBOOK OF CORPUS LINGUISTICS 14, 18 (Anne O'Keefe & Michael McCarthy eds., 2010).

[76] *Id.* at 18–19 (emphasis added).

[77] TONY MCENERY & ANDREW HARDIE, CORPUS LINGUISTICS: METHOD, THEORY AND PRACTICE 1–2 (2012). "Linguists have always used the term *corpus* to describe a collection of naturally occurring examples of language. . . . More recently, the word has been reserved for collections of texts (or parts of texts) that are stored and accessed electronically." SUSAN HUNSTON, CORPORA IN APPLIED LINGUISTICS 2 (2002). The goal is not to read the texts in the corpus (as one would in an archive), but rather to study the content "nonlinearly, and both quantitatively and qualitatively." *Id.*

[78] HUNSTON, *supra* note 77, at 20.

[79] *Id.* at 20.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

more frequent in one corpus than another."[80] Specifically, *keywords* "are those words which are identified by statistical comparison of a 'target' corpus with a larger corpus, which is referred to as the 'reference' or 'benchmark' corpus."[81] Having processed a group of texts into a corpus using an automated annotation program, thereby labelling each token[82] in the corpus with part-of-speech and lemma tags,[83] one can compare the target to a reference to determine which terms in the target occur unusually more frequently there (relative to the reference) and list terms in the target in descending order of *keyness*, i.e., unusualness.[84]

Take, for example, the Supreme Court's recent cases adjudicating civil-rights challenges to state-sanctioned legal restrictions imposed on lesbian and gay people, starting with *Romer v. Evans*.[85] One can create a corpus containing the texts of all the opinions in this line of cases—a line that includes, in addition to *Romer*, *Lawrence v. Texas*,[86] *United States v. Windsor*,[87] *Obergefell v. Hodges*,[88] and *Pavan v. Smith*.[89] Using corpus linguistics software such as Sketch Engine, a well-

[80] *Id.* at 68. Hunston reports that "[m]any researchers find 'keywords' a useful starting point in investigating a specialized corpus." *Id.*

[81] *See* Evison, *supra* note 13, at 127; *see id.* at 127–28 (providing example keyword analyses). The term "key-word" is also used, in contrast to my use here, to refer to subject-matter tags that an author, or similar authority (e.g., an authoring judge), places on the document. For example, when posting a draft paper to the Social Science Research Network, the author is asked to provide his or her own keywords as finding aids for the paper. *See SSRN, SSRN Support Page: Frequently Asked Questions*, https://www.ssrn.com/en/index.cfm/ssrn-faq/ (discussing keywords). These keywords are assigned top down, rather than emerging bottom-up from usage.

[82] A *token* is "[a]ny single, particular instance of an individual word in a text or corpus." MCENERY & HARDIE, *supra* note 77, at 252.

[83] *Id.* at 245 (defining "lemma" as "[a] group of wordforms that are related by being inflectional forms of the same base word," and "lemmatisation" as "[a] form of corpus annotation where every token in the corpus is labelled to indicate its lemma").

[84] *See* Evison, *supra* note 13, at 127–28 (providing examples); Mike Scott, *What Can Corpus Software Do?*, *in* THE ROUTLEDGE HANDBOOK OF CORPUS LINGUISTICS 136, 149–50 (Anne O'Keefe & Michael McCarthy eds., 2010) (same).

[85] Romer v. Evans, 517 U.S. 620 (1996).

[86] Lawrence v. Texas, 539 U.S. 558 (2003).

[87] United States v. Windsor, 570 U.S. 744 (2013).

[88] Obergefell v. Hodges, 135 S. Ct. 2584 (2015).

[89] Pavan v. Smith, 137 S. Ct. 2075 (2017).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

established[90] web-based suite of tools,[91] one can generate a list of the top ten words and phrases (in descending keyness-score order) that most distinguish these cases from a general English-language reference corpus.[92] The output of that process as it appears on Sketch Engine, along with the list of parameters used to generate it, is in Figure 5. Note that, among the single-word list on the left, two of the top ten terms—*ante* and *supp*—come from citation conventions. The Court uses "ante" from within an opinion in a case to refer to a prior opinion in the same case,[93] and "supp" is a standard part of a citation to a district court opinion in the *Federal Supplement* reporter. Other terms—*homosexual*, *DOMA* (an acronym for the Defense of Marriage Act, struck down in *Windsor*), *sodomy*, *marriage*, *liberty*, and *bowers* (from *Bowers v. Hardwick*[94])—comport with what lawyers familiar with the cases would expect to see on such a keyword list. Similarly, the noun phrases[95] in the multi-word list on the right are exactly the phrases lawyers would expect to see stand out in these opinions: *same-sex marriage*, *due process*, *equal protection*, etc. Indeed, the multi-word phrases may be a better guide than the single-word terms to determine what unifies these cases.

[90] *See* MCENERY & HARDIE, *supra* note 77, at 45 (describing Sketch Engine).

[91] *See What is Sketch Engine?*, SKETCH ENGINE, https://www.sketchengine.eu/ (last visited July 29, 2019).

[92] In all the keyword analyses I performed for this Article, I used the same reference corpus—the 2013 version of the TenTen Corpus of the English Web. *See enTenTen—English Corpus from the Web*, SKETCH ENGINE, https://www.sketchengine.eu/ententen-english-corpus/ (last visited July 29, 2019).

[93] In Justice Scalia's dissent in *Romer*, for example, I count fifteen such uses of "ante" as an intra-case cross-reference. *See* Romer v. Evans, 517 U.S. 620, 636–53 (1996) (Scalia, J., dissenting).

[94] Bowers v. Hardwick, 478 U.S. 186, 189 (1986) (rejecting a constitutional challenge to Georgia's anti-sodomy statute).

[95] The keyword analysis tool in Sketch Engine focuses on noun phrases:

> For example, a term in English can be composed of nouns (N), adjectives (J) and also prepositions so the phrase should match one of these patterns N+N, N of N, J+N, J+J+N, J+N of N, J+N of J+N etc. while preposition + article + adjective is unlikely to be considered a term.

The Best Term Extraction, SKETCH ENGINE, https://www.sketchengine.eu/the-best-term-extraction/ (last visited July 29, 2019).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

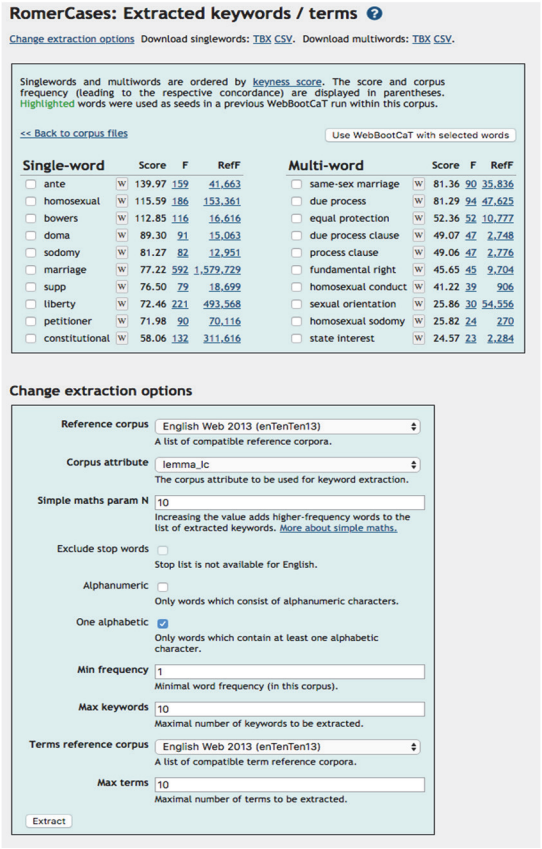

Figure 5: Keyword lists for the *Romer* line of cases

Keyword analysis is thus a valuable window into how one group of texts compares to another, revealing terms that semantically distinguish a target group from a reference group. The full value of the technique is plainer, however, when one examines corpora for which one has no well-grounded set of expectations—corpora such as those containing clusters of opinions identified, from the bottom up, by co-citation network analysis. The methods of the study follow.

III. METHODS

The first core dataset here is, at bottom, a set of citations from within a discrete group of United States Supreme Court decisions, pointing back to other Supreme Court decisions. The oldest case in the network is from 1796, and the newest one is from 2017.

To provide a starting group of Supreme Court cases with a common substantive focus and an unmistakably clear boundary, I began with the Court's eight decisions

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

about the scope and application of the Warsaw Convention.[96] The cases, which span twenty years, are—from earliest to most recent—as follows:

- *Trans World Airlines, Inc. v. Franklin Mint Corp.*, involving a suit to recover lost cargo;[97]
- *Air France v. Saks*, involving a negligence claim for physical injury;[98]
- *Chan v. Korean Air Lines, Ltd.*, involving a wrongful-death claim arising from the Soviet Union's 1983 attack on a 747 over the Sea of Japan, killing all 269 persons aboard the KAL flight;[99]
- *Eastern Airlines, Inc. v. Floyd*, involving an emotional-distress claim;[100]
- *Zicherman v. Korean Air Lines Co.*, involving a loss-of-society claim arising from the same downed KAL flight as *Chan*;[101]
- *Dooley v. Korean Air Lines Co.*, involving a pre-death pain and suffering claim arising from the same downed KAL flight as *Chan*;[102]
- *El Al Israel Airlines, Ltd. v. Tseng*, involving a psychological injury claim for a pre-boarding search;[103]
- *Olympic Airways v. Husain*, involving a wrongful-death claim.[104]

Using these eight cases, in round #1, I made a two-column list of citing and cited cases. The list is, in other words, a conventional edge list for mapping and

[96] Though the phrase "Warsaw Convention" occurs in thirteen Supreme Court cases, there are only eight such cases in which the phrase occurs at least two times. These eight cases, the only Supreme Court cases resolving Warsaw Convention questions, are the core of the first network.

[97] Trans World Airlines, Inc. v. Franklin Mint Corp., 466 U.S. 243, 245–46 (1984).

[98] Air Fr. v. Saks, 470 U.S. 392, 394 (1985).

[99] Chan v. Kor. Air Lines, Ltd., 490 U.S. 122, 123 (1989).

[100] E. Airlines, Inc. v. Floyd, 499 U.S. 530, 533 (1991).

[101] Zicherman v. Kor. Air Lines Co., 516 U.S. 217, 218–19 (1996).

[102] Dooley v. Kor. Air Lines Co., 524 U.S. 116, 118 (1998).

[103] El Al Isr. Airlines, Ltd. v. Tsui Yuan Tseng, 525 U.S. 155, 160 (1999).

[104] Olympic Airways v. Husain, 540 U.S. 644, 648 (2004).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

analyzing a network.[105] The cited list includes only Supreme Court cases cited one or more times in the citing case—the form of precedent the Supreme Court cites most frequently (a fact shown in multiple studies).[106] Note that this citation analysis, as is typical, does not measure varying intensity of citation;[107] a target case cited three times in a source case gets one row in the edge list, just as does a target case cited once.

Importantly, in collecting all the citation data described here, I included cited cases whether they were cited for the first time in a majority opinion, a concurrence, or a dissent. Each citation is the authoring justice's freely chosen indication that the cited case is an influence on what that justice views as the proper grounds for the prudent disposition of the case. All the opinions in a case, taken together, state the whole court's view(s). For the same reason, I included cited cases without respect to the stated reason, if any, for the citation, or the degree to which the citing case expressly analyzed or distinguished the cited case. The resulting network thus reflects all the explicit tags of precedent that all the authoring justices flagged in the cases.[108] In the creation of a new semantic input for more fully discerning multiple layers of a legal doctrine's texture, this seems only proper.

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[105] *See* M.E.J. NEWMAN, NETWORKS: AN INTRODUCTION 300 (2010) (noting that an edge list is "simply a list of the labels of pairs of vertices that are connected by edges," and that "edge lists are often used as a way to store network structures in computer files. . .").

[106] *See* Miller, *supra* note 15, at 6–8 (reviewing studies), 19–20 (reporting results). This finding applies generally to established apex courts with common-law roots: "Any court with a significant stock of its own opinions shows a marked preference for citing them." William H. Manz, *Citations in Supreme Court Opinions and Briefs: A Comparative Study*, 94 LAW LIBR. J. 267, 269 (2002). For a quite recent study confirming the finding—as applied to the Supreme Court of India—see Andrew Green & Albert H. Yoon, *Triaging the Law: Developing the Common Law on the Supreme Court of India*, 14 J. EMPIRICAL LEGAL STUD. 683, 693–95 (2017) (reporting citation patterns during the 1950–2010 period).

[107] *See, e.g.*, Miller, *supra* note 11, at 390; *see also* James H. Fowler & Sangick Jeon, *The Authority of Supreme Court Precedent*, 30 SOC. NETWORKS 16, 18 (2008); Green & Yoon, *supra* note 106, at 688–89; Miller, *supra* note 11, at 390.

[108] *See* Fowler & Jeon, *supra* note 107, at 18 ("Since legal rules are cited to provide convincing legal justifications, the fact that the opinion writer choose[s] to cite a case in an opinion rather than leave it out suggests that the citation, even if it is not a reliance on authority, provides applicable information about the role of various precedents in the legal network."); William M. Landes et al., *Judicial Influence: A Citation Analysis of Federal Courts of Appeals Judges*, 27 J. LEGAL STUD. 271, 273 (1998) ("We have not distinguished between favorable, critical, or distinguishing citations. It is not clear that we should. Critical citations . . . are also a gauge of influence since it is easier to ignore an unimportant decision than to spell out reasons for not following it."); Posner, *supra* note 17, at 386 ("[A judicial citation] can signify an acknowledgement of priority or influence, a useful source of information, a focus of disagreement, an acknowledgment of controlling authority, or the prestige of the cited work or its author. All of these are forms of influence, in a broad sense, and that may be enough to justify lumping them together for purposes

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http://lawreview.law.pitt.edu

To grow the citation network from its initial seventy-eight rows, with an eye toward examining which prior cases are *repeatedly* co-cited in subsequent cases, I determined which cases, other than the original eight, were cited two or more times by those original eight cases (to be *co*-cited often with another case, a case must itself be cited often[109]). This produced a list of eight additional cases. I then added to the edge list from round #1 both (a) all Supreme Court cases, beyond the original eight, that cite to the additional eight cases, and (b) all Supreme Court cases, beyond the original eight, that cite to the original eight. In this round #2, and in all subsequent rounds, I included citing cases through the Supreme Court's October 2016 Term, ending in June 2017. After round #2, the edge list had 195 rows. Next, I identified all citing cases that appeared two or more times in the "citing" column for which I had not yet collected all the Supreme Court cases that cite them (for the original eight Warsaw Convention cases, I had added all the cases citing them in round #2). This step, round #3, added sixteen more cases in the "cited" column, for which I gathered all the Supreme Court cases citing them. I continued this procedure through multiple rounds, until all multiple-entry citing cases were also treated as cited cases (with the cases citing them, in turn, listed in the "citing" column). The final edge list resulting from this process has 326 rows.[110]

Using this edge list, I generated and mapped two networks, including centrality measures and related values for the networks' nodes and edges. The first network, a simple citation network, relates all the citing and cited cases in the edge list to one another. Each node in the citation network is a case, and each edge is either a pointer from that case to a different case it cites (an out-pointing edge) or a pointer to that case from a different case that cites it (an in-pointing edge). The second network, a co-citation network, relates all the co-cited cases from the edge list to one another. Each node in the co-citation network is one-half of a pair of cases that has been co-cited at least x times (in this study, I set x at two), and each edge has a weight equal

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of citations studies concerned with measuring influence."). Of course, there are doubtless many influences, including many influences from precedents, that an authoring justice may be perfectly well aware of and choose, for whatever reason, *not* to cite explicitly in an opinion deciding the case. *See, e.g.*, Ross E. Davies, *A Handy "Cf." or Two for Citation Studies*, 7 J.L. 1, 3 (2017) (documenting one such example involving Justice Joseph Bradley's opinion in *Wallace v. Loomis*, 97 U.S. 146 (1878)). Such gaps, I think, simply counsel modesty and circumspection, rather than distrust or despair.

