The Autonomy of Law from Politics: Evidence from a network analysis of US Environmental Law[*]

Marion Dumas

Abstract

Laws – be they common law, statutes or the constitution itself – evolve continuously. People make use of them, and discovering ambiguities or disagreeing on their proper application, ask courts throughout the nation to re-interpret them. What are the political drivers of this process? This paper analyzes a dataset of over 10000 U.S. environmental court cases, reconstructing the network of citations to legal precedent for a period of forty years. This dynamic network provides full information about the use of precedent over time and whether precedent is affirmed or undermined by written opinions. The network is thus a reflection of the evolution of the legal rules of environmental governance in the United States. The paper introduces multiple statistics that capture dynamic features of this network. These statistics are designed to capture significant changes in the content of the law. Using these measures, the analysis tests whether legal change is affected by changes in the preferences of pivotal legislators. Overall, the dynamic properties of this network reveal that laws evolve largely independently from shifts in legislative power.

1 Introduction

Every week, American judges write several hundred legal opinions that re-interpret, clarify or modify the meaning of public laws[1] – whether they be statutes, constitutional clauses, or a regulation issued by an executive agency. Judges write these opinions prompted by members of the public, who put forth diverse arguments regarding what these public laws ought to mean and how they ought to be enforced. This flow of decisions is incremental – each decision addressing a very specific set of circumstances – yet, over time, creates policy by determining which behaviors are acceptable and which are not. What political forces come into play in this policy process?

The rational choice theory of courts predicts that shifts in the policy preferences of legislators should influence the decisions of judges. This paper therefore explores the question at hand by testing whether changes in the ideology of key legislators influences the rate at which environmental case law evolves over time. The focus on environmental case law is explained by the fact that few studies examine the trajectories of environmental legislation over time, even though the difficulty of maintaining a policy on the

[1]The focus is on *public* law – governing the relationship of individuals to the state and the public interest – as opposed to private law – governing the relationship between private parties.

long-term is seen as a major obstacle to effective environmental governance (Rodrik, 1996; Hovi, Sprinz, and Underdal, 2009; Jacobs, 2011). Furthermore, court decisions have had an important role in the lives of the United States' key environmental statutes. Together with the Administrative Procedures Act, the environmental statutes of the 1970's greatly expanded citizens' access to courts as a means of giving voice to citizens in the policy process and of facilitating enforcement. Legal action has accordingly become an important political strategy for special interests, local associations and local authorities, leading to an uninterrupted flow of decisions over more than four decades (see section 3). Yet, the statutes that provide the authority and the framework for these disputes and decisions are themselves very stable. The Clean Air Act was last amended in 1990, the Clean Water Act in 1981, the Endangered Species Act in 1988. Agencies and courts are thus the principal organizations directly modifying policy in the face of changes in the environment, the economy and changes in societal beliefs.

In the face of rapid changes in society, the stability of policy that appears flagrant to the observer of statutes can hide a wide range of actual policy changes on the ground. Hacker (2004) shows for example that the formal structure of social welfare policy in the United States stayed remarkably constant, but that this stability hid a growing mismatch between welfare policies and the new social risks faced by citizens. He brings our attention to the "subterranean political processes that shape ground-level policy effects", beyond the much more visible politics of formal reforms, and shows that these processes, too, are political. He argues that conservative interest groups and politicians actively prevented any adaptation of the policies to the changing social context and that incremental changes in the direction of weaker protection had far-reaching consequences. Patashnik (2003) examines the fate of several general-interest reforms, observing that if constituencies with a stake in the reform are not powerful enough, reforms are easily corrupted after enactment. These studies clearly show that to understand how institutional structure affects policies and social outcomes over time, we must study the mechanisms that affect incremental decision-making in courts and agencies, from the local to the national scale, and thereby build an account of how laws evolve over time.

Positive political theory sees laws as epiphenomenal to the political game (Pierson, 2003). Both their enactment and their post-enactment life depend on the resolution of political conflicts between political actors holding different policy preferences – within the constraints set by principal-agent relationships, coalition formation and the constellation of institutional veto players. Laws are thus born out of political dynamics and remain beholden to the same political dynamics throughout their life. Specifically, within positive political theory, separation-of-power (SOP) models make predictions about how the interaction between the courts and the legislative branch will affect policy. In these models, judges face the threat

of seeing their decisions overturned by legislators. They therefore make decisions that lie as close to their preferences as possible, but within the "gridlock interval" – the policy interval delineated by pivotal legislative actors, which defines a policy area immune from reversals (Ferejohn and Weingast, 1992; Spiller and Gely, 1992; McNollgast, 1994; Shipan, 2000). In this model, important policy change thus requires shifts in the distribution of preferences of pivotal legislative actors (Epstein, Kristensen, and O'Halloran, 2008).

This paper empirically tests the influence of changes in the preferences of political actors on the evolution of U.S. environmental case law over four decades. It does so by analyzing the dynamics of the network of citations to legal precedent in all court opinions that were written over that period of time. A citation to precedent means a judge is referring to a rule articulated in a past case to justify his decision. A positive citation reaffirms the validity of the rule, while a negative citation undermines its validity. In turn, citizens use that information to form their expectations about which course of action will be deemed wrongful in the future. Rules articulated in opinions, and references to them, thus constitute policy. In this paper, I use changes over time in the pattern of citations and the structure of the network as a measure for changes in the rules of environmental governance. This allows me to test whether the application of environmental laws is beholden to politics in the way political economy models of law and politics posit (Rodriguez and McCubbins, 2006).

Several other papers have tested the prediction of separation of power models that courts are constrained by the preferences of congressional actors (Spiller and Gely, 1992; Segal, 1997; Bergara, Richman, and Spiller, 2003). The most recent of these papers exposes biases and data insufficiencies in the other ones, and concludes that the congressional players posited by Krehbiel (2010) to be pivotal have a discernible influence on the Supreme Court's decisions. All these papers focus on the votes of Supreme Court justices. As elaborated below, this paper attempts to move away from the study of votes to the study of policy change. Furthermore, most important court decisions about environmental law are not made by the U.S. Supreme Court. There is no reason why the separation of power model should apply solely to the Supreme Court – its formulation makes it relevant to any court decision that has policy implications. Instead of focusing on the votes of justices in all Supreme Court cases, this paper focuses solely on environmental law – albeit the full record of this body of law, generated by district courts and appeals courts throughout the twelve circuits, as well as the Supreme Court. The important question is whether the strategic logic espoused by separation of power models leaves a discernible and important trace in the legal record of opinions, even though this record is built from decisions by numerous actors in a structurally decentralized system. This paper concludes that it does not. It seems likely that to

understand the trajectory of environmental laws, looking at shifts in legislative preferences will provide little traction.

Methodologically, this paper presents a few innovations. First, it attempts to move from political behavior to policy substance, a move that has been called for by several scholars and seems warranted if we are to understand the output of institutions (Lapinski, 2008). Second, in order to study changes in policy substance in a large-N framework, I derive measures of legal change from the network of citations to legal precedent, anchoring myself in existing analyses of the role of precedent as a carrier of legal policy. Finally, I use a combination of parametric and non-parametric tests, based on the careful construction of a null model, to test the influence of changes in the distribution of preferences in the political branches. It is worth noting that a few papers propose descriptive analyses of the network of legal citations formed by Supreme Court decisions (Fowler et al., 2007; Fowler and Jeon, 2008; Leicht et al., 2007). With the exception of the pioneering study of Hansford and Spriggs (2006), none use network analysis to test theories of the political and legal drivers of legal dynamics, and none considers the entire court system.

Section 2 reviews the theory of congressional constraints on court decisions and discusses the dynamic implications of this theory. Section 3 then presents the dataset and introduces the measures of legal change proposed in this paper. Section 4 presents the results of the statistical analysis, showing that there is little trace of the influence of congressional preferences in the evolution of environmental case law – at least as conceptualized in this paper. Section 5 concludes by outlining possible shortcomings in the analysis and putting the results in light of other theories of the law and of policy processes.