[109] *See* Small, *supra* note 32, at 265 ("When two papers are frequently co-cited, they are also necessarily frequently cited individually as well.").

[110] This edge list is available, as an Excel file, at this Journal's website. Prior to January 1, 2020, please use the following URL: https://lawreview.law.pitt.edu/ojs/index.php/lawreview. After January 1, 2020, please use the following URL: https://lawreview.pitt.edu.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

to the number of times the pair it connects has been co-cited. To generate the simple citation network, and to map and gather metrics on both networks, I used Gephi, an open-source application for network analysis and mapping.[111] To generate the co-citation network, which Gephi cannot compute on its own, I used Sci2,[112] another readily available application that both generates co-citation data and exports the resulting network data to Gephi for mapping.

To determine what, if any, keywords differentiate groups of cases in the co-citation network, I used Sketch Engine to provide the top twenty single-word and multi-word keywords from corpora comprising co-cited cases. For a given cluster of co-cited cases of interest, I first created a text file comprising all the opinions in the cases, retrieving the text using Google Scholar's database of judicial opinions.[113] In creating the text file, I included the party names, but not the docket number, argument and decision date, lawyers' names, or other text between the case caption and the authoring justice's name.[114] I then used the Sketch Engine functionality that processes a text file into a tagged, lemmatized corpus, using Sketch Engine's default options for doing so.[115] Once Sketch Engine compiles the text file into a corpus ready

[111] *See* GEPHI, https://gephi.org/ (last visited July 29, 2019). The maps are made with a force-directed layout algorithm, known as ForceAtlas2, that effectively treats the edges as springs holding nodes together, and treats the nodes as charged particles that repel each other. The map rests at the point of balance among these forces. *See* Mathieu Jacomy et al., *ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software*, 9 PLoS ONE e98679, at 2 (June 2014) (describing this mapping approach). Gephi's maps also incorporate a community detection algorithm, known as Modularity, and a convenient means for assigning a common color to the nodes in a given community. "Community detection" is simply "the division of the vertices [*i.e.*, the nodes] of a network into groups . . . according to the pattern of edges in the network. Most commonly . . . so that the groups formed" have more connecting edges inside the group than connect them to outside groups. NEWMAN, *supra* note 105, at 354. The number of groups detected is a function of the specific network's actual structure, not a predetermined number. *See id.* at 378.

[112] *See* SCI2 TOOL, https://sci2.cns.iu.edu/user/index.php (last visited July 29, 2019). For step-by-step instructions for using Sci2 to generate a co-citation network, see Scott Weingart, *Networks Demystified 7: Doing Co-Citation Analysis*, THE SCOTTBOT IRREGULAR (Sept. 23, 2013), http://www.scottbot.net/HIAL/ index.html@p=39432.html.

[113] GOOGLE SCHOLAR, https://scholar.google.com/ (last visited July 29, 2019).

[114] Consider, for example, *Air Fr. v. Saks*, 470 U.S. 392 (1985). When I copied the text of the opinion from the case's Google Scholar page, https://scholar.google.com/scholar_case?case=10442512243664719758, I began with the three lines stating the parties' names and omitted the information between "Saks" and "Justice O'Connor" (thirteen lines of text later).

[115] The two options I had, other than choosing English as the corpus language, were for the automated annotation programs for what Sketch Engine calls "Sketch grammar" and "Term definition." I used the defaults for both: English 3.1 for TreeTagger pipeline v2, and English (Tree Tagger-PennTB) for terms

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

for analysis, generating a list of keywords is simply a matter of choosing the reference corpus, setting a parameter (known as "Simple Maths" in Sketch Engine[116]) that varies the keyword search's preference for more or less unusual terms, and running the analysis.

The second core dataset, which I examined using the same network software and techniques just described, is an updated version of an edge list I first analyzed in a previous paper.[117] The prior edge list included, as citing cases, all Supreme Court intellectual property decisions from 1947 to 2017. The dataset now includes, as citing cases, all such decisions through June 2018, the end of the Court's October 2017 term. The cited cases are simply all Supreme Court cases cited in the citing cases.

In identifying the citing cases, I defined "intellectual property" broadly. It includes not only cases decided under the Patent, Copyright, or Lanham Acts, but also cases that materially turn on the scope of an intellectual property right. The edge list thus includes citing cases such as *FTC v. Actavis*,[118] an antitrust case about whether a type of patent-litigation-settlement agreement can violate § 1 of the Sherman Act; and *Zacchini v. Scripps-Howard Broadcasting Co.*,[119] a case involving a "human cannonball" performer's right-of-publicity claim against a broadcast television station that had reported film footage of his act. I identified the cases using searches (in the Westlaw SCT database) of decisions during the relevant time period, with search terms such as "Patent Act," "Copyright Act," "Lanham Act," and "(licens! or infring! or valid! or invalid!) /s (patent or copyright or trademark)."[120] I

extraction 2.3, respectively. The options are provided on the "Compile corpus" page, when creating a user-generated corpus in Sketch Engine.

[116] *Simple Maths*, SKETCH ENGINE, https://www.sketchengine.eu/documentation/simple-maths/ (last visited July 29, 2019).

[117] *See* Miller, *supra* note 11, at 389–90 (describing the then-current version of this edge list).

[118] FTC v. Actavis, 570 U.S. 136 (2013).

[119] Zacchini v. Scripps-Howard Broad., Inc., 433 U.S. 562 (1977). The federal question in *Zacchini* was whether the broadcaster's free-press right to publish news about the performance immunized the broadcaster against the performer's right-of-publicity claim. *Id.* at 565–66. The Court's answer, in brief, was "no." Zacchini's asserted right of publicity is conventionally understood to be an intellectual-property right akin to a trademark right. *See* J. THOMAS MCCARTHY, MCCARTHY ON TRADEMARKS AND UNFAIR COMPETITION § 28.8 (5th ed. 2019).

[120] In the Westlaw database, the "!" symbol is a truncation operator; any term with the stem to the left of the "!" is responsive. For example, the search term "infring!" calls for infringe, infringed, infringement, and infringing. The "/s" is a proximity operator; items that have the connected search terms in the same sentence are responsive. *WestlawNext: Searching with Boolean Terms and Connectors*, THOMSON

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

also relied on my familiarity with the cases from teaching them in intellectual property courses, which I have done continuously, in one form or fashion, since 2001. The full edge list of these intellectual property cases has 1,648 rows.[121]

IV. RESULTS & DISCUSSION

A. The Simple Citation Network of the Warsaw Convention Cases

The oldest case in the simple citation network of the Warsaw Convention cases is *Ware v. Hylton*,[122] which was cited once—by *TWA v. Franklin Mint*,[123] the first of the Supreme Court's Warsaw Convention cases. The most recent case in the network is *California Public Employees' Retirement System v. ANZ Securities*,[124] for its citation to *Lozano v. Montoya Alvarez*.[125] The network has 215 nodes and 326 edges, with node *in-degree* ranging from zero to seventeen and node *out-degree* varying from zero to twenty-eight.[126] The community detection algorithm groups the network into nine clusters of cases.

Network analysis not only allows one to graph the citing and cited relationships in a group of cases, it also enables one to differentiate cases by their relative importance to—their *centrality* in—the network using those very citation relationships. "A citation analysis is an ideal way to tap 'case importance' . . . define[d] as the legal relevance of a case for the network of law at the Supreme Court."[127] Because we can treat a citation "as a latent judgment by a judge regarding the relevance of the [cited] case for helping to resolve a legal dispute," it is "reasonable to determine how relevant a particular opinion is by considering how,"

REUTERS, https://lscontent.westlaw.com/images/content/WLN_Boolean-Connectors-S023352_Final.pdf (last visited July 29, 2019).

[121] *See supra* note 110.

[122] Ware v. Hylton, 3 U.S. (3 Dall.) 199 (1796).

[123] Trans World Airlines, Inc. v. Franklin Mint Co., 466 U.S. 243, 262 (1984).

[124] Cal. Pub. Emps. Ret. Sys. v. ANZ Sec., Inc., 137 S. Ct. 2042, 2045 (2017).

[125] Lozano v. Montoya Alvarez, 572 U.S. 1 (2014).

[126] "The *degree* of a vertex in a graph is the number of edges connected to it." NEWMAN, *supra* note 105, at 133. "The *in-degree* is the number of ingoing edges connected to a vertex and the *out-degree* is the number of outgoing edges." *Id.* at 135.

[127] James H. Fowler et al., *Network Analysis and the Law: Measuring the Legal Importance of Precedents at the U.S. Supreme Court*, 15 POL. ANALYSIS 324, 325 (2007).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

in granular detail, "it is embedded in the broader network of opinions comprising the law."[128]

Which are the most important cases in the network comprising the Warsaw Convention cases? There are, as it happens, "many possible definitions of importance, and correspondingly many centrality measures for networks."[129] One way to quantify a node's centrality in the network is with a count of the links the node possesses. Node degree is "[p]erhaps the simplest centrality measure in a network," and doubtless "it can be very illuminating."[130] For example, in a body of scholarly literature, "[t]he number of citations a paper receives from other papers, which is simply its in-degree in the citation network, gives a crude measure of whether the paper has been influential or not and is widely used as a metric for judging the impact of scientific research."[131] And just so with a citation network that transits a set of judicial opinions: "At the most basic level one might use the number of inward citations, or *degree centrality*, to measure the importance of a given decision."[132]

As scholars have noted, however, degree centrality is a second-best, precisely because it treats every citing case's citation to a target case as equal in weight to every other—even though the very citation network under examination can provide information that negates the premise.[133] To illustrate this shortcoming of degree centrality as an importance metric, consider the simple citation network analyzed here. It includes *Medellin v. Dretke*,[134] a case, dismissed after oral argument at the Supreme Court, involving a claim for relief under the Vienna Convention on Consular Relations. To date, the Supreme Court has cited *Dretke* in two other Vienna

[128] *Id.* at 326.

[129] NEWMAN, *supra* note 105, at 168–69; *see also* Iain Carmichael et al., Comment, *Examining the Evolution of Legal Precedent Through Citation Network Analysis*, 96 N.C. L. REV. 227, 230 (2017) ("There are many different ways to quantify the importance of a vertex in a network, called *vertex centrality metrics*.").

[130] NEWMAN, *supra* note 105, at 169; *see also* Carmichael et al., *supra* note 129, at 230 ("Two of the simplest vertex centrality metrics are *in-degree* and *out-degree*.").

[131] NEWMAN, *supra* note 105, at 169.

[132] Fowler & Jeon, *supra* note 107, at 20.

[133] *Id.* (observing that degree centrality "does not fully use information in the precedent network because it treats all inward citations in exactly the same way").

[134] Medellin v. Dretke, 544 U.S. 660 (2005). Notwithstanding its formal status as a dismissal of review, the five separate opinions in the case run to 34 pages in the *United States Reports*. *Id.* at 662–95.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

Convention cases that are also in the network—*Medellin v. Texas*[135] and *Sanchez-Llamas v. Oregon*.[136] In this network, *Dretke* thus has a degree centrality score of two, with *Medellin* and *Sanchez-Llamas* each contributing one. To date, however, the Supreme Court—as this network itself shows—has cited *Medellin* in twelve subsequent cases,[137] but cited *Sanchez-Llamas* in only five subsequent cases.[138] The degree centrality metric makes no use of that information, even though *Medellin*'s greater importance, compared to *Sanchez-Llamas*, is evident on the face of the very network they share with *Dretke*.

There is need, then, of a centrality metric that *does* value inward citations according to the centrality of the cases from which they originate. As before, more than one is available.[139] The metric that has become the norm in studies of judicial case-citation networks,[140] which is known in the network-analysis literature as "hubs and authorities," was developed by information scientist Jon Kleinberg to organize web pages for topical searches.[141] Specifically, in the Kleinberg approach,

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[135] Medellin v. Texas, 552 U.S. 491, 503 (2008).

[136] Sanchez-Llamas v. Oregon, 548 U.S. 331, 371 (2006).

[137] *See* Water Splash, Inc. v. Menon, 137 S. Ct. 1504, 1511 (2017); Bank Markazi v. Peterson, 136 S. Ct. 1310, 1337 (2016); Zivotofsky *ex rel.* Zivotofsky v. Kerry, 135 S. Ct. 2076, 2090 (2015); NLRB v. Canning, 134 S. Ct. 2550, 2594 (2014); Util. Air Regulatory Grp. v. EPA, 134 S. Ct. 2427, 2446 (2014); Bond v. United States, 134 S. Ct. 2077, 2086 (2014); Lozano v. Montoya Alvarez, 134 S. Ct. 1224, 1232 (2014); BG Grp. PLC v. Argentina, 134 S. Ct. 1198, 1218 (2014); Arizona v. United States, 567 U.S. 387, 424 (2012); Garcia v. Texas, 564 U.S. 940, 941 (2011); Abbott v. Abbott, 560 U.S. 1, 10 (2010); Noriega v. Pastrana, 559 U.S. 917, 922 (2010).

[138] *See* Johnson v. Lee, 136 S. Ct. 1802, 1805 (2016); Henderson *ex rel.* Henderson v. Shinseki, 562 U.S. 428, 434 (2011); Noriega v. Pastrana, 559 U.S. 917, 918 (2010); Medellin v. Texas, 552 U.S. 491, 498 (2008); Lawrence v. Florida, 549 U.S. 327, 343 (2007).

[139] *See* NEWMAN, *supra* note 105, at 169–81 (describing Eigenvector, Katz, PageRank, and Hubs & Authorities' centrality measures); *see also* Carmichael, *supra* note 129, at 237–38 (discussing the "class of eigenvector centrality metrics," which "judge a case to be more important if it is cited by many cases that are themselves cited by many other cases" and include "PageRank, Eigenvector centrality, and hubs and authorities") (footnotes omitted).

[140] *See* Bommarito, *supra* note 15, at 541–44; Mattias Derlén & Johan Lindholm, *Peek-A-Boo, It's a Case Law System! Comparing the European Court of Justice and the United States Supreme Court from a Network Perspective*, 18 GER. L.J. 647, 656–59 (2017); Fowler & Jeon, *supra* note 107, at 20; Green & Yoon, *supra* note 106, at 689–90; Yonatan Lupu & Erik Voeten, *Precedent in International Courts: A Network Analysis of Case Citations by the European Court of Human Rights*, 42 BRIT. J. POL. SCI. 413, 427–33 (2011); Miller, *supra* note 11, at 389–98.

[141] *See* Jon M. Kleinberg, *Authoritative Sources in a Hyperlinked Environment*, 46 J. ASSOC. FOR COMPUTING MACHINERY 604, 605 (1999) ("In particular, we focus on the use of links for analyzing the

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

> [a] *hub* is a case that cites many other decisions, helping to define which legally relevant decisions are pertinent to a given precedent, while an *authority* is a case that is widely cited by other decisions. Most cases act as both hubs and authorities, and the degree to which cases fulfill these roles is mutually reinforcing within the precedent network. A case that is a *good hub* cites many *good authorities*, and a case that is a *good authority* is cited by many *good hubs*. . . . The resulting [numerical] hub and authority scores allow us to identify the key precedents in the network—precedents that are influential (authorities) and precedents that are well founded in law (hubs).[142]

Using the authority scores computed for each node in a case-citation network, then, one can rank in order the included cases by importance.[143]

In the simple citation network analyzed here, the twenty most important cases, ranked by their respective authority scores, include seven of the eight Warsaw Convention cases.[144] The remaining Warsaw Convention case, *Dooley v. Korean Air Lines*,[145] is tied for seventy-seventh place with three other cases, all having an authority score of 0.002. Table 1 lists the top twenty cases, in descending authority-score order.

Among the top five most central cases, three are Warsaw Convention cases: *Air France*, *Zicherman*, and *TWA*. Two, however, are not. In *Sumitomo Shoji America, Inc. v. Avagliano*,[146] the second-most central case, the Court considered the question "whether Article VIII(1) of the Friendship, Commerce and Navigation Treaty between the United States and Japan provide[d] a defense to a Title VII employment discrimination suit against an American subsidiary of a Japanese company."[147] In

collection of pages relevant to a broad search topic, and for discovering the most 'authoritative' pages on such topics.").

[142] Fowler & Jeon, *supra* note 107, at 20; *accord* Kleinberg, *supra* note 141, at 611 ("Hubs and authorities exhibit what could be called a *mutually reinforcing relationship*: a good *hub* is a page that points to many good authorities; a good *authority* is a page that is pointed to by many good hubs.").

[143] GEPHI, *supra* note 111 (computes authority and hub scores as a matter of routine).

[144] *See supra* notes 97–104 and accompanying text.

[145] Dooley v. Kor. Air Lines Co., 524 U.S. 116 (1998).

[146] Sumitomo Shoji Am., Inc. v. Avagliano, 457 U.S. 176 (1982).

[147] *Id.* at 177–78. The Court answered this question "no." *See id.* at 189–90.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

Choctaw Nation of Indians v. United States,[148] a case with roots in the post-Civil War abolition of slavery among the Chickasaws and Choctaws, the Court considered "whether the Chickasaw Nation[, which had started the suit,] [wa]s entitled to compensation for its one-fourth interest in the common lands of the two nations allotted to the Choctaw freedmen" under an 1866 treaty and a series of implementing statutes.[149] Thus, *Sumitomo* and *Choctaw Nation* both involve the scope of a United States treaty, albeit one other than the Warsaw Convention.

Case	Citation	Authority Score
Air France v. Saks*	470 U.S. 392 (1985)	0.503
Sumitomo Shoji America, Inc. v. Avagliano	457 U.S. 176 (1982)	0.400
Choctaw Nation of Indians v. United States	318 U.S. 423 (1943)	0.272
Zicherman v. Korean Air Lines Co.*	516 U.S. 217 (1996)	0.248
TWA, Inc. v. Franklin Mint Corp.*	466 U.S. 243 (1984)	0.242
Société Nationale Industrielle Aérospatiale v. United States District Court for the District of Iowa	482 U.S. 522 (1987)	0.240
Olympic Airways v. Husain*	540 U.S. 644 (2004)	0.228
Breard v. Greene	523 U.S. 371 (1998)	0.194
The Amiable Isabella	19 U.S. (6 Wheat.) 1 (1821)	0.191
El Al Israel Airlines, Ltd. v. Tseng*	525 U.S. 155 (1999)	0.180
Medellin v. Texas	552 U.S. 491 (2008)	0.167
United States v. Stuart	489 U.S. 353 (1989)	0.160
Volkswagen Aktiengesellschaft v. Schlunk	486 U.S. 694 (1988)	0.151
Eastern Airlines, Inc. v. Floyd*	499 U.S. 530 (1991)	0.134
Chan v. Korean Air Lines, Ltd.*	490 U.S. 122 (1989)	0.116
Medellin v. Dretke	544 U.S. 660 (2005)	0.108
Hamdan v. Rumsfeld	548 U.S. 557 (2006)	0.096
Abbott v. Abbott	560 U.S. 1 (2010)	0.091
Maximov v. United States	373 U.S. 49 (1963)	0.084
Sanchez-Llamas v. Oregon	548 U.S. 331 (2006)	0.078

Table 1: Top 20 Cases, by Authority Score, in the Simple Citation Network Comprising the Supreme Court's Warsaw Convention Cases and Related Cases (asterisk notes a Warsaw Convention case)

In fact, all eleven of the remaining non-Warsaw Convention cases listed in Table 1 also involve the meaning or effect of a United States treaty. Four of the cases—*Breard*, *Medellin v. Texas*, *Medellin v. Dretke*, and *Sanchez-Lamas*—turn on

[148] Choctaw Nation of Indians v. United States, 318 U.S. 423 (1943).

[149] *Id.* at 424–28 (describing the treaty and statutes). The Court answered this question "no." *See id.* at 433.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

the effect of the Vienna Convention on Consular Relations.[150] Two of the cases, *Société Nationale* and *Schlunk*, turn on the scope of litigation-procedure treaties: the Hague Convention on the Taking of Evidence Abroad in Civil or Commercial Matters,[151] and the Convention on Service Abroad of Judicial and Extrajudicial Documents in Civil and Commercial Matters.[152] Two of the cases, *Stuart* and *Maximov*, turn on tax treaties: the Convention between the United States and Canada Respecting Double Taxation,[153] and the Income Tax Convention between the United States of America and the United Kingdom.[154] *Abbott* turns on the scope of a term in the Hague Convention on the Civil Aspects of International Child Abduction.[155] *The Amiable Isabella* turns on a purported immunity from prize capture by privateers, set forth in a 1795 treaty between the United States and Spain.[156] And *Hamdan* turns on, among other things, the requirements of Common Article 3 of the Geneva Conventions.[157]

The list of high-authority cases in the network is informative, but it does not present the stronger or weaker groups of interconnections among the cases. We can, though, use the same citation data and authority scores to visualize the network in a map. "Visualization can be an extraordinarily useful tool in the analysis of network data, allowing one to see instantly [the] important structural features of a network that would otherwise be difficult to pick out of the raw data."[158] Focusing on the

[150] *See* Breard v. Greene, 523 U.S. 371, 373 (1998); Medellin v. Texas, 552 U.S. 491, 499–500; Medellin v. Dretke, 544 U.S. 660, 661–62 (2005); Sanchez-Llamas v. Oregon, 548 U.S. 331, 337 (2006).

[151] Société Nationale Industrielle Aérospatiale v. U.S. Dist. Court S. Dist. Iowa, 482 U.S 522, 524 (1987).

[152] Volkswagenwerk Aktiengesellschaft v. Schlunk, 486 U.S. 694, 696 (1988).

[153] United States v. Stuart, 489 U.S. 353, 355–56 (1989).

[154] Maximov v. United States, 373 U.S. 49, 49–50 (1963).

[155] Abbot v. Abbot, 560 U.S. 1, 5 (1983).

[156] *In re* The Amiable Isabella, 19 U.S. (6 Wheat.) 1, 14–15 (1821) (reporter's preliminary materials, describing the parties' arguments).

[157] Hamdan v. Rumsfeld, 548 U.S. 557, 625–35 (2006) (plurality opinion); *id.* at 641–43 (Kennedy, J., concurring); *see also* Mark A. Drumble, *The Expressive Value of Prosecuting and Punishing Terrorists:* Hamdan*, the Geneva Conventions, and International Criminal Law*, 75 GEO. WASH. L. REV. 1165 (2007) (discussing the role of the Geneva Conventions in *Hamdan*); Stephen I. Vladeck, *Military Courts and Article III*, 103 GEO. L.J. 933, 965–66 (2015) (same).

[158] NEWMAN, *supra* note 105, at 8. The Gephi application enables one to visualize a network using a variety of mapping algorithms, the choice among which is largely a matter of aesthetic preference: "the information in [such] graph layouts is contained in the pattern of which nodes are connected to which

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

same top twenty cases by authority score, which is about nine percent of the total network nodes, a force-directed mapping algorithm can depict this sub-network and group the cases into citation-based clusters.[159] That map is in Figure 6.[160] Node color varies with cluster group, and node size varies with authority score.

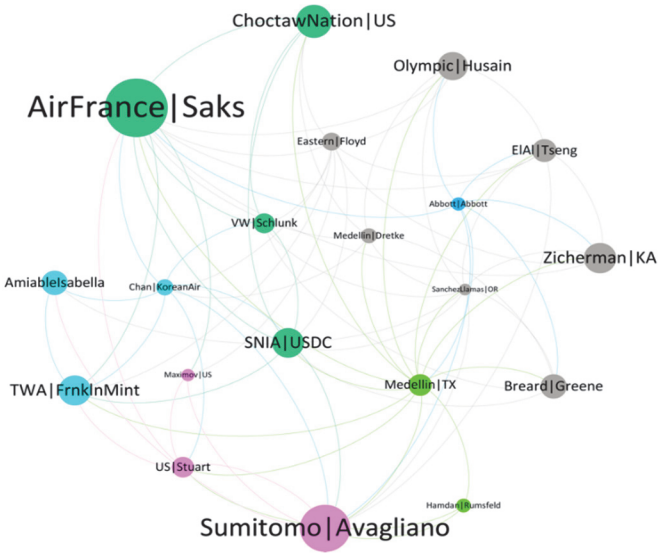

Figure 6: Map of the Top 20 Cases, by Authority Score, in the Simple Citation Network Comprising the Supreme Court's Warsaw Convention Cases and Related Cases

The complete map groups the cases into six clusters, where the citations among a cluster's nodes are greater than the citations between it and the other clusters. The cluster containing *Air France*, the highest-scoring authority in the network, has *no* other Warsaw Convention cases. The other cases in that group are *Choctaw Nation*, *Société Nationale*, and *Schlunck*. The cluster containing *Zicherman*, the next-highest scoring authority among the Warsaw Convention cases after *Air France*, also has three of the other Warsaw Convention cases in the map (*Olympic*, *El Al*, and

other nodes. . . . Ultimately, any arrangement of nodes in space is equally valid as long as no ties are added or dropped." STEPHEN P. BORGATTI ET AL., ANALYZING SOCIAL NETWORKS 105 (2013).

[159] *See supra* note 111 and accompanying text (describing the methods).

[160] A map of the full citation network, with all 215 nodes and 326 edges, is provided in Appendix A to this Article.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

Eastern), as well as three of the four consular relations cases (*Breard*, *Dretke*, and *Sanchez-Llamas*), making it the most populous group. The third-ranked Warsaw case, *TWA*, shares a group with *Chan* (the last Warsaw case on the map) and *The Amiable Isabella*. The remaining three clusters in the map contain no Warsaw Convention cases.[161] They are *Sumitomo*, *Stuart*, and *Maximov*; *Medellin v. Texas* and *Hamdan*; and, in a cluster of one, *Abbott*.

The network map in Figure 6, along with the authority-score data in Table 1, provides citation-data facts for those seeking to better understand the Supreme Court's Warsaw Convention jurisprudence, and how that body of law relates to the Supreme Court's wider treaty-interpretation jurisprudence. No amount of traditional legal analysis or conceptual reflection would reveal these facts. Consider, for example, that the Court has thoroughly interwoven its decisions about a treaty governing private-law claims for losses in international air travel into its treaty cases involving criminal-law-related consular relations claims, transnational taxation and trade, transnational litigation processes, and matters of war and peace (including both Justice Story's decision in *The Amiable Isabella*, a prize case from the War of 1812, and the due-process minima for post-9/11 military commissions). These data support the view that there is a vibrant trans-substantive treaty-interpretation jurisprudence that draws on a long line of decisions, reaching back to the early days of the Republic. Experts in the treaty-interpretation field can doubtlessly incorporate these newly revealed facts into further doctrinal analysis.

The edge list that yields the simple citation network can also yield a co-citation network. The clusters in that semantically denser network can also point to corpora for keyword analysis. It is to these next-level analyses of the Warsaw Convention cases that I now turn.

B. Co-Citation Network Clusters & Keyword Analysis of the Warsaw Convention Cases

A co-citation network measures the strength "of the association between pairs of frequently-cited documents," thus "provid[ing] a natural and quantitative way to group or cluster the cited documents."[162] The primary input for a co-citation analysis of the Warsaw Convention cases is, once again, the edge list used to generate the

[161] The last of the eight Warsaw Convention cases, *Dooley*, does not appear in the citation map in Figure 5. Indeed, none of the cases in the cluster containing *Dooley* appears in Figure 5.

[162] Small & Griffith, *supra* note 63, at 19; *see also* Tang et al., *supra* note 45, at 295 (describing co-citation network analysis as a form of "powerful computational analysis . . . [that] is used to detect the most frequently referenced topics underlying the literature structure").