2 Theory of the politically constrained court

As Pierson has noted, political scientists generally believe that "policies, unlike formal institutions, are relatively easy to change (or 'plastic'), they are essentially epiphenomenal" (Pierson, 2003). For those who see laws as epiphenomenal to the political game, the main immediate effect of legislation is to change the status quo policy[2] and legislation has an effect on long-term social outcomes only in so far as 1) those in charge of implementing legislation have sufficient incentives to implement it faithfully (principal-agent theory), and 2) future policy-makers cannot easily change the status quo policy (veto player theory). In this framework, courts' decisions are conceptualized as movements of the policy in ideological space, and these movements are theorized to be constrained by the preferences of key players

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[2]In this perspective, there exists no fundamental difference between law and policy – laws are conceptualized as a point in policy space, thus implementing a policy outcome. This stands in contrast to other approaches in which laws reflect and articulate a structure for normative reasoning.
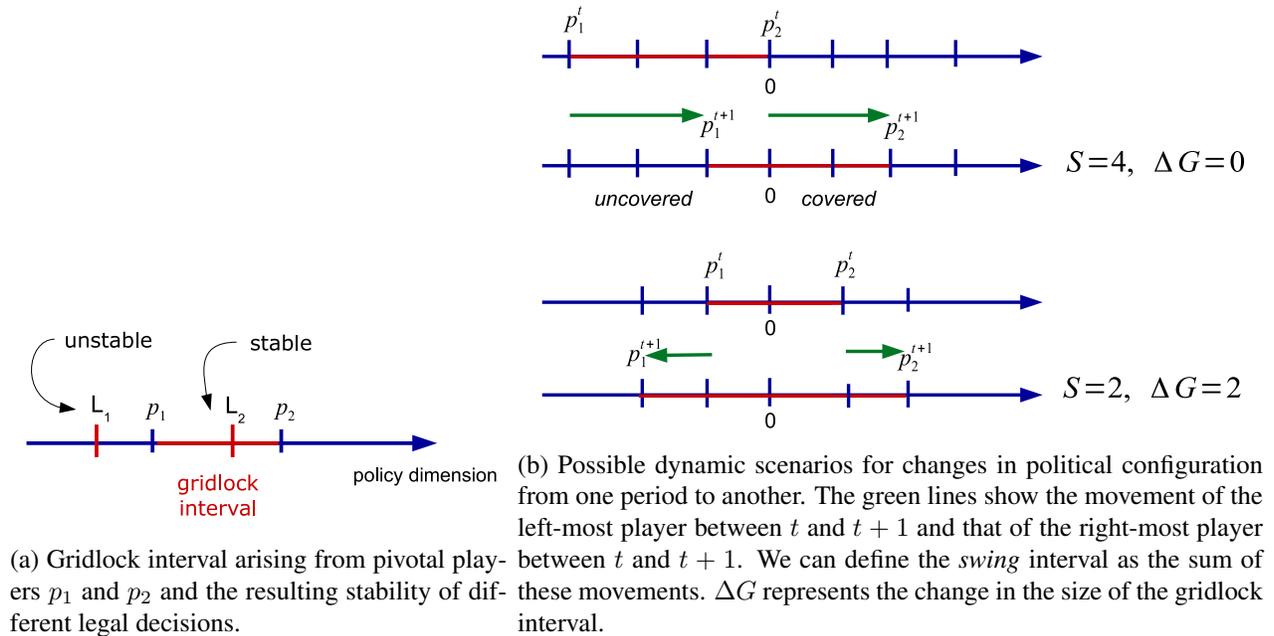
(a) Gridlock interval arising from pivotal players p_1 and p_2 and the resulting stability of different legal decisions.

(b) Possible dynamic scenarios for changes in political configuration from one period to another. The green lines show the movement of the left-most player between t and $t + 1$ and that of the right-most player between t and $t + 1$. We can define the *swing* interval as the sum of these movements. ΔG represents the change in the size of the gridlock interval.

Figure 1: Static and dynamic versions of the separations-of-power models.

in the elected branches. In turn, courts enjoy autonomy only when political actors are strongly divided (Rodriguez and McCubbins, 2006; Ramseyer, 1994).

This viewpoint was clearly formalized in a series of models called "separation-of-power" models. Figure 1a represents the main logic of the separation of power models: the preferences of pivotal players (those who can defeat a policy proposal) in the policy space form an interval, called the gridlock interval. Courts can change the status quo policy within that interval but are constrained by the preferences of pivotal players outside of that interval because the pivotal players can agree to modify the courts' rulings. Since judges are assumed to maximize their satisfaction with resulting policies, they will act strategically, moving policy as close to their ideal point as possible within the gridlock interval.

If we consider this theory from a dynamic point of view, we see that changes in the gridlock interval will induce changes in courts' statutory interpretation decisions. Consider the first scenario in 1b. As we move from period 1 to period 2, part of the policy space is uncovered. Any statutory interpretation lying in that region becomes vulnerable to being changed since all pivotal players would agree with that change. Additionally, part of the policy space becomes covered by the new gridlock interval. All movements in statutory interpretation decisions in that region become possible, thus opening a window of opportunity for legal change. Thus, both the newly uncovered and the newly covered regions offer opportunities for legal change.

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As illustrated in figure 1b, I define S, the swing interval. S is the sum of the absolute movement of the lower bound and upper bounds of the gridlock intervals from one period to the next. This measure gives us the sum of the newly uncovered and newly covered regions. Comparing scenario 1 and scenario 2 in figure 1b, we see that the size of the gridlock interval can remain unchanged, yet the swing be important, while the size of the gridlock interval can change but generate only a moderate measure of swing. I argue that, even without taking into account the policy preferences of judges, SOP models imply that larger swing intervals should induce more changes in statutory case law. This argument is based on the assumption that legal change is a distributed process that engages many actors and on the further assumption that the engaged public holds a wide diversity of preferences (see section 3 for evidence supporting the assumption that law is shaped in a highly distributed fashion). As a result, if courts are politically constrained by pivotal players in the other branches of government, any change in the preferences of these pivotal players opens a window of opportunity for some actor in society to push for a change in environmental law. If the window of opportunity moves in the direction of allowing more pro-environmental protection interpretations, environmental groups would exploit it, and if the window of opportunity moves in a more pro-business direction, industrial associations would exploit it.

The relevant veto players in SOP models are typically the median voter of each house and the president. The logic can easily be extended to include instead the pivotal players of Krehbiel's super-majority theory of congressional politics (the filibuster pivot, the President and the presidential override veto player), or the key majority-party and committee players in Cox and McCubbins's (2007) theory of legislative decision-making. The gridlock interval and measure of swing used in this paper are based on Krehbiel's (2010) super-majority players. Indeed, the most recent and careful test of the SOP model, by Bergara, Richman, and Spiller (2003), found these pivotal players to yield the most robust and significant influence on Supreme Court decisions. The appendix considers pivotal players arising from alternative theories of legislative decision-making, particularly committee gatekeeping theories[3] Furthermore, given that many actors could play pivotal roles (depending on the type of decision that is made and the negociations that underlie it), the analysis also considers the effects of changes in the median ideology of Congress, as a measure of the overall support for environmental protection in Congress.

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[3]It is likely that real legislative decision-making actually gives a key role to some actors in some circumstances, and other actors in other circumstances. A legislative move to overturn a court decision may take a wide variety of forms: formal statutory amendments that attract the attention of many legislators, obscure budget riders, budget cuts, non-enforcement of rulings (Staton and Vanberg, 2008; Helmke and Rosenbluth, 2009). Given the diversity of ways courts could suffer political backlash, courts may thus be sensitive to changes in the overall distribution of politicians' preferences. It would thus be fruitful to consider more probabilistic formulations of "gridlock" and swing that capture the distribution of players who could act in a pivotal fashion on any one decision and captures our uncertainty regarding his/her precise identity.