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

simple citation network.[163] Each node in the resulting network represents one of a pair of co-cited cases, and each edge connecting two nodes varies in weight according to the number of times the two cases it connects were co-cited in the subsequent cases in the network. In computing this network, I included all edges with a weight greater than or equal to two, reflecting case pairs that were co-cited in at least two subsequent cases.[164]

The resulting co-citation network has twenty-four nodes connected by seventy-seven edges, which vary in weight from two to seven. The network map is in Figure 7, below. The community detection algorithm groups the network into four clusters of cases. Node color varies with cluster group, node size varies with weighted degree,[165] and edge thickness varies with co-citation strength. Edge weights of four and higher are labeled on the map. Again, traditional legal analysis cannot produce these data.

[163] *See supra* notes 103–10 and accompanying text.

[164] Setting a threshold to focus one's analysis on the more frequently co-cited items is a standard step in this method. *See, e.g.*, Bommarito et al., *supra* note 15, at 542 (setting a co-citation strength threshold of five); Small, *supra* note 32, at 266, fig.1 (setting a threshold of seven); Small & Griffith, *supra* note 63, at 22–28 (comparing results for thresholds of one, three, six, and ten).

[165] A node's weighted degree is the sum of the weights of the edges connected to it. *See* A. Barrat et al., *The Architecture of Complex Weighted Networks*, 101 PROC. NAT'L ACAD. SCI. 3747, 3748 (2004) (referring to this sum as "vertex strength"). In an undirected network such as a co-citation network—that is, a network where the edges have no inward or outward directionality, but simply connect paired items—weighted degree is an appropriate centrality measure. *See* NEWMAN, *supra* note 105, at 69–70, 114–16 (explaining this contrast between citation and co-citation networks). The Kleinberg "hubs and authorities" measure, by contrast, depends on the difference between inward and outward directionality, and thus has no application to a co-citation network. *Id.* at 178–81.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

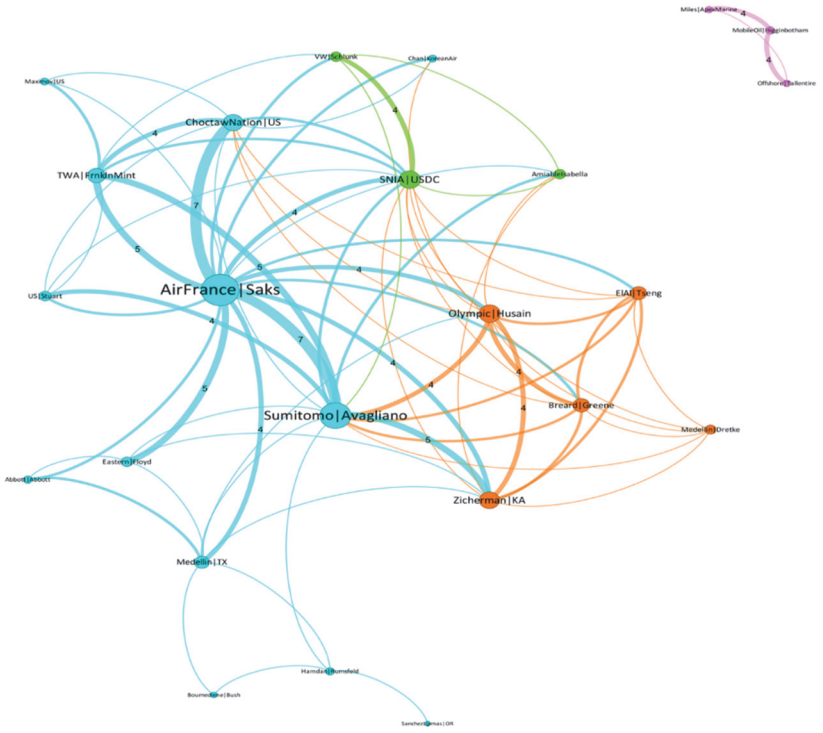

Figure 7: Co-Citation Network Map of the Supreme Court's Warsaw Convention Cases and Related Cases

The twenty-four cases in the co-citation network are the twenty top-authority-score cases from the simple network, listed in Table 1, along with four more cases from the total network. Though none of these four additional cases are among the top twenty of the simple network by authority score, all *are* in the top thirty-five. The four additional cases are *Boumedienne v. Bush*,[166] a post-*Hamdan* case about the availability of *habeas* review for enemy combatants that the United States has imprisoned at Guantanamo Bay; and three cases involving fatal maritime

[166] Boumediene v. Bush, 553 U.S. 723 (2008).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

accidents—*Mobil Oil Corp. v. Higginbotham*,[167] *Offshore Logistics, Inc. v. Tallentire*,[168] and *Miles v. Apex Marine Corp.*[169]

Boumedienne, like all the twenty top-authority-score cases in Table 1, turns in part on the meaning of a treaty—namely, the 1934 Treaty Defining Relations with Cuba.[170] The three maritime-accident cases do *not* involve a treaty. They *do*, however, raise questions about the scope of the Death on the High Seas Act ("DOHSA"),[171] a statute that plays a role in both the *Dooley* and *Zicherman* Warsaw Convention cases.[172]

In the co-citation network, the cluster of the three DOHSA cases (which is in the upper right-hand corner of Figure 6) does not connect to the remaining three clusters. Those three clusters of treaty cases, by contrast, thoroughly interconnect with one another. Each cluster has a dominant node, and they are three of the top four co-citation nodes by weighted degree: *Air France*, with a weighted degree of sixty-two, at the core of a thirteen-node cluster; *Olympic*, with a weighted degree of thirty-one, at the core of a five-node cluster; and *Société Nationale*, also with a weighted degree of thirty-one, at the core of a three-node cluster. The nodes in the three interconnected clusters, as well as in the isolated cluster, are listed in Table 2, below. The *Olympic* cluster has three of the seven Warsaw Convention cases in this network (*Olympic*, *Zicherman*, and *El Al*) and two of the four Consular Relations cases (*Breard* and *Dretke*). The *Société Nationale* cluster has none of the Warsaw cases, but both of the litigation-procedure-treaty cases (along with *The Amiable Isabella* prize case). The *Air France* cluster, the largest of the three treaty-case clusters, has the balance of both the Warsaw cases (*Air France*, *TWA*, *Eastern*, and *Chan*) and the Consular Relations cases (*Medellin* and *Sanchez-Llamas*), as well as the tax treaty cases (*Stuart* and *Maximov*), the Guantanamo cases (*Hamdan* and

[167] Mobil Oil Corp. v. Higginbotham, 436 U.S. 618 (1978).

[168] Offshore Logistics, Inc. v. Tallentire, 477 U.S. 207 (1986).

[169] Miles v. Apex Marine Corp., 498 U.S. 19 (1990).

[170] *See Boumediene*, 553 U.S. at 753–55 (discussing the treaty).

[171] 46 U.S.C. §§ 30301–08 (2018); *see Mobil Oil*, 436 U.S. at 620–25 (discussing DOHSA); *Offshore Logistics*, 477 U.S. at 214–33 (same); *Miles*, 498 U.S. at 24–33 (same).

[172] *See* Dooley v. Kor. Air Lines Co., 524 U.S. 116, 118 (1998); Zicherman v. Kor. Air Lines Co., 516 U.S. 217, 229–32 (1996). *Dooley* is absent from the co-citation network, just as it was absent from the top twenty highest authority-score cases in the simple network. *See supra* note 145 and accompanying text.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

Boumedienne), the child abduction case (*Abbott*), and the other two top-authority-score cases, *Sumitomo* and *Choctaw Nation*.

The *Air France* node has both the highest weighted degree in the largest group and the highest weighted degree over all. It is also in both of the network's strongest co-citation pairings, having been co-cited seven times each with *Sumitomo* and *Choctaw Nation*. *Air France* is also in two of the four pairings with an edge weight of five, having been co-cited that often with both *TWA* and *Eastern*. *Sumitomo* has the other two five-weight pairings, with *TWA* and *Zicherman*. Finally, *Air France* has a third of the twelve four-weight pairings[173] and a third of the eighteen three-weight pairings.[174] It is thus the most central Warsaw Convention case in both the citation and co-citation networks, which situate the Warsaw Convention cases in the landscape of United States treaty law more generally (*Olympic*, *Zicherman*, and *TWA*, the next three Warsaw Convention cases after *Air France* in the co-citation network, by weighted degree, are also the next three Warsaw cases after *Air France* in the citation network, by authority score).

The Supreme Court has cited *Air France* for key treaty interpretation principles seventeen times, from 1988 to 2017. Five of the cases are Warsaw Convention cases, and twelve are not. How has *Air France* come to play such a prominent role in the Supreme Court's treaty cases, from the perspective of traditional legal doctrine? With the analysis in *Air France* itself as a backdrop, we can use the citation data that put *Air France* in the spotlight as a map for understanding the concept(s) for which the *Air France* sign has become a symbol. As I read these cases, and explain in a moment, the primary concept appears to be "start with treaty text," and the secondary concept appears to be "consider treaty context." These are quite handy trans-treaty principles.

Case	Co-citation Cluster	Weighted Degree
Air France v. Saks*	1	62
Sumitomo Shoji America, Inc. v. Avagliano	1	49
Choctaw Nation of Indians v. United States	1	28
TWA, Inc. v. Franklin Mint Corp.*	1	24
Medellin v. Texas	1	19
Eastern Airlines, Inc. v. Floyd*	1	13
United States v. Stuart	1	13
Abbott v. Abbott	1	8
Hamdan v. Rumsfeld	1	8
Maximov v. United States	1	7
Chan v. Korean Air Lines, Ltd.*	1	7

[173] These are with *Medellin*, *Olympic*, *Société Nationale*, and *Zicherman*.

[174] These are with *Abbott*, *Breard*, *Chan*, *El Al*, *Schlunk*, and *Stuart*.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

Case	Co-citation Cluster	Weighted Degree
Boumedienne v. Bush	1	4
Sanchez-Llamas v. Oregon	1	2
Olympic Airways v. Husain*	2	31
Zicherman v. Korean Air Lines Co.*	2	29
Breard v. Greene	2	22
El Al Israel Airlines, Ltd. v. Tseng*	2	21
Medellin v. Dretke	2	12
Société Nationale Industrielle Aérospatiale v. United States District Court for the District of Iowa	3	31
The Amiable Isabella	3	13
Volkswagen Aktiengesellschaft v. Schlunk	3	13
Mobil Oil Corp. v. Higginbotham	4	8
Offshore Logistics, Inc. v. Tallentire	4	6
Miles v. Apex Marine Corp.	4	6

Table 2: Cases, by Cluster and Weighted-Degree Score, in the Co-Citation Network Comprising the Supreme Court's Warsaw Convention Cases and Related Cases (asterisk notes a Warsaw Convention case)

In *Air France*, a unanimous decision,[175] the tort plaintiff—Valerie Saks—had suffered "severe pressure and pain in her left ear"[176] as her Air France flight from Paris made its descent to Los Angeles. A doctor determined, a few days later, "that she had become permanently deaf in her left ear."[177] According to all the evidence in the case, however, "the aircraft's pressurization system had operated in the usual manner."[178] Saks' right to recover thus turned on whether the operative language in Article 17 of the Warsaw Convention—"the accident which caused the damage"—was limited to unintended, unexpected occurrences that cause injury (in which event she could not recover), or more broadly covered any hazard of international air travel (in which case she could recover).[179] To decide the question, Justice O'Connor framed the inquiry as follows:

[175] In other words, the *most* central Warsaw Convention case from a network-analysis point of view is, from the perspective of the attitudinal model, an empty space. *See supra* notes 52–56 and accompanying text.

[176] Air France v. Saks, 470 U.S. 392, 394 (1985).

[177] *Id.*

[178] *Id.* at 395.

[179] *Id.* at 395–96. The Court likened this treaty-scope question to "American jurisprudence [which] has long recognized this distinction between an accident that is the *cause* of an injury and an injury that is itself an accident." *Id.* at 399. In an insurance coverage case five decades before *Air France*, Justice Cardozo warned—in dissent—that "[t]he attempted distinction between accidental results and accidental

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

> "[T]reaties are construed more liberally than private agreement, and to ascertain their meaning we may look beyond the written words to the history of the treaty, the negotiations, and the practical construction adopted by the parties." *Choctaw Nation of Indians v. United States*, 318 U.S. 423, 431–32 (1943). The analysis must begin, however, with the text of the treaty and the context in which the written words are used. See *Maximov v. United States*, 373 U.S. 49, 53–54 (1963).[180]

In other words, organize interpretive resources as follows: first disputed text and surrounding text, then wider context (including backdrop, negotiations, and course of performance). The Court also described this wider context as "the shared expectations of the contracting parties."[181]

The disputed text and surrounding text was insufficient, in *Air France*, to resolve the scope of the term "accident" in Article 17: "While the text of the Convention gives . . . two clues to the meaning of 'accident,' it does not define the term. Nor is the context in which the term is used illuminating."[182] As a result, Justice O'Connor proceeded through the additional contextual materials, considering both its meaning in French legal materials (the Convention's original drafting language)[183] and the clues to be gleaned from "the negotiating history of the Convention, the conduct of the parties to the Convention, and the weight of precedent in foreign and American courts."[184] Only after detailed discussion of all these materials did the Court conclude that an "accident," in Article 17 terms, "arises only if a passenger's injury is caused by an unexpected or unusual event or happening that is external to the passenger,"[185] blocking Saks' Warsaw Convention claim.

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means will plunge this branch of the law into a Serbonian Bog." Landress v. Phoenix Mut. Life Ins. Co., 291 U.S. 491, 499 (1934) (Cardozo, J., dissenting). Quagmire-curious or not, the distinction decided Saks' claim.

[180] *Air France*, 470 U.S. at 396–97.

[181] *Id.* at 399.

[182] *Id.*

[183] *Id.* at 399–400 (discussing these materials).

[184] *Id.* at 400; *see also id.* at 400–05 (discussing all these sources in turn).

[185] *Id.* at 405.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

The catholic contours of *Air France*, as a sequence of wide-ranging interpretive steps for resolving a case about treaty scope, give it universal appeal.[186] An opinion cast in textualist terms can quote *Air France*'s "must begin . . . with the text" directive.[187] An opinion cast in a purposive, contextualist vein can quote either the case's history-negotiations-practical construction trio or the "shared expectations of the contracting parties" guidance.[188] There is a preferred half to which each of these two main methodological camps can point. Indeed, *Air France* has twice appeared in both the majority and dissenting opinions in a given case, straddling just this difference between textualism and contextualism. In *United States v. Alvarez-Machain*, the majority says, "[i]n construing a treaty, as in construing a statute, we first look to its terms to determine its meaning. *Air France v. Saks*, 470 U.S. 392, 397 (1985)"; whereas the dissent says, "[i]n construing a treaty, the Court has the 'responsibility to give the specific words of the treaty a meaning consistent with the shared expectations of the contracting parties.' *Air France v. Saks*, 470 U.S. 392, 399 (1985)."[189] Similarly, in *Itel Containers International Corp. v. Huddleston*, the majority says, "[o]ur interpretation must begin, as always, with the text of the Conventions. *See Air France v. Saks*, 470 U.S. 392, 397 (1985)"; whereas the dissent says, of other treaty members, "[t]heir consistent practice is persuasive evidence of the Conventions' meaning. *See Air France v. Saks*, 470 U.S. 392, 396 (1985), quoting *Choctaw Nation v. United States*, 318 U.S. 423, 431–32 (1943)."[190] It is not difficult to understand *Air France*'s longstanding popularity with the justices, when we follow the pointers that network analysis provides for us.

What, then, of the broader semantic content of these co-citation clusters? In prior co-co-citation studies, the resulting clusters of strongly co-cited items embody groups of concepts that one can differentiate semantically. The *Air France* "start with

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[186] *See, e.g.*, Kristen E. Eichensehr, *Foreign Sovereigns as Friends of the Court*, 102 VA. L. REV. 289, 295 n.24 (2016) (citing *Air France* for the proposition that, "[w]hen interpreting treaties, the Court begins with the treaty text, but explicitly gives weight to the views of *both* the United States and foreign sovereigns that are party to the treaty") (emphasis added).

[187] *See* Medellin v. Texas, 552 U.S. 491, 506–07 (2008); E. Airlines, Inc. v. Floyd, 499 U.S. 530, 534–35 (1991); Société Nationale Industrielle Aérospatiale v. U.S. Dist. Court S. Dist. Iowa, 482 U.S. 522, 534 (1987).

[188] *See* Lozano v. Montoya Alvarez, 572 U.S. 1, 12 (2014); *see also e.g.*, BG Group PLC v. Argentina, 572 U.S. 25, 37 (2014); Abbott v. Abbott, 560 U.S. 1, 16 (2010); New Jersey v. New York, 523 U.S. 767, 831 (1998) (Scalia, J., dissenting); Zicherman v. Kor. Air Lines Co., 516 U.S. 217, 223 (1996); Chan v. Kor. Air Lines, Ltd., 490 U.S. 122, 128 (1989) (Brennan, J., concurring).

[189] United States v. Alvarez-Machain, 504 U.S. 655, 663, 675 n.14 (1992).

[190] Itel Containers Int'l Corp. v. Huddleston, 507 U.S. 60, 65, 84 (1993).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

treaty text" concept is one element. But, using corpora comprising the texts of cases in the four clusters of the Warsaw Convention co-citation network, we can characterize the clusters' respective semantic profiles in more granular detail.

Consider, first, the two clusters that contain *no* Warsaw Convention cases. The larger of the two (by weighted degree) contains *Société Nationale* and *Schlunk*, two cases about litigation-procedure treaties, as well as *The Amiable Isabella*. The other cluster contains *Mobil Oil* and the other two fatal-maritime-accident cases. If we create a corpus comprising all of each cluster's constituent cases, we can generate a list of the keywords that most strongly distinguish the cluster from a corpus of general English-language usage.[191] The top twenty multi-word keywords[192] for these two clusters, listed in descending keyness-score order, are in Table 3.

The *Société Nationale* Cluster	**The *Mobil Oil* Cluster**
internal law	wrongful death
contracting state	maritime law
evidence convention	general maritime law
due process	death action
obtaining evidence	state wrongful death
comity analysis	wrongful death action
judicial assistance	saving clause
proprietary interest	state law
negotiating history	maritime wrongful death
17th article	pecuniary loss
first resort	jurisdictional saving
requesting state	jurisdictional saving clause
pretrial discovery	death statute
foreign state	wrongful death statute
american court	common law
civil law	maritime wrongful death action
taking evidence	death remedy
preliminary draft	general maritime wrongful death
contracting party	state wrongful-death
foreign discovery	federal maritime law

Table 3: Top 20 Keywords for the Co-Citation Network Clusters Anchored by *Société Nationale* and *Mobile Oil*

From the *Société Nationale* corpus, some of the keywords might just as readily appear in disputes involving other treaties—phrases such as "contracting state,"

[191] *See supra* notes 73–75 and accompanying text.

[192] Note that, in extracting keywords, Sketch Engine is set to ignore letter capitalization. Also, the keyword results are in lemma form, so, for example, "savings clause" becomes "saving clause."

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

"comity analysis," "negotiating history," and "foreign state." Other keywords from the corpus, however, point squarely at the litigation-procedure treaties at issue in the cases—"evidence convention," "due process," "obtaining evidence," "pretrial discovery," "taking evidence," and "foreign discovery." The phrase "17th article" is a quirk of *The Amiable Isabella* case, the core disputed provision of which was the "17th article" of a treaty between the United States and Spain.[193] With respect to the *Mobil Oil* corpus, it is difficult to imagine a list of keywords more befitting a trio of cases about fatal maritime accidents. Eleven of the twenty keyword phrases contain the word "death," and six of the twenty contain the word "maritime." Three, each a variation of the others, contain both: "maritime wrongful death," "maritime wrongful death action," and "general maritime wrongful death."

Consider, next, the two clusters that *do* contain Warsaw Convention cases. Both also contain the Consular Relations cases in the co-citation network. And the *Air France* cluster, in contrast to the *Olympic* cluster, contains much else besides. I prepared two different corpora for the *Air France* cluster. One contains the texts of all thirteen cases, and the other contains the seven cases having an edge weight equal to or greater than the lowest edge weight in the *Olympic* cluster (twelve)—thus providing a common threshold minimum.[194] The top twenty keywords from each of these three corpora are in Table 4. The obvious difference between the full and partial *Air France* clusters is that, with the inclusion of *Hamdan* and *Boumedienne*, we see "military commission" (as the most distinguishing keyword), "ex parte," a common case-name portion that appears repeatedly in the Guantanamo cases,[195] "enemy

[193] *See In re* The Amiable Isabella, 19 U.S. (6 Wheat.) 1, 68–69 (1821) ("The point to which the Court will first direct its attention, is the last made, viz. whether the 17th article of the Treaty of 1795, so far as it respects passports, is inoperative and imperfect in consequence of the omission to annex the form of the passport to the treaty."). This matter of the passport form, which was never annexed to the treaty, propelled the case into the jurisprudence of prize and privateers:

> it is the opinion of the Court . . . that the form of the passport not having been annexed to the 17th article of the treaty, the immunity, whatever it was, intended by that article, never took effect, and therefore, in examining and deciding the case before us, we must be governed by the general law of prize.

Id. at 76.

[194] *See supra* note 164 and accompanying text. At this minimum edge weight, the *Société Nationale* corpus would be unchanged. The *Mobil Oil* corpus, however, would be empty; the highest edge weight score in that cluster is eight (for the *Mobil Oil* case).

[195] Of the forty-one occurrences of the "ex parte" in the full *Air France* corpus, only one is not in a case name. Of the remaining forty, twenty-three are in citations to *McCardle*, *Milligan*, *Quirin*, and *Yerger*—all of central importance in the Guantanamo cases. *See* McCardle v. Indianapolis Water Co., 272 U.S. 400 (1926); *Ex parte* Milligan, 71 U.S. (4 Wall.) 2 (1866); *Ex parte* Quirin, 317 U.S. 1 (1942); *Ex parte*

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

combatant," and "martial law." None of these is a keyword in the smaller *Air France* corpus, or in the *Olympic* corpus. The lists do have some overlapping terms. The term "domestic law" is in all three lists in Table 4. The keyword "procedural default" is common to the *Olympic* and full *Air France* corpora. Both "bodily injury" and "international air" are common to the *Olympic* and shorter *Air France* corpora. Perhaps the largest difference between the *Air France* and *Olympic* clusters, reflected in the contrast between the *Olympic* and the shorter *Air France* corpora, is the tilt in the *Air France* cluster toward matters of money and finance. Of the twenty keywords for the smaller *Air France* cluster, eight of them are of this type: liability limit, liability limitation, French franc, official price, tax investigation, Canadian tax, 07-per-pound liability, and 07-per-pound liability limit.[196] The *Olympic* cluster, featuring both "bodily injury" and "personal injury" keywords, has no counterparts for these *Air France* monetary keywords; nor, for that matter, do the *Société Nationale* or *Mobil Oil* clusters.

***Air France* Cluster – All**	***Air France* Cluster – Top 7**	***Olympic* Cluster**
military commission	liability limit	local law
procedural default*	lésion corporelle	state court
liability limit	domestic law**	domestic law**
domestic law**	treaty provision	procedural default*
passenger ticket	liability limitation	bodily injury†
lésion corporelle	federal law	wilful misconduct
ex parte	french franc	international air‡
liability limitation	bodily injury†	air carrier
common law	domestic effect	treaty interpretation
full effect	treaty language	federal court
enemy combatant	criminal prosecution	flight attendant
travel restriction	official price	personal injury
treaty provision	state law	carrier liability
international law	07-per-pound liability	drafting history
martial law	07-per-pound liability limit	unusual event
due process	non-self-executing treaty	uniform treaty interpretation
federal law	psychic injury	air carrier liability
return remedy	tax investigation	uniform treaty

Yerger, 75 U.S. (8 Wall.) 85 (1868). In the shorter *Air France* corpus, the phrase "ex parte" appears six times, in six case citations (including one to *Milligan*).

[196] These last two are truncated forms of reference to language, from the *Trans World Airlines v. Franklin Mint Corp.* case, about a liability cap in a formula for calculating the value of lost property. *See Trans World Airlines*, 466 U.S. at 245 ("We conclude that . . . a *$9.07-per-pound liability limit* is not inconsistent with the Convention.") (emphasis added).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

Air France Cluster – All	*Air France* Cluster – Top 7	*Olympic* Cluster
internal quotation	international air‡	willful misconduct
habitual residence	canadian tax	state procedural default*

Table 4: Top 20 Keywords for the Co-Citation Network Clusters Anchored by *Air France* (both full and partial) and by *Olympic Airways*. Terms that appear in two lists are marked with an asterisk or similar indicator.

These semantic profiles of the co-citation network's case clusters show that the clusters occupy different conceptual regions, within the Warsaw Convention cases and the surrounding treaty cases in which judicial citations enmesh them. And the semantic profiles, like the clusters themselves, emerge from the citation network that undergirds and animates them. As lawyers seek fully to understand the Supreme Court's Warsaw Convention jurisprudence, and what it may portend in future air-travel or other treaty domains, these facts are new data-driven, bottom-up inputs.

One thing lacking from the Warsaw Convention network is a sense of dynamic change over time, a view of how citation clusters have changed as new cases cite old and new pairs of cases that reinforce existing linkages or forge new ones. To see some dynamism, we require a network large enough, spanning a sufficient number of years, to afford time-wise snapshots for comparison. The network of intellectual property cases decided over 70+ years, with an edge list more than five times larger than that of the Warsaw Convention network, enables just such comparisons over time.

C. Co-Citation Network Analysis of the Supreme Court's Intellectual Property Cases, 1947–2018

The second core network I examine is the one comprising all the citations to earlier Supreme Court cases one finds in all the Supreme Court's intellectual property decisions from 1947 to June 2018, the end of the Supreme Court's October 2017 Term. The network has 1,648 nodes and 2,940 edges; node in-degree ranges from zero to twenty, and node out-degree ranges from zero to fifty-seven. Of the 1,648 nodes, 183 have an out-degree of one or more, i.e., are citing cases. Patent cases dominate the network, comprising 117 of the 183 (63.9%); copyright cases account for 35 (19.1%) and trademark matters cases for 31 (16.9%).[197] A graph

[197] The data file for this edge list includes, for each citing case, a tag for the intellectual property area in which I categorized it. *See supra* note 110. When making these category tallies, I assigned to the patent group both the one design patent case (Samsung Electrs. Co. v. Apple Inc., 137 S. Ct. 429 (2016)) and the one trade secret case (Ruckelshaus v. Monsanto Co., 467 U.S. 986 (1984)) in the lot. I assigned the *Zacchini* case to the trademark group. *See supra* note 119 and accompanying text.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

depicting the rolling four-year average of each type of case, from 1950 to 2018, is provided in Appendix B.

The community detection algorithm groups the simple citation network of all the cases into twenty-one clusters. Only nine of these clusters have more than 5% (83) of the nodes, and the top five clusters account for almost 46% (751) of the nodes. The top forty-one cases in the network by authority score, for example, can be mapped using a force-directed algorithm. In the resulting map, in Figure 8,[198] all but six of the nodes are from the same cluster, which is the largest single cluster in the overall map.

We can also parse the seventy-two-year span into two versions, to assess how the central cases' authority scores have changed over time. Using 1982 as the half-way mark from 1947 to 2018,[199] we can put the authority scores of top cases in 2018 alongside the top authority scores as they stood in 1982. In other words, we take two snapshots of the top authority scores as the network grows from 1947 onward, one after thirty-six years have elapsed and another after seventy-two years have elapsed. Table 5, below, presents these two snapshots. A few things stand out. First, the two lists are remarkably similar, notwithstanding the additional thirty-six years of case-law development that took place from 1983 to 2018. Of the top twenty in 2018, eighteen were also in the top twenty at the end of 1982, though some were in different ordinal positions. The two cases that joined the top twenty, as of 2018, are *United States v. Paramount Pictures, Inc.*,[200] and *Kendall v. Winsor*;[201] the two cases they displaced from the top twenty of 1982 are *B.B. Chemical Co. v. Ellis*[202] and *United Shoe Machinery Corp. v. United States*.[203] It would be a mistake, I think, to attribute this high degree of stability in the top authority scores to the idea that older cases, simply by virtue of having been around longer, have garnered and continue to garner more and more inward citations (thus driving up their authority scores). If that were true, the correlation between a case's year of decision and its authority score would be large and negative, as higher authority scores pair to smaller calendar-year

[198] A map of the full citation network is provided in Appendix C to this Article.

[199] In the original project that used the first iteration of this dataset, I chose 1947 as the start year precisely so that 1982, the year that the national intermediate appellate court for all patent cases went into operation, would be the midpoint of the covered time span. *See* Miller, *supra* note 11, at 389. A different start year would yield different networks.

[200] United States v. Paramount Pictures, Inc., 334 U.S. 131 (1948).

[201] Kendall v. Winsor, 62 U.S. (1 Howe.) 322 (1859).