3   The Network of Legal Citations and Measures of Legal Change

One contribution of this paper is to show how we can make use of legal opinions – and specifically their citations to precedent – to test political economy theories of regulation. In this section I first introduce this novel dataset and highlight some of its key features before showing how I use this data to derive measures of legal change.

The focus on precedents stems from the fact that "the doctrinal and therefore political content of most opinions is only tenuously related to which party won the case" (Shapiro, 1964). It is not the case outcome, nor the votes, but the written opinion that affects policy (see also Epstein and Knight, 2013; De Mesquita and Stephenson, 2002; Hansford and Spriggs, 2006). Furthermore, it is only because the opinion forms a precedent to be followed in similar circumstances in the future that it has any policy-bearing content. Every attorney in the nation consults opinions to determine which behaviors are likely to be condoned in a specific context in the future. And every attorney checks how the opinion has been cited to verify that it is still "good law". It is thus the content of the opinion and the pattern of citation to it that helps attorneys, firms and citizens determine what the current state of the law is.

3.1   The Legal Data

The dataset is derived from the Federal Reporter, published by Westlaw. The Federal Reporter consists of the full record of every case for which an opinion was published. Westlaw clerks identify each legal issue discussed in the opinion and classify this issue according to the Westlaw nomenclature of legal issues. In this nomenclature, there are 589 legal issues in environmental law. I downloaded all court cases since 1970 that include at least one issue classified as an environmental issue. I thus obtained 12270 court cases. All the issues a case deals with appear in a list of headnotes at the beginning of the opinion, which allows to disaggregate each case into its individual decisions (see appendix figure 1). Headnotes are a more meaningful unit of analysis than cases. Indeed, each case is an idiosyncratic set of legal issues. Each headnote, on the other hand, deals with a distinct issue and its governing rules. The claim summarized in a specific headnote can be reversed by a future ruling, while other claims in the case, summarized in other headnotes, can remain valid. Thus, the correct unit of analysis to study legal change are the individual claims as captured by headnotes. After splitting the cases into individual issues by headnotes, and keeping only environmental issues in the dataset, I obtained 49690 environmental decisions.

A citation network is composed of nodes and directed links. The nodes in this case are the headnotes, i.e. a legal decision at a given point in time by a given court on a specific issue. The directed links are
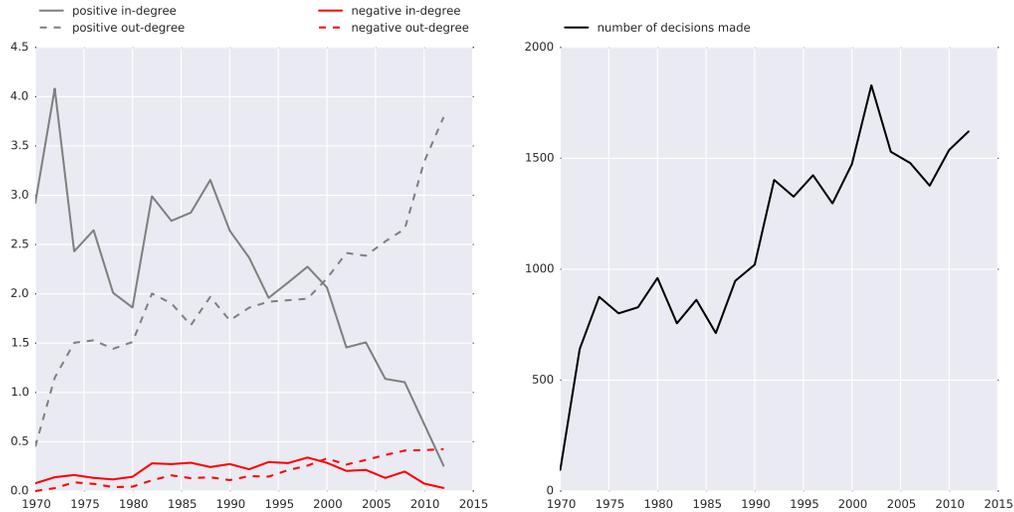
Figure 2: Average negative and positive citations made and received by environmental nodes over time, as well as the total volume of decisions over time.

the citations between headnotes. These citations are retrieved from the argumentation in the opinion in which prior decisions are cited. These citations are usually positive (affirming the validity of that decision), with a small percentage of citations being negative (refuting or narrowing the scope of a prior decision)[4]. Since links can only go towards past cases, the network is a directed acyclic graph, that is also signed – in plain English, a network connecting headnotes to prior headnotes, either in a positive or negative way.

The resulting network of decisions spans the full federal judiciary hierarchy. Figure 2 shows some features of this body of law. First, we see that the number of decisions per year seems to have stabilized at around 1700 per year[5]. Decisions are cited positively about 2 times on average (this is the *in-degree* of the node). However, this variable is characterized by a power-law distribution, so that some decisions are cited hundreds of times while most decisions are hardly ever cited (the downward slope over time is due to the fact that more recent cases haven't had time to cumulate as many citations). The number of past decisions cited in justifying a decision (the *out-degree* of the node) is distributed more evenly with an average of 1.5 citations, which, interestingly, has been increasing in the last decade[6]. Finally, we see

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[4]To obtain the links, I paired the headnotes to the set of cases cited in the opinion in support of the headnote's resolution. Subsequently, by parsing the text of the cited cases, I could uncover the specific headnote thus cited and the sign of the citation (negative or positive).

[5]This number refers to the number of headnotes, not the number of cases. There are about 300 cases per year, and on average 6 environmental headnotes per cases.

[6]This may be reflecting the increasing complexity of the law, or perhaps a desire of judges to anchor ever more firmly their decisions in precedent to bolster their legitimacy in the face of increasing party polarization.
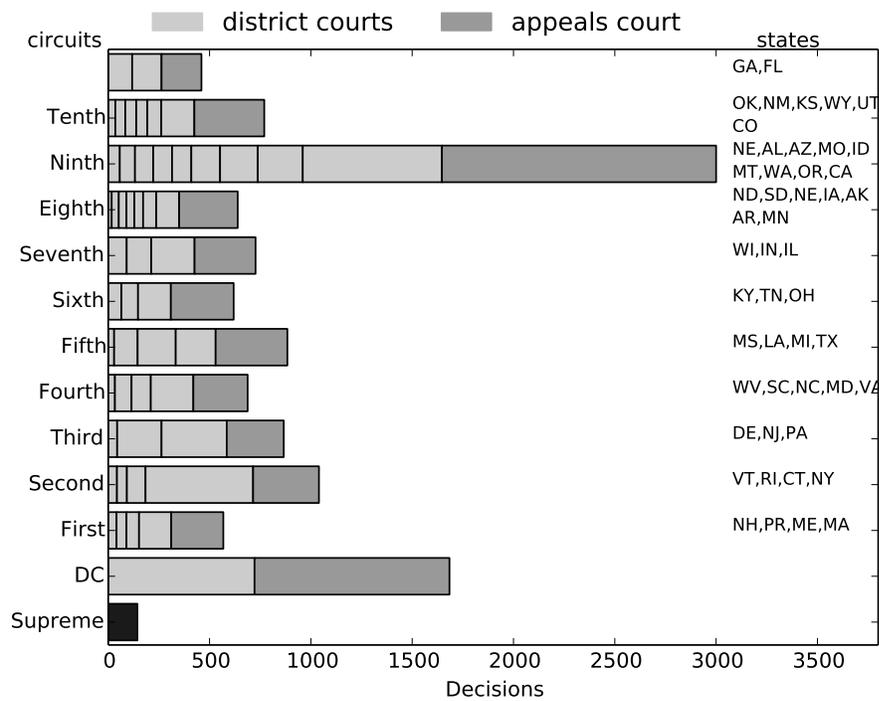
Figure 3: The distribution of decisions across district courts and appeals courts of the eleven circuits, plus the D.C circuit and the Supreme Court.

that the rate of negative citations is low, but has been increasing over time, targetting decisions ranging from 1970 to 2005 at a rather even rate.