[202] B.B. Chem. Co. v. Ellis, 314 U.S. 495 (1942).

[203] U.S. Mach. Corp. v. United States, 258 U.S. 451 (1922), *superseded by statute*, Patent Misuse Reform Act of 1988, 35 U.S.C. § 271 (2018).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

numbers. But that is *not* true. The Pearson *r* between decisional year and authority score among the top 100 cases in the 1947–2018 network is 0.065, i.e., small and positive. Second, sixteen of the top twenty (or 80%) were decided in a *single* decade, the 1940s.

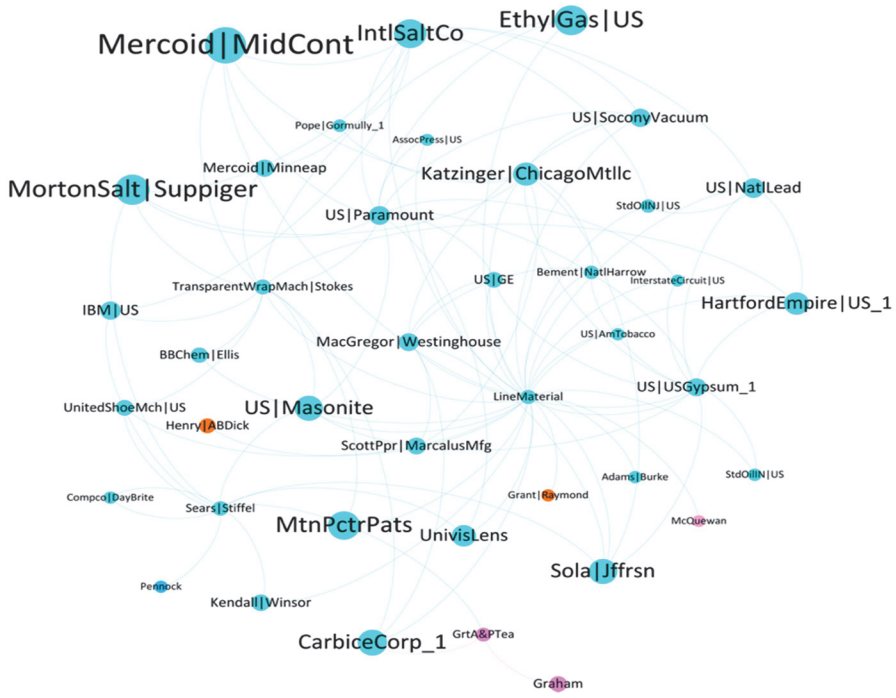

Figure 8: Map of the Top 41 Cases, by Authority Score, in the Simple Citation Network Generated from the Supreme Court's Intellectual Property Cases from 1947 to June 2018

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

1947 to 2018		Case	1947 to 1982	
Authority Score	**Ordinal Rank**		**Ordinal Rank**	**Authority Score**
0.265	1	Mercoid Corp. v. Mid-Continent Inv. Co., 320 U.S. 661 (1944)	1	0.275
0218	2	Morton Salt Co. v. G.S. Suppiger Co., 314 U.S. 488 (1942)	4	0.216
0.214	s3	Ethyl Gasoline Corp. v. United States, 309 U.S. 436 (1940)	2	0.235
0.206	4	International Salt Co. v. United States, 332 U.S. 392 (1947)	3	0.220
0.203	5	Motion Picture Pats. Co. v. Universal Film Mfg., 243 U.S. 502 (1917)	11	0.156
0.185	6	Carbice Corp. v. American Pats. Dev. Corp., 283 U.S. 27 (1931)	9	0.180
0.179	7	Sola Elec. Co. v. Jefferson Elec. Co., 317 U.S. 173 (1942)	5	0.204
0.178	8	United States v. Masonite Corp., 316 U.S. 265 (1942)	6	0.187
0.162	9	Edward Katzinger Co. v. Chicago Metallic Mfg., 329 U.S. 394 (1947)	8	0.181
0.157	10	Hartford-Empire Co. v. United States, 323 U.S. 386 (1945)	7	0.183
0.150	11	United States v. Univis Lens Co., 316 U.S. 241 (1942)	13	0.142
0.134	12	United States v. National Lead Co., 332 U.S. 319 (1947)	10	0.161
0.128	13	United States v. Paramount Pictures, Inc., 334 U.S. 131 (1948)	27	0.097
0.125	14	United States v. Socony-Vaccum Oil Co., 310 U.S. 150 (1940)	12	0.147
0.124	15	International Bus. Machs. Corp. v. United States, 298 U.S. 131 (1936)	17	0.125
0.121	16	United States v. U.S. Gypsum Co., 333 U.S. 364 (1948)	15	0.136
0.121	17	MacGregor v. Westinghouse Elec. & Mfg., 329 U.S. 402 (1947)	14	0.140
0.116	18	Mercoid Corp. v. Minneapolis-Honeywell Regulator Co., 320 U.S. 680 (1944)	16	0.129
0.114	19	Scott Paper Co. v. Marcalus Mfg. Co., 326 U.S. 249 (1945)	18	0.123
0.111	20	Kendall v. Winsor, 62 U.S. 322 (1858)	25	0.097

Table 5: Top 20 Cases, by Authority Score, in the Simple Citation Networks Derived from the Supreme Court's Intellectual Property Cases, from 1947 to 2018 (left) and from 1947 to 1982 (right)

Third, and perhaps most surprising given that the family of citing cases is pegged squarely to intellectual property law, is the dominance of *antitrust* cases among the top authorities in this simple citation network. Of the top twenty in 2018,

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

fully half—including four of the top ten—began as antitrust enforcement actions: *Ethyl Gasoline*, *International Salt*, *Masonite Corp.*, *Hartford-Empire Co.*, *Univis Lens*, *National Lead*, *Paramount Pictures*, *Socony-Vaccum Oil*, *International Business Machines*, and *U.S. Gypsum*.[204] That there are deep and important connections between intellectual property law (patent law especially) and antitrust law has long been appreciated, of course.[205] But this degree of centrality for antitrust cases within 70+ years of the Supreme Court's intellectual property cases took me by surprise, and I teach both intellectual property law and antitrust law.

What, then, of the co-citation network? How did it change, from 1982 to 2018? In what fashion, if at all, does it show the stability of the authority scores in the simple citation network? What else does it teach us about the fabric of the Supreme Court's current intellectual property jurisprudence?

I determined the co-citation networks from the edge lists for the 1947–1982 and 1947–2018 periods, including all edges with a weight greater than or equal to two.[206] The **1947–1982 network** has 201 nodes and 1,329 edges. Edge weights ranging from two to ten. The top three nodes by weighted degree—*Mercoid* (261), *Ethyl Gasoline* (212), and *International Salt* (197)—are the same nodes, in the same order, as the top three authority scores in the corresponding citation network. The community detection algorithm groups the network into eleven clusters of cases. Ordering these clusters by the edge weights of their most central modes, the top five clusters account for 85% of the nodes. The **1947–2018 network** has 400 nodes and 2,184 edges, with edge weights ranging from two to eleven. The top three nodes by weighted degree have not changed, though their weights have grown from continued citations—*Mercoid* (279), *Ethyl Gasoline* (224), and *International Salt* (214) (in the corresponding citation network, they rank first, third, and fourth by authority score). The community detection algorithm groups the network into thirty-one clusters of cases. Ordering the clusters by central-node edge weight, the top five clusters account for sixty-three percent of the nodes.

Putting the top five clusters of each of these co-citation networks side by side helps one discern how the doctrinal fabric has shifted from 1982 to 2018. Table 6,

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[204] The net change in number of antitrust cases from the 1982 top twenty is zero: *Paramount Pictures* (antitrust) and *Kendall* (patent) replaced *B.B. Chemical* (patent) and *United Shoe Machinery* (antitrust).

[205] *See generally* CHRISTINA BOHANNON & HERBERT HOVENKAMP, CREATION WITHOUT RESTRAINT: PROMOTING LIBERTY AND RIVALRY IN INNOVATION (2012); WARD S. BOWMAN, JR., PATENT AND ANTITRUST LAW: A LEGAL AND ECONOMIC APPRAISAL (1973); HERBERT HOVENKAMP ET AL., IP AND ANTITRUST: AN ANALYSIS OF ANTITRUST PRINCIPLES APPLIED TO INTELLECTUAL PROPERTY LAW (3d ed. 2017); Joseph Scott Miller, *Patent Ships Sail an Antitrust Sea*, 30 SEATTLE U.L. REV. 395 (2007).

[206] *See supra* note 164 and accompanying text.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

below, puts the top five clusters from the two co-citation networks in an illuminating juxtaposition; it shows the top ten nodes, by edge weight, in each of the top five clusters. Two of the five clusters—the first and the fifth—show notable continuity, even as the individual nodes' edge-weights grew from additional citations over time. For example, in the first cluster, anchored by *Mercoid v. Mid-Continent*, nine of the cases are in both the 1947–1982 cluster and the 1947–2018 cluster, though ordinal positions changed. *Leitch Mfg.* dropped out and *A.B. Dick* stepped in, which I have highlighted in grey. Similarly, in the fifth cluster, one finds seven of the ten cases in both the earlier and later clusters. I have highlighted in grey the three that dropped out from 1982, and two of the three that stepped in by 2018; the third addition by 2018, the *Great Atlantic & Pacific Tea* case (highlighted in purple), jumped from the third to the fifth cluster. There are also intriguing discontinuities. The third-ranked cluster from 1982 splits basically in two, sending three nodes to the second-ranked 2018 cluster (*Sola*, *Katzinger*, and *MacGregor*, highlighted in blue) and three nodes to the third-ranked 2018 cluster (*Stiffel*, *Compco*, and *Graham*, highlighted in yellow). The fourth-ranked cluster from 1982 simply slips out of sight, below the top five. In 2018, the fourth-ranked cluster is dominated by copyright law, for eight of ten cases.

The interplay of patent law and antitrust law remains prominent. In the second-ranked cluster, in both networks, antitrust enforcement cases dominate the group. In the 1947–1982 network, they are nine of the ten cases; *Bement* did not begin as an antitrust case (though the only federal question in the case was, in fact, about the validity of a contract term under the Sherman Act). In the 1947–2018 network, they are seven of the ten. Turning to the top-ranked cluster, in both eras, there are three antitrust enforcement cases (*Univis Lens*, *IBM*, and *United Shoe*). In addition, in both eras, all seven of the remaining cases in the top cluster played important roles in the doctrine of patent misuse,[207] an affirmative defense to patent infringement that sounds in antitrust.[208] Four of the five clusters in 2018, then, have a substantive doctrinal focus that is readily apparent to a person familiar with the Supreme Court's intellectual property and antitrust cases: patent and antitrust (clusters 1 and 2), copyright (cluster 4), and patentable subject matter under § 101 of the Patent Act (cluster 5).[209] That leaves cluster 3, an intriguing core of preemption cases (*Sears*,

[207] *See* 6 MOY'S WALKER ON PATENTS §§ 18:1–18:16 (4th ed. 2017) (discussing the origins and history of misuse).

[208] *See* WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 372–73 (2003) (discussing the doctrine).

[209] *See generally* JANICE M. MUELLER, PATENT LAW 453–537 (5th ed. 2016) (discussing this facet of patent jurisprudence).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

Compco, *Bonito Boats*, and *Kewanee*) and patent validity cases (*Graham*, *Pennock*, *Grant*, *Pfaff*, and *Seymour*). What more is it?

1947 to 1982 Co-citation Network		1947 to 2018 Co-citation Network	
Weight	**Case**	**Case**	**Weight**
261	Mercoid v. Mid-Continent (1944)	Mercoid v. Mid-Continent (1944)	279
178	Morton Salt v. G.S. Suppiger (1942)	Motion Picture Pats. v. Universal Film (1917)	206
150	Carbice Corp. v. American Pats. (1931)	Morton Salt v. G.S. Suppiger (1942)	204
117	United States v. Univis Lens (1942)	Carbice Corp. v. American Pats. (1931)	174
108	Motion Picture Pats. v. Universal Film (1917)	United States v. Univis Lens (1942)	149
95	Mercoid v. Minneapolis-Honeywell (1944)	IBM v. United States (1936)	95
83	IBM v. United States (1936)	Mercoid v. Minneapolis-Honeywell (1944)	95
75	B.B. Chemical v. Ellis (1942)	Henry v. A.B. Dick Co. (1912)	79
66	United Shoe Mach. v. United States (1926)	B.B. Chemical v. Ellis (1942)	75
41	Leitch Mfg. v. Barber (1938)	United Shoe Mach. v. United States (1926)	69
212	Ethyl Gasoline v. United States (1940)	Ethyl Gasoline v. United States (1940)	224
197	International Salt v. United States (1947)	International Salt v. United States (1947)	214
153	United States v. Masonite (1942)	Sola Elec. v. Jefferson Elec. (1942)	179
151	United States v. National Lead (1947)	United States v. Masonite (1942)	171
147	Hartford-Empire v. United States (1945)	Edward Katzinger v. Chicago Metallic (1947)	160
131	United States v. Socony-Vacuum Oil (1940)	United States v. National Lead (1947)	151
98	United States v. U.S. Gypsum (1948)	Hartford-Empire v. United States (1945)	147
83	United States v. General Elec. (1926)	United States v. Socony-Vacuum Oil (1940)	131
81	United States v. Paramount Pictures (1948)	United States v. General Elec. (1926)	109
76	Bement v. National Harrow Co. (1902)	MacGregor v. Westinghouse Elec. (1947)	107
179	Sola Elec. v. Jefferson Elec. (1942)	Graham v. John Deere Co. (1966)	159
150	Edward Katzinger v. Chicago Metallic (1947)	Sears, Roebuck v. Stiffel (1964)	106
107	MacGregor v. Westinghouse Elec. (1947)	Bonito Boats v. Thunder Craft Boats (1989)	99

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

1947 to 1982 Co-citation Network		1947 to 2018 Co-citation Network	
Weight	**Case**	**Case**	**Weight**
95	Scott Paper v. Marcalus Mfg. (1945)	Compco v. Day-Brite (1964)	83
78	Great Atl. & Pac. v. Supermarket (1950)	Kewanee Oil v. Bicron Corp. (1974)	83
72	Kendall v. Winsor (1858)	Pennock v. Dialogue (1829)	69
61	Pope v. Gormully (1892)	Lear, Inc. v. Adkins (1969)	65
56	Sears, Roebuck v. Stiffel (1964)	Grant v. Raymond (1832)	65
56	Compco v. Day-Brite (1964)	Pfaff v. Wells Elecs. (1998)	48
43	Graham v. John Deere Co. (1966)	Seymour v. Osborne (1871)	42
56	Cuno Eng'g v. Automatic Devices (1941)	United States v. Paramount Pictures (1948)	133
37	McClain v. Ortmayer (1891)	Kendall v. Winsor (1858)	102
20	Hotchkiss v. Greenwood (1851)	Fox Film v. Doyal (1932)	99
18	Lincoln Eng'g v. Stewart-Warner (1938)	Twentieth Century Music v. Aiken (1975)	75
12	Concrete Appliances v. Gomery (1925)	Mazer v. Stein (1954)	72
12	Potts v. Creager (1895)	Sony Corp. v. Universal City Studios (1984)	71
12	Reckendorfer v. Faber (1876)	The Trade-Mark Cases (1879)	70
11	Graver Tank v. Linde Air Prods. (1949)	Burrow-Giles Lithographic v. Sarony (1884)	60
11	Mahn v. Harwood (1884)	Wheaton v. Peters (1834)	60
9	Milcor Steel v. G.A. Fuller (1942)	Harper & Row Publ'rs v. Nation Enters. (1985)	55
47	Le Roy v. Tatham (1852)	Great Atl. & Pac. v. Supermarket (1950)	117
44	United States v. Dubilier Condenser (1933)	Le Roy v. Tatham (1852)	96
44	Funk Bros. Seed v. Kalo Inoculant (1948)	O'Reilly v. Morse (1853)	94
44	O'Reilly v. Morse (1853)	Funk Bros. Seed v. Kalo Inoculant (1948)	92
36	Gottschalk v. Benson (1972)	Gottschalk v. Benson (1972)	86
35	Mackay Radio v. Radio Corp. (1939)	Parker v. Flook (1978)	70
34	Deepsouth Packing v. Laitram Corp. (1972)	Cochrane v. Deener (1877)	70
32	Cochrane v. Deener (1877)	Deepsouth Packing v. Laitram Corp. (1972)	67
32	Rubber-Tip Pencil v. Howard (1874)	United States v. Dubilier Condenser (1933)	61
32	Tilghman v. Proctor (1881)	Diamond v. Chakrabarty (1980)	59

Table 6: Top 5 Clusters, by Anchor Node's Edge-Weight, in the 1947–1982 and 1947–2018 Co-Citation Networks

Before delving further into the substantive content of cluster 3 in the 2018 network, it is helpful to map both the 1947–1982 and 1947–2018 co-citation patterns.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

Figures 9 and 10, which—like Table 6, comprise the top 5 clusters—are the force-directed maps of the co-citation networks.[210] Node size varies with weighted degree, edge thickness varies with edge weight, and the color palette is the same for both maps (in descending order of cluster node-count, from blue to grey).

[210] Larger, higher-resolution versions of these images are available at this Journal's website. Prior to January 1, 2020, please use the following URL: https://lawreview.law.pitt.edu/ojs/index.php/lawreview. After January 1, 2020, please use the following URL: https://lawreview.pitt.edu.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

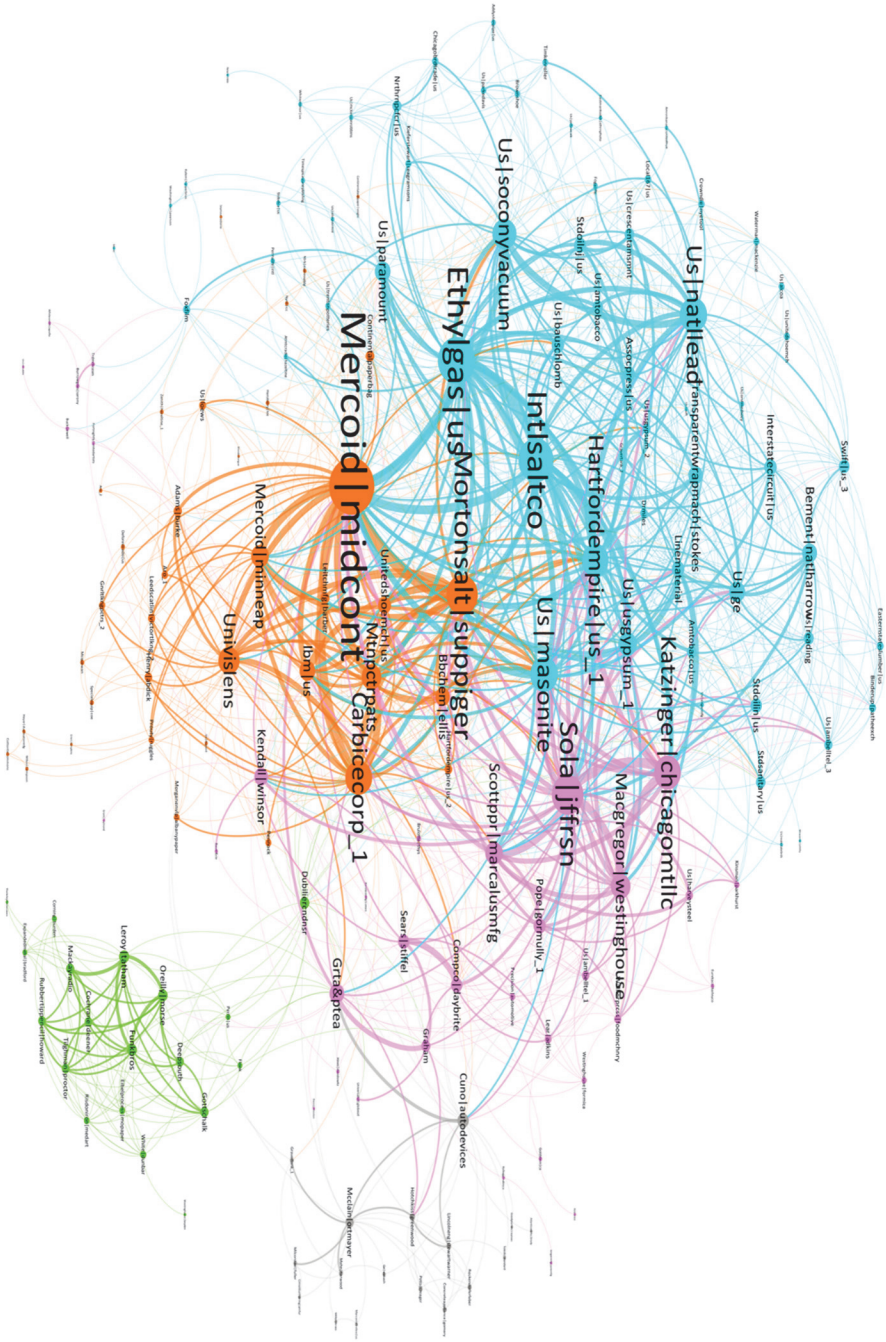

Figure 9: Top 5 Clusters, by Anchor Node's Edge-Weight, in the 1947–1982 Co-Citation Network

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

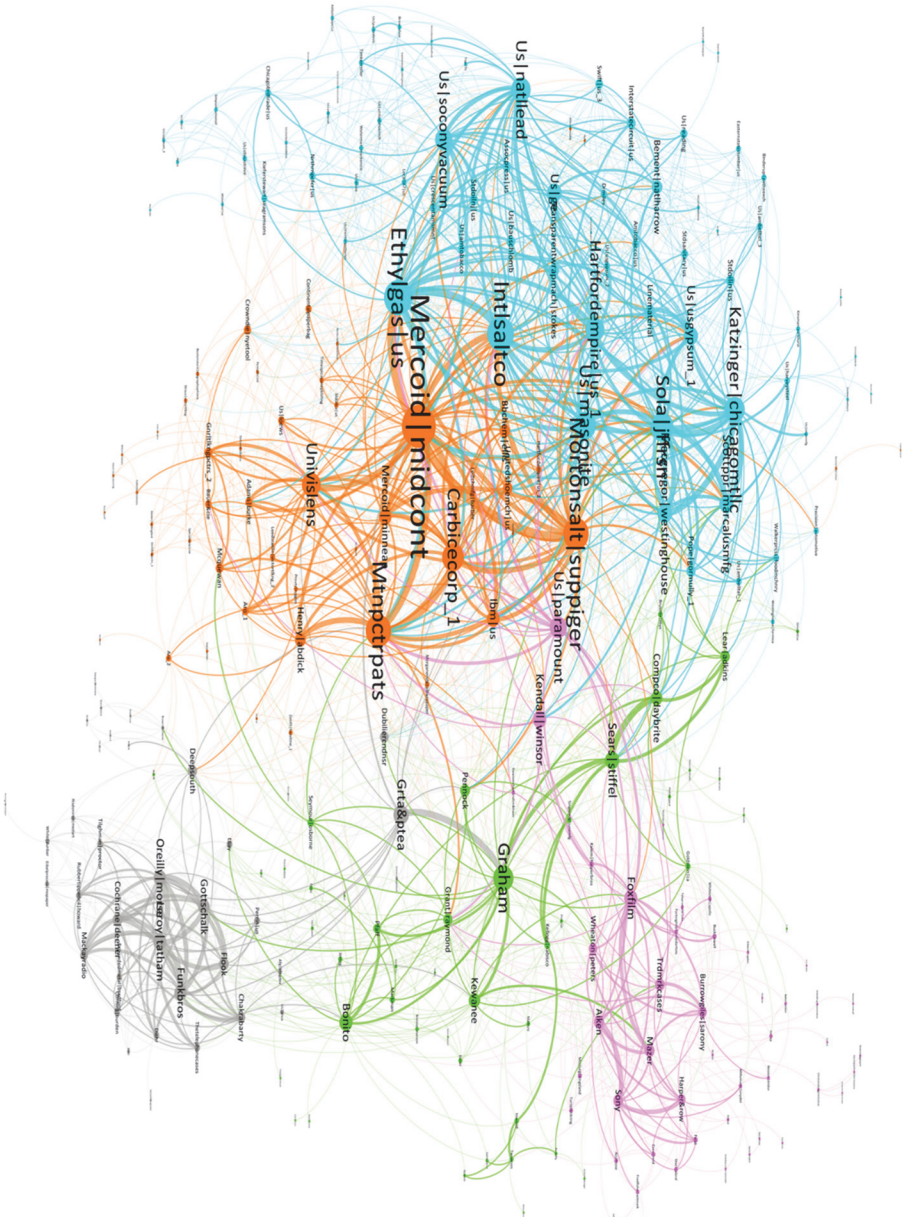

Figure 10: Top 5 Clusters, by Anchor Node's Edge-Weight, in the 1947–2018 Co-Citation Network

In the 1947 to 1982 map, the first three clusters—and especially the *Mercoid* and *Ethyl Gas* patent and antitrust clusters—dominate the map. In the 1947 to 2018 map, the *Mercoid* and *Ethyl Gas* clusters are still present and significant. The *Sola* cluster of the earlier map, however, has disappeared (its top three nodes having been absorbed into the *Ethyl Gas* cluster). The patentable-subject-matter cluster, in the

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

lower-right corner of both maps, has become thicker in the 2018 map; the Supreme Court, which has decided four cases in this area since 2010,[211] continues to rely on the same core group of precedents to explain their current approach to questions about patentable subject matter.

The two new clusters to emerge in the 1947 to 2018 map—one pink, anchored by *Paramount* and one green, anchored by *Graham*—focus on copyright and a mix, respectively. *Paramount*, an antitrust enforcement action involving copyright rights in motion pictures, connects the copyright cluster back to the patent and antitrust clusters (with edge-weight-five links to *Ethyl Gas*, *International Salt*, and *Motion Picture Patents*, and edge-weight-four links to *Carbice*, *Hartford-Empire*, and *Mercoid v. Mid-Continent*). The mix cluster's strongest link to another cluster is *Graham's* link to *Great A&P Tea*, with an edge weight of eight—echoing the pair's common membership in the 1982 map's now-dissolved *Sola* cluster. Both *Graham* and *Great A&P Tea* focus on patent law's non-obviousness requirement,[212] so this high co-citation count is not terribly surprising. Can we glean anything further about the doctrinal substance of the mixed cluster's congeries of preemption, patent-validity, and other cases using keyword analysis?

[211] *See* Alice Corp. v. CLS Bank Int'l, 573 U.S. 208 (2014); Ass'n for Molecular Pathology v. Myriad Genetics, 569 U.S. 576 (2013); Mayo Collab. Servs. v. Prometheus Labs., Inc., 566 U.S. 66 (2012); Bilski v. Kappos, 561 U.S. 593 (2010).

[212] *See* MUELLER, *supra* note 209, at 358–61 (discussing the cases).

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

***Graham*-Cluster Keywords**
federal patent
unfair competition
trade dress
secondary meaning
subject matter
patent law
prior art
exclusive right
trade secret
public domain
secret law
patent protection
trade secret law
shredded wheat
patent system
hinge plate
utility patent
state law
patent application
secret protection
trade secret protection
federal law

The *Graham* cluster has forty-five member nodes. The nodes range in weighted degree from 159 (for *Graham*) to 2, with a median value of 12. Including all twenty-two cases with edge weights above the median,[213] the resulting corpus can be used for keyword analysis.[214] The table at left lists the top twenty-two keywords for this corpus, in descending keyness-score order.

Some of the keywords are a by-product of the detailed fact-settings of particular cases, such as the "shredded wheat" of *Kellogg*[215] and the "hinge plate" of

[213] The additional twelve cases, beyond the ten already identified in Table 6, are—in descending order by weighted degree—as follows: Kellogg Co. v. Nat'l Biscuit Co., 305 U.S. 111 (1938); Markman v. Westview Instruments, Inc., 517 U.S. 370 (1996); Goldstein v. California, 412 U.S. 546 (1973), *superseded by statute* Copyright Act of 1978, 17 U.S.C. § 101 *et seq.* (2016); Brulotte v. Thys Co., 379 U.S. 29 (1964); J.E.M. Agric. Supply, Inc. v. Pioneer Hi-Bred Int'l, Inc., 534 U.S. 124 (2001); Inwood Labs., Inc. v. Ives Labs., Inc., 456 U.S. 844 (1982); Singer Mfg. v. June Mfg., 163 U.S. 169 (1896); N.Y. Trust Co. v. Eisner, 256 U.S. 345 (1921); Two Pesos, Inc. v. Taco Cabana, Inc., 505 U.S. 763 (1992); Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., 535 U.S. 722 (2002); Marbury v. Madison, 5 U.S. (1 Cranch) 137 (1803); Brenner v. Manson, 383 U.S. 519 (1966).

[214] *See supra* notes 74–94, 112–15 and accompanying text.

[215] The phrase appears thirty-nine times, excluding use in case names, in *Kellogg*.