Figure 3 summarizes the distribution of court opinions throughout the federal court system. 56% of opinions come from district courts and 43% from appeals courts. Of these appeals court opinions, only 18% come from the District of Columbia, which is the highest appeals court for administrative law aside from the Supreme Court. Supreme Court cases make up only 1 % of all opinions in this dataset. These figures demonstrate that environmental law evolves in a distributed fashion – many courts contribute to it throughout the country, and only a small fraction of opinions arise from the higher echelons of the judicial hierarchy[7].

The network is 98% connected, which shows that decisions are hardly independent of each other. However, not all issues are as closely connected as others: the network is to a strong degree organized

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[7]Skeptics may argue that cases arising from the Supreme Court or the D.C court of appeals are much more influential and highly cited and that we should therefore look at the distribution of citations instead of decisions. Indeed, the distribution of citations shows that appeals courts decisions concentrate more citations than district court decisions. Nonetheless, repeating the exercise with citation counts still shows that decision-making is highly distributed. Indeed, about 18% of citations are to district court decisions, another 18% to Supreme Court decisions, 9% to the D.C circuit appeals court, and the remaining 53% from other the appeals court of other circuits.

in *communities*, i.e. groups of issues that are more likely to cite other issues in the group than issues outside the group[8]. These groups can be identified using community detection algorithms, such as that of Newman (2006)[9]. Appendix figure 2 shows that using this method, the body of environmental law can be meaningfully split into eight categories: air pollution (CAA), water pollution (CWA), environmental impact assessments (NEPA), plants and wildlife (ESA), historical preservation, management of waste (RCRA), cleanup of hazardous waste (CERCLA) and judicial review (specifically rules for legal standing and distribution of costs and attorney fees)[10].

How do decisions build influence over time? Are younger decisions more likely to be cited? How fast do decisions age? These patterns are important to grasp in order to build time-sensitive measures of the importance of cases and build indicators of legal change. The probability of citing a decision declines very slowly as a function of its age. More than 50% of citations are to decisions that are more than 10 years old and 20% of citations are to decisions older than 25 years. This can be put in contrast with scientific citation networks in which 50% of citations are to studies that are younger than 4 years old and only 20% of citations are to studies older than 15 years (Martin et al., 2013). Thus, legal norms stay relevant longer than scientific studies. Second, the probability of citing an older case has increased steadily over time, indicating that the body of law is cumulative. To understand how decisions mature, consider figure 4. It plots $P(\Delta t)$, the distribution of time from a decision to the decision being cited. This distribution is best described by a log-normal survival probability function – a common function for decay processes such as this one (Wang, Song, and Barabási, 2013). The location parameter μ can be thought of as a measure of immediacy – governing the time for a decision to reach its citation peak, while σ, the decay rate, captures the decision's longevity. We will use this distribution to adjust for time in deriving measures of a decision's importance.

3.2 Measures of Legal Change

Rational choice theories conceptualize legal decisions as policy changes, or, equivalently, movements in ideological space. How should policy change manifest itself in the network of legal citations? To answer this, I use common descriptions of how common law develops and of judges' use of legal precedent to determine what patterns in the use of precedent are indicative of change in the content of the law.

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[8]The concept of community is central to network analysis. It is the equivalent for networks of the concept of clusters, well known in the analysis of regular datasets

[9]See appendix for details on the community structure and the method of inference.

[10]These communities correspond well to the major groupings of environmental issues in the Westlaw nomenclature. However, most of the procedural issues in the Westlaw nomenclature are too enmeshed with substantive issues to form their own independent doctrines, except for the issue of standing and distribution of fees.
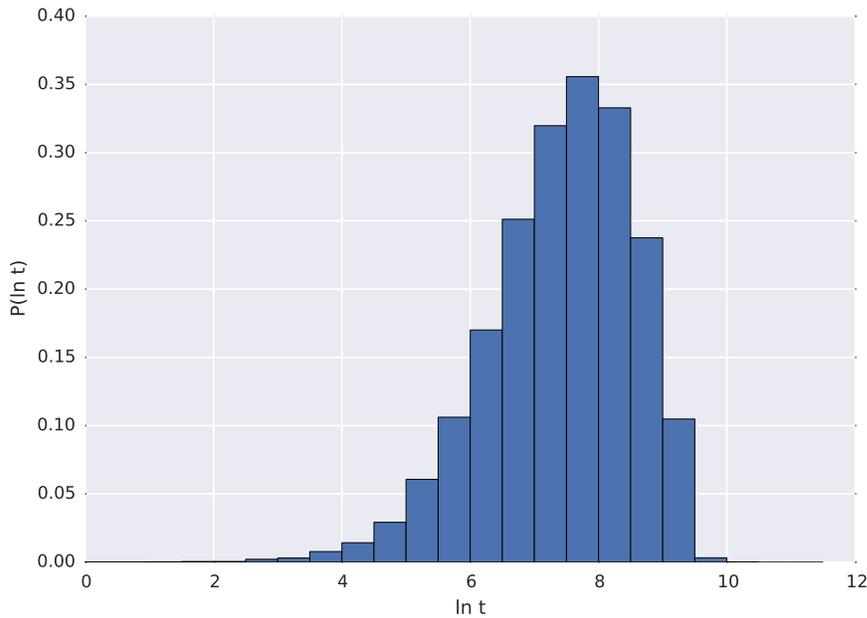
Figure 4: Probability distribution of delay between decision and its citation (time is in days). The best fit curve gives $\mu = 7.46$ and $\sigma = 1.14$, indicating that immediacy is on average close to 5 years.

Legal opinions express rules and standards, which map the factual characteristics of a dispute over a behavior to a judgment about the behavior (Dworkin, 1982; Lax, 2011). Yet, a given opinion never stands alone; rather, it stands in relation to other opinions. Sometimes it restricts the scope of a prior decision, or expands it, or simply refines an existing rule in light of local circumstances. Indeed, a single opinion cannot define a doctrine in a comprehensive way. It usually takes a series of opinions to clarify a rule, or a set of rules (De Mesquita and Stephenson, 2002; Shapiro, 1972). Court cases that lead to an opinion often feature a new, idiosyncratic feature. Each decision thus comes with a justification – based on precedent – that interweaves the old and the new and feeds in that line of justification for future cases (just as academic authors cite the literature to which they are adding or with which they are arguing). This means that a highly novel case – one that articulates a new rule, breaks with precedent or deals with an entirely new situation (*casus sui generis*) – should attract a large number of citations by future decisions, because to become operational, the rule needs opinions that will incrementally refine it.

Thus, important opinions tend to be highly cited because they require refinement. Hence, the appearance of a decision that becomes highly cited over time is an indicator of novel change. But citations themselves can also directly shape the influence of an opinion. Positive citations increase the validity of the precedent (Hansford and Spriggs, 2006: say that it increases the "vitality" of the opinion), whereas

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negative citations undermine its validity. Since future opinions that positively cite well-established precedents are more legitimate – and more clearly understandable by the population – a precedent's citation count affects how influential it might be in future rulings, thus affecting policy[11](Wald, 1995; McGuire and MacKuen, N.d.; Knight and Epstein, 1996). In other words, because citation patterns convey information and signal the relative authority of rules, change in the citation profile of an opinion represents a form of legal change as well (Hansford and Spriggs, 2006).

Given the role and meaning of citation to precedent outlined above, how would judges use precedent if they wanted to shape the law[12]? First, judges may choose to preferentially cite certain doctrines over others. Doing so can both allow them to justify a specific case outcome, which they prefer, and to reinvigorate a particular policy-bearing doctrine, by signalling its current relevance (Hansford and Spriggs, 2006). Second, judges may also propose new principles. A new principle may explicitly seek to break with an old doctrine by overruling it. Or, more subtly, it may simply propose an alternative interpretation without explicitly overruling past approaches (a prominent example is *Chevron*). This may occur, too, if citizens bring new issues to the courts that invite new rulings.