ISSN 0041-9915 (print) 1942-8405 (online) ● DOI 10.5195/lawreview.2019.660
http://lawreview.law.pitt.edu

Graham.[216] Others, however, suggest a Court repeatedly grappling with the proper relationships among state trade secret law, state unfair competition law, and federal patent law. The phrases "exclusive right" and "public domain," the Castor and Pollux of intellectual property law (or is it Romulus and Remus?), indicate the Court's concern not only with the federalism questions animating preemption, but the with the equally weighty policy questions of polyarchy and propertization[217] that sit at the very heart of intellectual property law.[218] Given that the 1947 to 2018 network is but a snapshot, and thus a co-citation network derived from an even larger cohort of Supreme Court intellectual property cases might reveal additional important clusters and connections, it is important to remain tentative in one's assessment. All the same, as the Court continues to hear intellectual property cases at an increased pace (see Appendix B), this topical cluster, touching on intellectual property's broader systemic themes, bears watching.

V. CONCLUSION

Where there are citations, there are signs. Where there are recurring citations, there are symbols. The semantic self-portrait that decisional law paints in the co-citation networks and keyword lists that we can derive takes human judgment both to generate and to interpret. The techniques and results reported here are, not, in other words, a flight from interpretive judgment—at least, not as I understand them.[219] Rather, they are an aid to, a further input for, interpretive judgment. Professor Howard White's observation about the hunch that animates exploration of author-level co-citation networks is equally applicable to the case-level co-citation analysis conducted here: "since most authors are *never* co-cited, recurrent co-citation is a signal that something interpretable is happening."[220] It is that *something interpretable* among both the Supreme Court's Warsaw Convention cases and its

[216] The phrase appears twenty-nine times in *Graham*.

[217] *See generally* Tim Wu, *Intellectual Property, Innovation, and Decentralized Decisions*, 92 VA. L. REV. 123, 126 (2006) (exploring, for intellectual property law, the upshot of the fact "that government's decisions with respect to property assignments can steer decision architectures toward a polyarchical or hierarchical architecture").

[218] The 2003 issue of *Law & Contemporary Problems* devoted to papers on "The Public Domain" remains a critically valuable guide to the subject. *See Journal of Law and Contemporary Problems*, DUKE SCHOOL OF LAW, https://scholarship.law.duke.edu/lcp/vol66/iss1/ (last visited Apr. 6, 2019).

[219] *Cf.* Stanley Fish, *The Interpretive Poverty of Data*, BALKINIZATION (Mar. 2, 2018), https://balkin.blogspot.com/2018/03/the-interpretive-poverty-of-data.html ("The desire to generate human meaning by eliminating from the patterns that convey it all traces of the human is at once perennial and doomed to be ever un-fulfilled.").

[220] Howard D. White, *Citation Analysis and Disclosure Analysis Revisited*, 25 APPLIED LINGUISTICS 89, 93 (2004).

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intellectual property cases (of the last 70+ years) that I have sought to uncover. To the degree I have succeeded, I have shown at least some of the ways that co-citation and keyword analyses can deepen our understanding of any patch of the semantic fabric of our decisional law. Further insights await further work using network-analysis-driven methods.

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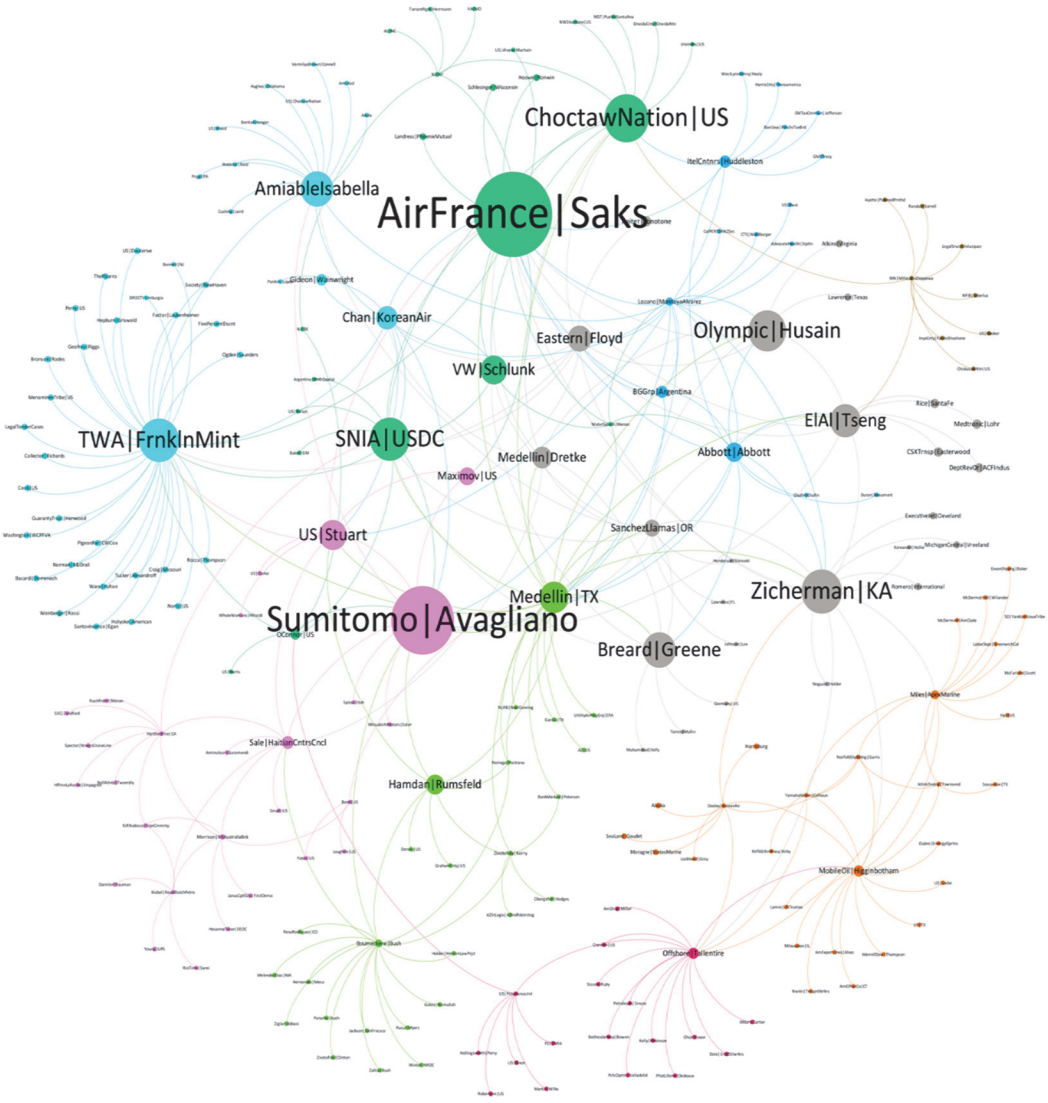
APPENDIX A

This figure is the force-directed map of the full network that embraces the Warsaw Convention cases. It has 215 nodes, 326 edges, and 9 clusters (grouped by Gephi's community detection algorithm, with its "modularity" parameter set to 1.0). Node size varies by authority score.



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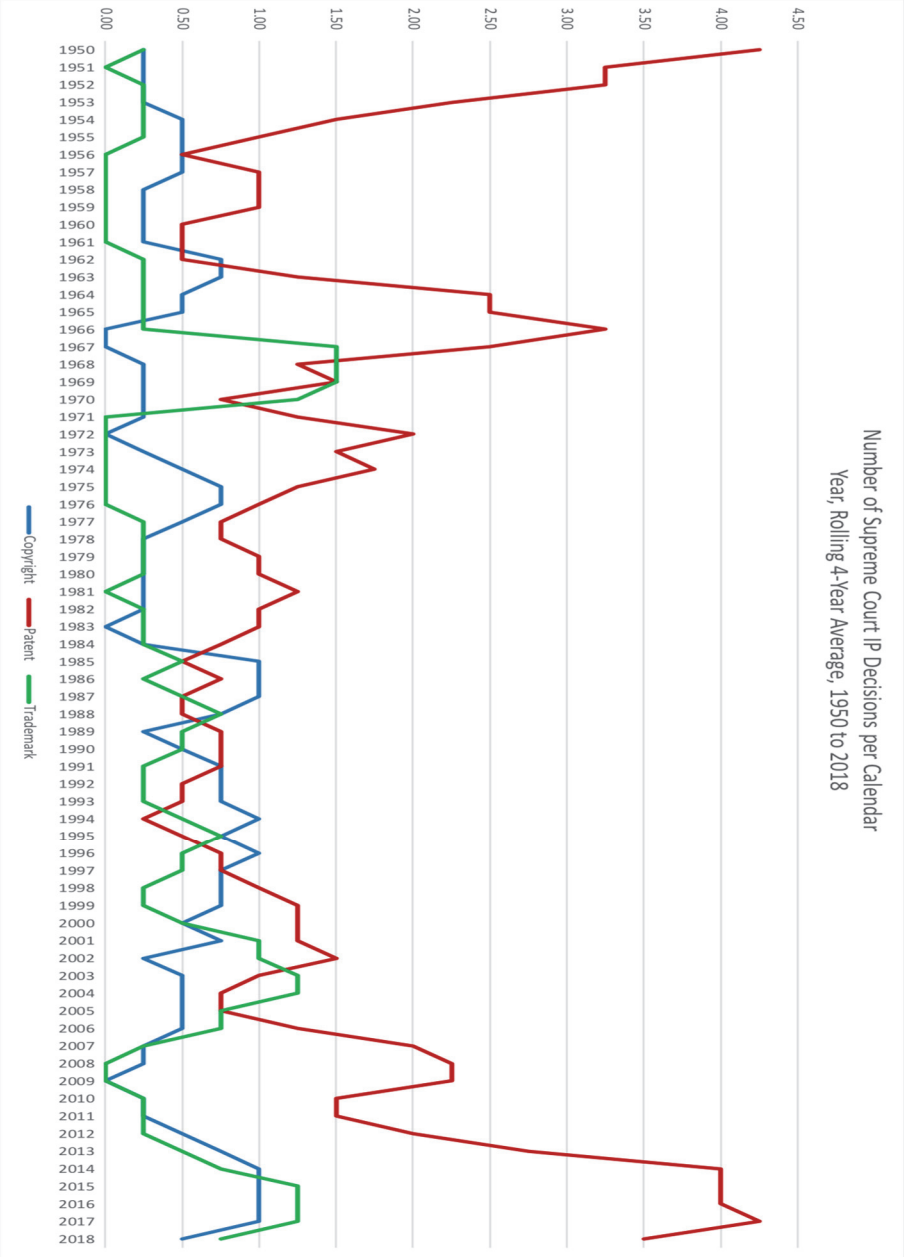
APPENDIX B

The graph below shows the rolling four-year average of the number of patent, copyright, and trademark decisions from the Supreme Court, from 1950 to 2018. The graph begins in 1950 with the average of cases from 1947 to 1950, inclusive. In all but a few of the years shown, patent cases dominate the group.



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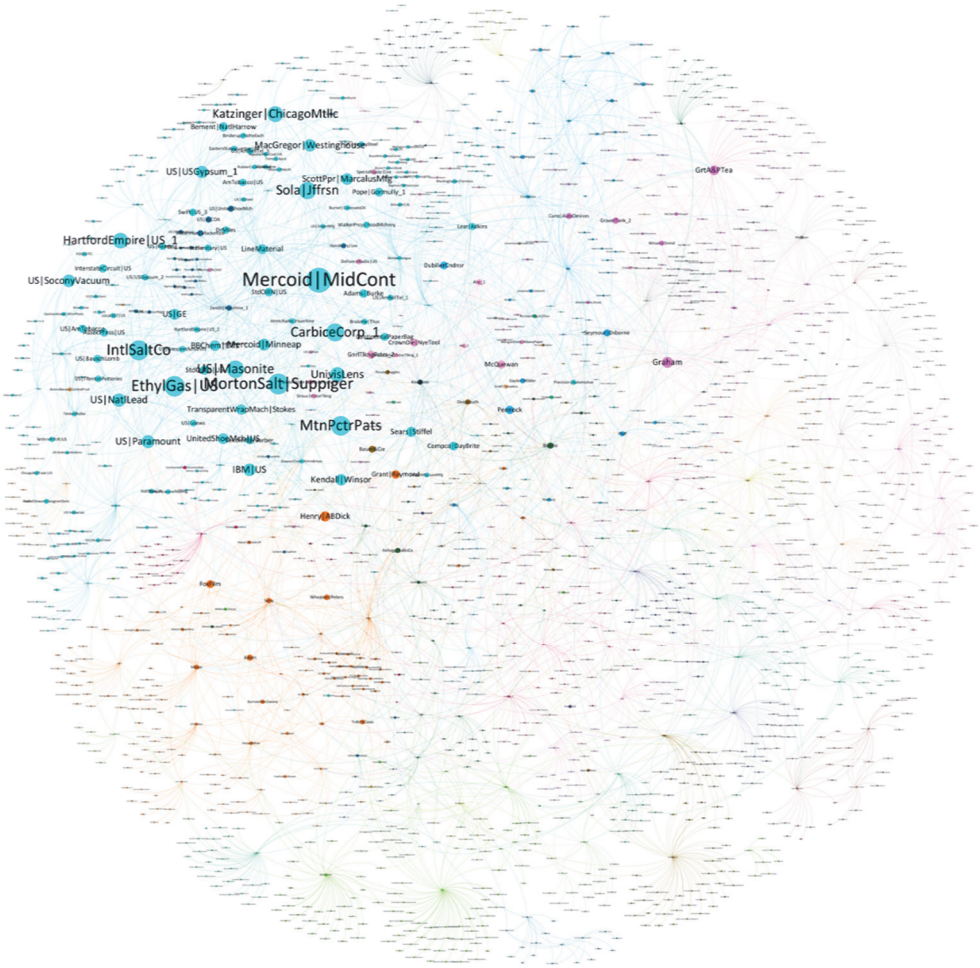
APPENDIX C

This figure is the force-directed map of the full network of Supreme Court cases cited in the Supreme Court's intellectual property decisions from 1947 to June 2018. It has 1,648 nodes and 2,940 edges in 21 clusters (grouped by Gephi's community detection algorithm, with its "modularity" parameter set to 1.0). Node size varies by authority score. A larger, higher-resolution version of this image is available at this Journal's website. Prior to January 1, 2020, please use the following URL: https://lawreview.law.pitt.edu/ojs/index.php/lawreview. After January 1, 2020, please use the following URL: https://lawreview.pitt.edu.



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