With this understanding of precedent, I propose three indicators of legal change from the network of citation to precedent: 1) *novelty* 2) *controversy* and 3) *preferential reinforcement*. *Novelty* refers to the appearance of opinions that articulate new principles. They are revealed by their importance in the network since they seed a new line of precedent and become highly cited over time. *Controversy* involves actively undermining a past principle by citing it negatively, stating that its scope should be reduced or that it is no longer valid. The more influential the opinion being undermined, the more significant the change and the controversy. *Preferential reinforcement* refers to the propensity to cite particular doctrines (i.e. precedents), thus reinforcing the authority of one strand of the law over another.

Reformulating the claims of the political model in terms of the measures of legal change above, I put forth the following hypotheses:

- H 1 *Novelty* and *controversy* increase as the swing interval increases.

- H 2 There are differential patterns of *preferential reinforcement* across periods that have different levels of political support for environmental policy.

Hypothesis 1 relate the appearance of novel and important decisions, and the appearance of decisions

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[11]It is the role of clerks working at WestLaw and LexisNexis to determine whether an interpretation was positive or negative. This information is then encoded in the court documents downloaded from these databases.

[12]The fact that every opinion is given a justification in terms of existing legal principles does not imply per se that opinions are fully determined by past case law, even controlling for the idiosyncratic features of the case. The law is often both indeterminate and complex enough to allow for contradictory justifications, so that a judge often has some freedom in making the final determination and writing a justification (Posner, 2009).

that explicitly overturn older ones, to the swing interval. As we saw earlier, the larger the swing interval the larger the window of opportunity to change aspects of the law, under the theory of the separation-of-powers. Hypothesis 2 proposes that decisions made in periods of strong congressional support for environmental policy should preferentially cite doctrines that also arose in periods of strong congressional support. Vice versa, decisions made in periods of congressional opposition to environmental policy should preferentially cite doctrines that also arose in periods of congressional opposition.

I shall now formalize the notions of novelty, controversy and preferential reinforcement. Recall that the measure of novelty and controversy rely on the importance of a headnote in the subsequent sequence of decisions. A simple measure of the importance of a node in a network is simply the number of its citations. However, since citations do not occur instantaneously (see figure 4), we must adjust for the time of observation, necessarily longer for older decisions than for new ones. A simple model for the number of citations to a decision over T years (2014, the year of observation, minus the year the decision appeared) combines a measure of importance λ_i with the function previously defined for $P(\Delta t | \mu, \sigma)$:

$$c_i^T = \lambda_i \Phi((ln(T) - \mu)/\sigma) \tag{1}$$

where Φ is the cumulative normal and μ and σ are the immediacy and longevity parameters. It is thus straightforward to obtain λ_i given the total number of citations c_i^T and the observation period T.

Note that the proposed measure of importance only takes into account direct or local influence (only counting the in-degree). Measures that fully exploit the network structure of the data take into account the indirect influence of a node: a node that is cited by other nodes that are themselves highly cited is deemed important by virtue of the citations that exist downstream. Network analysts have defined a number of measures to assess the global importance of a node in the network, given the full structure of the network (e.g. for citation networks, Kleinberg et al.'s (1999) authority measure). However, these measures are difficult to apply to dynamic networks because they lack comparability over time, as the network grows in size.

Given the importance λ_i of a decision, I define

$$\mathcal{N}_{j,t} = \sum_{i \in t \ \& \ \in j} \lambda_i$$

where t is a political period and j denotes the legal topic (out of the eight identified earlier). Novelty in period t and for topic j is the sum of the importance scores for all nodes in topic j that appeared during

period t.

The measure of controversy focuses on nodes that are negatively cited during a political period. It counts the appearance of negative citations, weighted by the importance of the decision being undermined by this negative citation. Define controversy in period t and topic j as $\mathcal{C}_{t,j}$:

$$\mathcal{C}_{t,j} = \sum_{i \in L_{j,t}^{-}} \lambda_i$$

The measure of controversy is the sum of the importance of the nodes in $L_{j,t}^{-}$, where $L_{j,t}^{-}$ represents the set of nodes in topic j that are negatively cited in period t.

Figure 5 shows the variation in novelty and in controversy from congresses 92 to 113 for each of the eight areas of the law. First, we see that novelty and controversy capture different dynamics of the law: novelty seems to vary in a stationary manner throughout the life of the environmental statutes, whereas controversy increases over time, presumably reflecting the need to modify laws over time to fit changing circumstances. Finally, there is variation in these measures for all topics except for historical preservation, which will be dropped in subsequent analyses.

To formalize the idea of preferential reinforcement, we will compare patterns of citations during political periods marked by support for environmental policy amongst congressmen and political periods that do not have strong support for environmental policy. Define $E(t) = 1$ if median support for environmental policy is positive in period t and $E(t) = 0$ otherwise. Let t_i indicate the period in which headnote (or node) i was published. Consider the following ratio:

$$R_{\Delta t} = \frac{P(\text{``}i \text{ cites } j \text{ published at date } t_i - \Delta t \text{''} | E(t_i) = E(t_j))}{P(\text{``}i \text{ cites } j \text{ published at date } t_i - \Delta t\text{''})} \tag{2}$$

The ratio represents the fraction by which the probability of a node i citing a node j that is Δt years older is increased if j was published in a political period marked by a similar ideology (characterized by $E(t_j)$) as the political period in which i was published, relative to the baseline probability that a node i cites a node that is Δt years older. Expressed this way, the comparison controls for the time elapsed between the two decisions.

4 Results

I start by examining the proposition that novelty and controversy should increase with the overall level of change in the constraints set by key political players – captured by the measure of swing. To compute
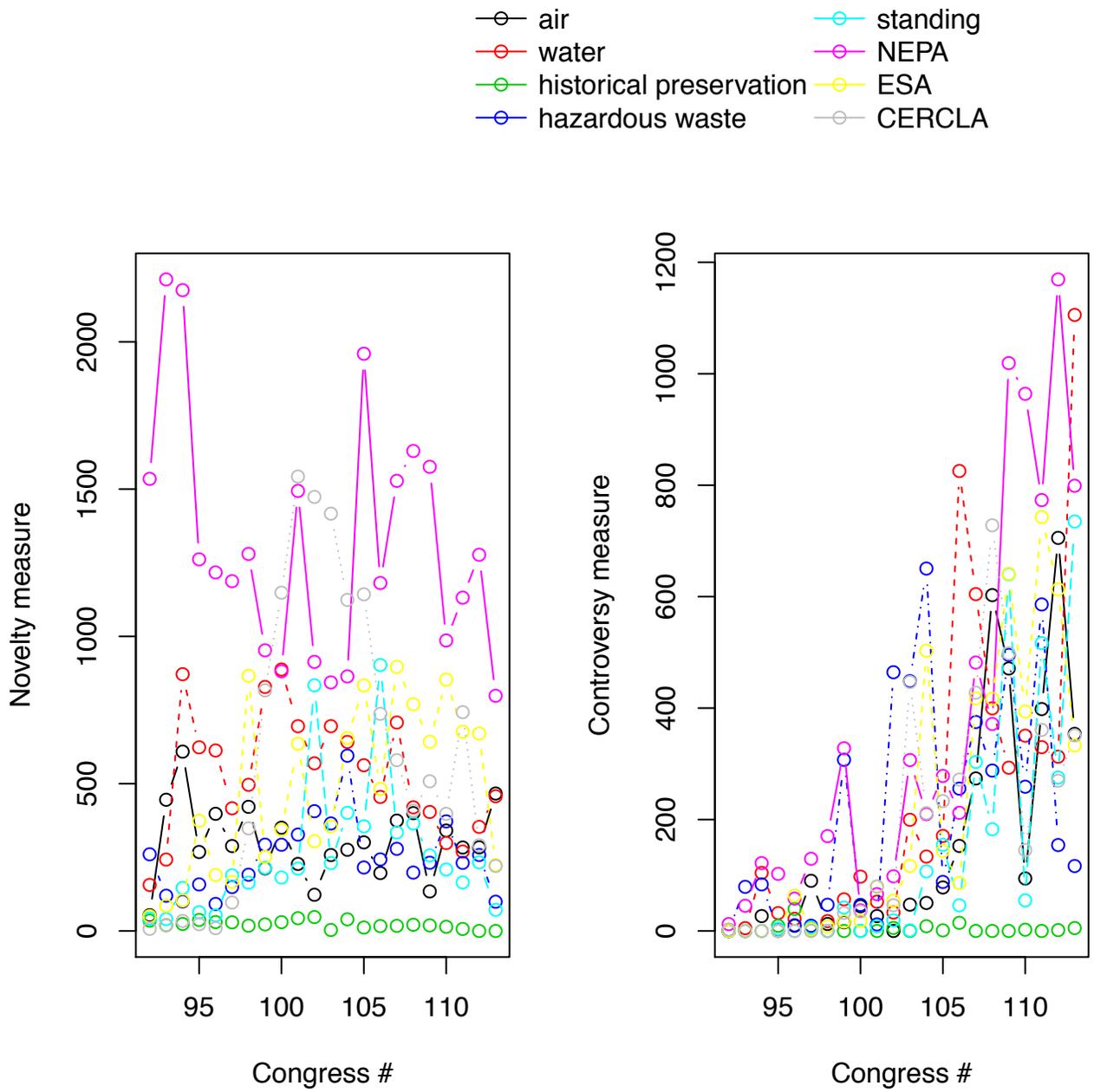
Figure 5: Novelty and controversy from the 92nd to the 113th Congress, broken down by major topics of environmental law.

the swing interval, I first characterize the environmental policy preferences of Congressional members in each year using roll-call votes on environmental issues from 1972 to 2014, available from the League of Conservation Voters. The bayesian item-response model presented in Clinton, Jackman, and Rivers (2004) is then used to infer ideal points from these votes[13]. These ideal points are finally adjusted to be comparable over time and across the two chambers, using the model proposed by Groseclose, Levitt, and Snyder (1999).

Figure 6 shows the resulting gridlock interval for each Congress, and the associated measures of swing. These are calculated using Krehbiel's theory of legislative decision-making, based on the filibuster and presidential veto pivots. This filibuster-veto (FV) gridlock interval is given by:

$$G^{FV} = [min(V_H^-, V_S^-), F^+] \; if \; P \le min(V_H^-, V_S^-)$$

$$G^{FV} = [F^-, max(V_H^+, V_S^+)] \; if \; max(V_H^+, V_S^+) \le P$$

$F^-(F^+)$ designates the filibuster pivot in the Senate, the most liberal (conservative) senator needed for a 3/5 cloture vote to end a conservative (liberal) filibuster. $V_H^-(V_H^+)$ is the ideal point of the presidential veto player in the House – the most liberal (conservative) member of the House needed to overturn a veto by a conservative (liberal) president. Since a 2/3 vote by both chambers is needed, we take the most extreme of the relevant presidential veto players across the two chambers. The measure of swing is then calculated as:

$$S_t = |G_t^- - G_{t-1}^-| + |G_t^+ - G_{t-1}^+|$$

where $G_t^-(G_t^+)$ designates the lower (upper) bound of the Gridlock interval at time t (here the gridlock interval is G^{FV} but the same expression applies if the gridlock is defined based on other players, according to alternative theories of legislative decision-making).

To test the hypotheses that novelty and controversy increase with swing measure, I run the following

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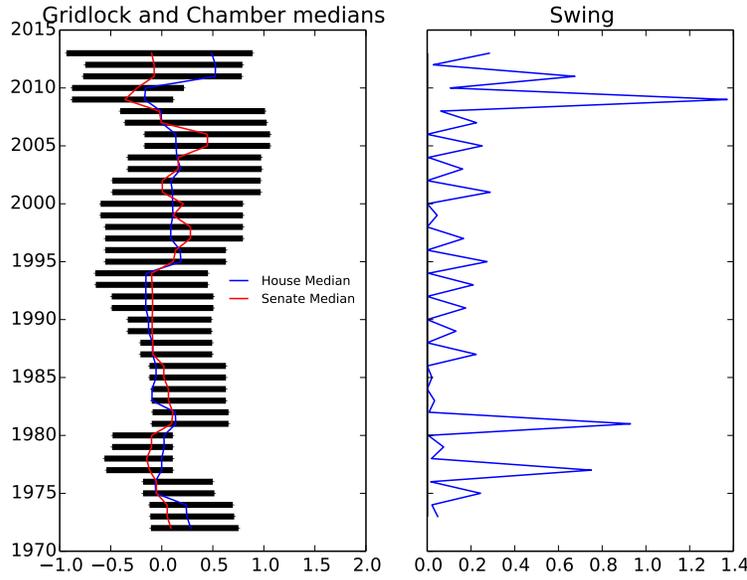[13]The R package pcsl implements the model.

Figure 6: Left: the FV gridlock interval and chamber medians for each Congress on a 1-D pro-environment to anti-environment regulation policy space. Right: the resulting swing measure.

time-series cross-sectional linear regressions on the panel of the six areas of the law:

$$\mathcal{N}_{j,t} \sim N(n_{j,t}|\mu^N_{j,t}, \Sigma^N)$$

$$\text{where } \mu^N_{j,t} = \gamma^N_j + \beta^N_1 S_t + \beta^N_2 G_t + \beta_3 \mathcal{N}_{t-1}$$

and

$$\mathcal{C}_{j,t} \sim N(c_{j,t}|\mu^C_{j,t}, \Sigma^C)$$

$$\text{where } \mu^C_{j,t} = \gamma^C_j + \beta^C_1 S_t + \beta^C_2 G_t + \beta_4 \mathcal{C}_{t-1} + \beta_5 t$$

γ_j a vector of fixed effects, for each sub-network j (representing a distinct area of environmental law).

This equation is estimated with Beck and Katz's (1995) panel-corrected standard errors, which allow the distribution of errors to differ for each time series and also allows for contemporary correlations in the errors of each time series. As seen in figure 5, the measure of controversy has a clear time trend while the measure of novelty does not, which is reflected in the equation. Durbin-Watson tests show that after including a lag in the equation, the series are no longer autocorrelated.

The results of the analysis are shown in figure 7. These graphs clearly demonstrate that the chosen measure of swing has no influence on the chosen measures of legal change. These graphs represent the

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Test of political influence on legal novelty

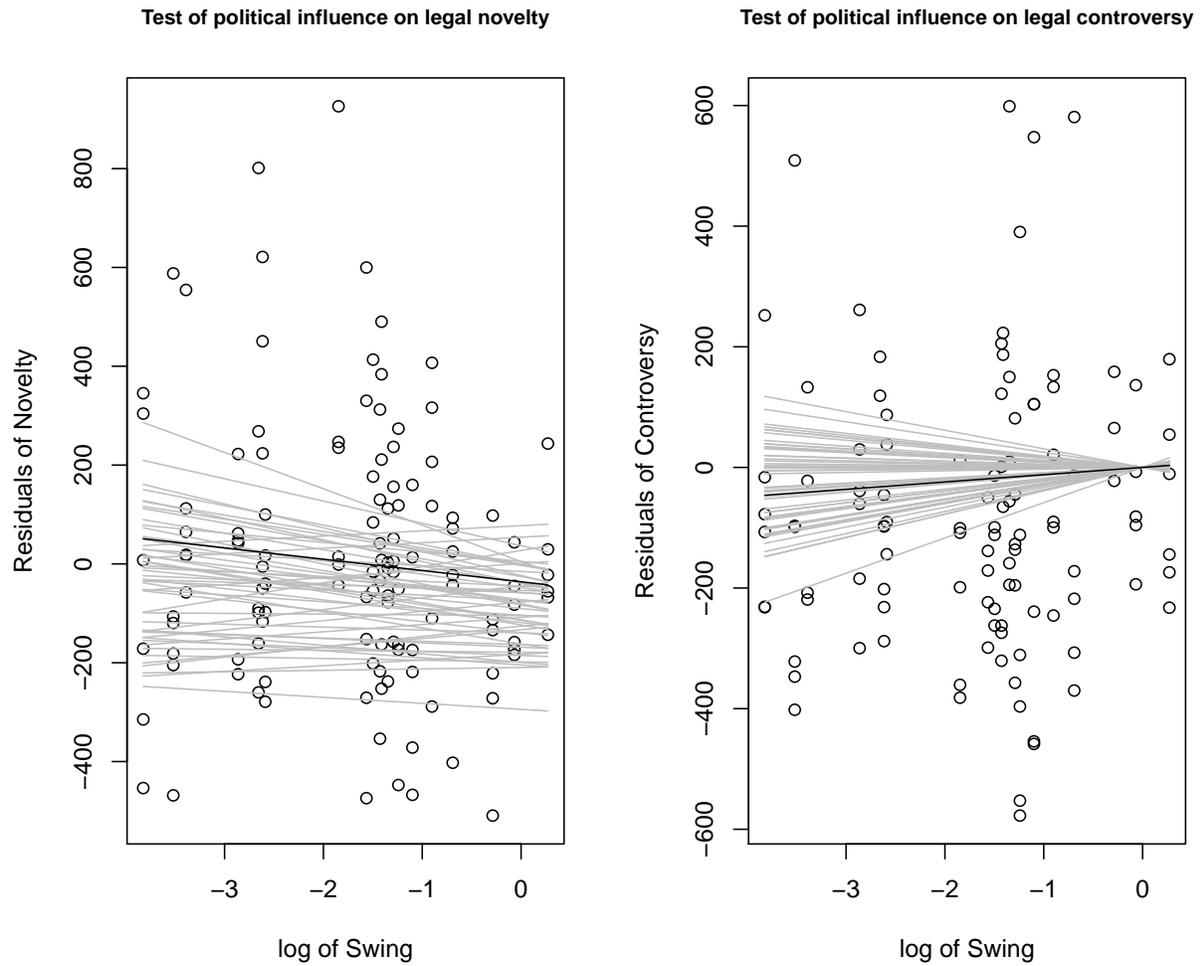**Test of political influence on legal controversy**

Figure 7: Measures of novelty and controversy as a function of the logarithm of the swing measure, after controlling for the fixed effect for each area of the law, and after removing the time structure (serial auto-correlation and trend in the case of the controversy measure). **Right:** novelty measure, **Left:** controversy measure.

detrended, deserialized and demeaned novelty and controversy values as a function of the measure of swing. These residuals show no trend, as shown by the fitted black line. The gray lines correspond to different realizations of the inferred distribution of $(\hat{\beta}_1)$, confirming that the distribution clearly includes $\beta_1 = 0$ as a likely value. The regression tables are available in the appendix. The appendix also explores different measures of swing based on different assumptions regarding which actor is pivotal. None of these are found to have an influence on legal change, as defined in this paper.

I now turn to the hypothesis of preferential reinforcement. To estimate the ratio $R_{\Delta t}$ defined by Equation 2, we need to estimate the probabilities $P(j \text{ cites } i)$, the probability that there exists a citation from j to i. Karrer and Newman (2009) developed a model for directed acyclic graphs that gives us an exact theoretical solution for this probability. To understand it, consider the notion of a stub: a stub is the tail or head of an edge, pointing either in or out of a node. $P(j \text{ cites } i)$ is equal to the probability that an outgoing stub of node j is connected to an incoming stub of node i, times the number of incoming stubs of i and outgoing stubs of j (i.e. the incoming and outgoing number of citations of i and j respectively). To test hypothesis 2, I reformulate the ratio R in terms of the stub probabilities only (the probability that two stubs are connected given that the stubs exist), controlling for each node's indegree (k_i^{in}) and outdegree (k_i^{out}). There are two reasons for this. First, to estimate the statistical significance of the ratio, I simulate a large number of null networks keeping constant the empirical sequence of degrees $(k_0^{in}, k_1^{in}, k_1^{out}, ..., k_N^{out})$. Second, the variation in the indegrees is captured by the novelty measure and modeled by the previous regressions. In this hypothesis, we are interested in the pattern of where the citations *go*, taking as a given the appearance of nodes and their respective indegree over time. Finally, the estimate of the stub probabilities is less noisy than the estimate of $P(j \text{ cites } i)$. I follow (Karrer and Newman, 2009) to estimate the stub probabilities, as explained in the appendix.

The results of this analysis are presented in figures 8 and 9. Figure 8 shows the distribution of $< \hat{R} >$, average taken over the different values of Δ, for the ensemble of 1000 null networks and the value for the observed legal network. Recall that the null hypothesis says that the choice of legal decision to cite is not influenced by the presence or absence of a congressional majority that is in support of environmental regulation. Theoretically, under this null, the ratio R should be close to 1. On the contrary, if the hypothesis of a political influence is true, the observed ratio R is predicted to be higher than that of the null networks in which the citation patterns are randomized. The specific sequence of nodes, which we take as fixed for the purpose of evaluating this hypothesis, in fact induces a distribution of the statistic in the ensemble of null networks that is centered a little above 1, at 1.067, with a standard
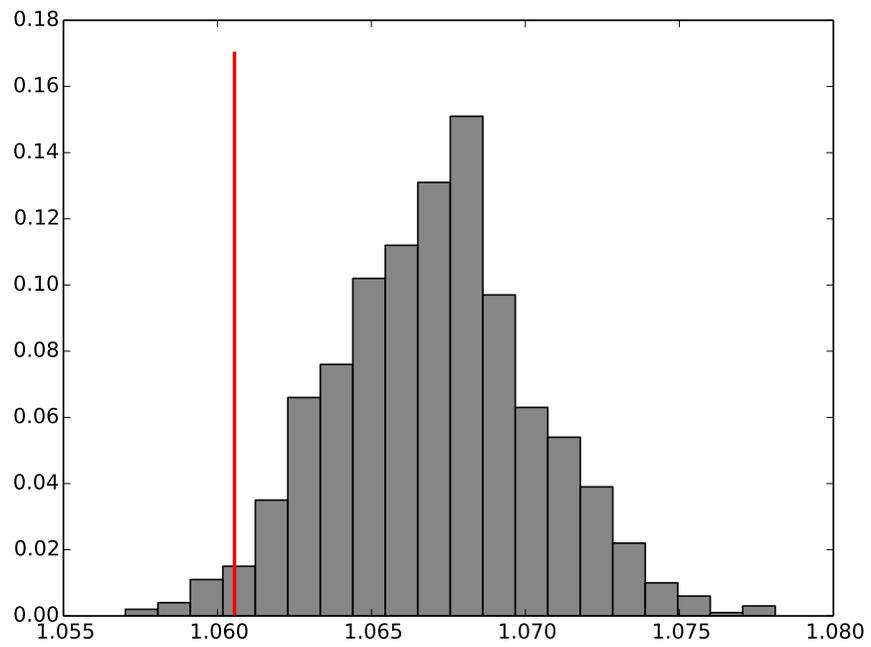
Figure 8: The distribution of the ratio statistic $\hat{R}$ over the 1000 simulated null networks and the value of $\hat{R}$ in the observed network.
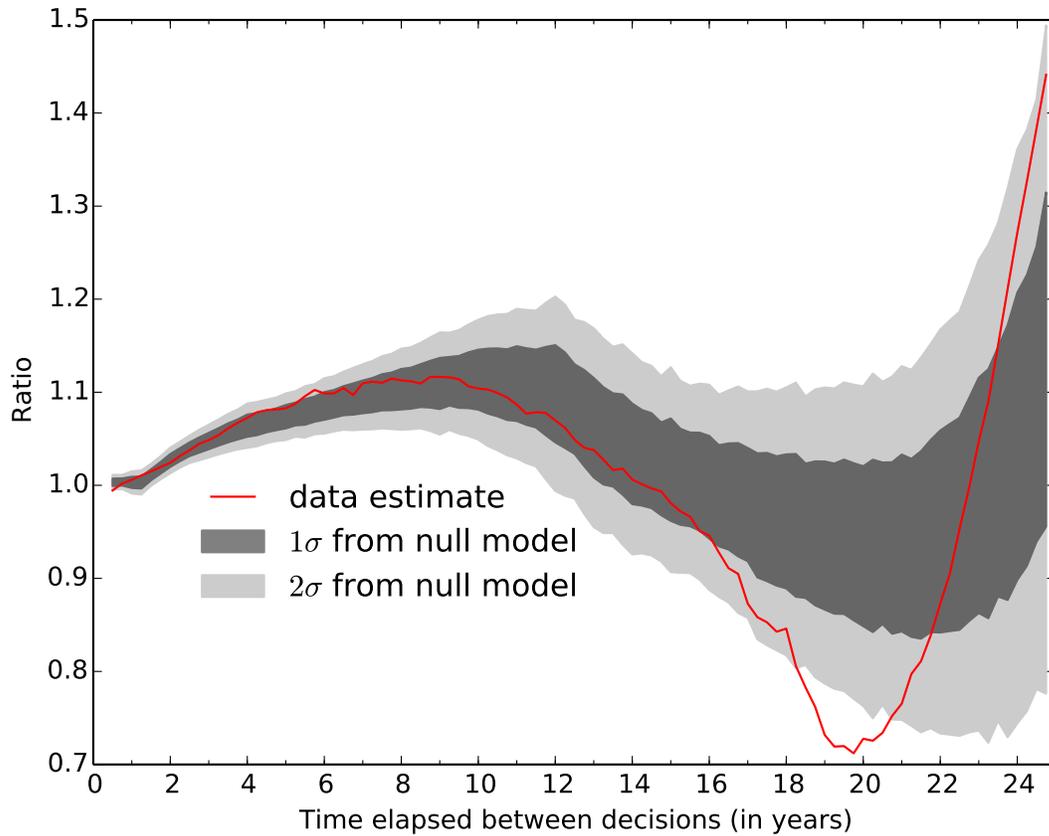
Figure 9: Comparison of $\hat{R}_\Delta$ in the observed network and $\hat{R}_\Delta$ in the ensemble of null networks in which any politically driven pattern of citation is removed. The observed statistic is compatible with the null that legal citations between political periods enjoying a congressional majority of supporters of environmental regulation are no more likely than between political periods in which the congressional majority opposes environmental regulation.

deviation of 0.003. The statistic in the observed network is 1.06, which is in fact *lower* than in the ensemble of null networks, clearly contradicting the hypothesis that we are testing.

Figure 9 shows that $\hat{R}$ in the observed network falls within one standard deviation of the null distribution for most of the range of the Δ considered, with larger deviations for larger values of Δ. At large values of Δ, the estimates are driven by a much smaller set of observations, which explains why the values are more erratic and may explain the more extreme deviations from the null in that range.

5 Discussion

If courts felt constrained by Congress in the interpretation of environmental statutes, then changes in the preferences of pivotal legislators would both create new political constraints and open new windows of opportunity and should therefore trigger changes in the policy decisions of courts. This paper proposed different ways of detecting changes in the decisions of courts. These measures of change build on the idea that the influence of a decision is both shaped by citations made to it and reflected by citations. They use temporal variation in the appearance of influential decisions, in the appearance of negative citations and temporal variation in the probability of citing decisions made under different political circumstances. It was found that changes in legislators' preferences – at least those legislators posited to be pivotal according to specific theories of legislative decision-making – did not have a discernible influence on these measures of legal change.

Before discussing the meaning of these results, it is important to consider their robustness. There are several ways in which the measures should be tested and refined. First, the measure of importance λ_i is possibly too simple. Different decisions may have different life cycles, with the immediacy parameter μ and the longevity parameter σ varying from one decision to the next (plots of citation histories show that while all decisions follow a peak-and-decay pattern, the peak time and decay rates vary greatly). Wang, Song, and Barabási (2013) propose a mechanistic model for the citation dynamics of scientific papers that allows each paper to have its down logarithm decay function, with idiosyncratic parameters μ_i and σ_i. The authors consider the probability of a citation over time to be a function of this decay function, the intrinsic attractiveness (or importance) of the paper λ_i, and its current number of citations. The latter factor reflects the fact that papers (or decisions, or people) tend to receive attention in proportion to the attention they have already received. In modeling this rich-get-richer mechanism explicitly (technically called preferential attachment), their measure of intrinsic importance λ_i captures the initial importance of the paper, before its influence becomes inflated by popularity dynamics. The resulting measure is likely a more robust measure, better reflecting the importance of a decision as it may have appeared to the

actors at the time the decision was made. Preliminary steps to adapt this model to the data presented in this paper show that preferential attachment is less marked for laws than for scientific papers or internet pages, but that the model fit with preferential attachment is better than without. The model by Wang, Song, and Barabási (2013) is therefore a better model of the citation histories of decisions. Estimating μ_i, σ_i and λ_i for each decision requires a bayesian model (Shen et al., 2014), which should be implemented in a refined version of this analysis.

More importantly, the novelty and controversy measures capture only the magnitude of change, not the *direction* of change. To measure the direction of a decision in policy space, it is necessary to use the texts of the decisions. Grimmer and Stewart (2013) review the different natural language processing methods and machine learning algorithms that are used to extract sustantive variables from large amounts of textual data. In the case at hand, the goal is to build a classifier that can sort decisions depending on whether they expand, maintain or narrow the scope of environmental protection. O'Halloran et al. (2015) are amongst the first to apply these techniques to the automatic classification of laws. Using a Naive Bayes Classifier with a feature selection algorithm on a new dataset of all federal laws and agency rules enacted from 1950 to 2010 that regulate the financial sector, they obtain a 67% accuracy in their task of predicting the level of discretion granted by the law. Their experiment thus demonstrates the applicability of these techniques to monitor changes in the policy substance of laws over time in large corporea of texts. A training set of 100 coded decisions from the data in this paper has been developed and the important next step is therefore to use this training step to develop directional measures of policy change.

Notwithstanding the shortcomings of the current measures, addressed above, the results presented in this paper suggest that adaptation of environmental legislation over time and across localities via the legal process is largely autonomous from changes in the constellation of congressmen's preferences. One could object that the stakes in all but a small fraction of these decisions are too low to warrant the attention of legislators. This of course is a valid explanation for the null results presented. However, within the rational choice theory of how courts implement and interpret statutes, the model of courts constrained by pivotal legislators is the dominant paradigm. It should be tested according to its capacity to explain shifts in policy happening in courts rather than votes in the Supreme Court, even if these shifts are happening via many incremental decisions throughout a decentralized system.

How might courts gain such autonomy? One possibility is that they are an important forum for social learning (Heclo, 2010) – where the implications of legislation and regulations in specific circumstances are debated and weighed in terms of the goals of the legislation and of the different interests. As such,

briefs, hearings and opinions generate information and ideas that are useful to actors involved, including political actors (which might, for example, use this information to better monitor the implementation of laws, as suggested by McCubbins, Noll, and Weingast, 1987). In a study of changes in macroeconomic policy, Hall (1993) shows through a qualitative analysis that the process of "puzzling" over policy, generating new ideas, is as much a driver of policy change as the political pressures exerted by one organ of government upon another, or by constituencies upon the state. Another possibility is that environmental legislation itself – rather than the organizations implementing it – has gained autonomy from the daily struggles of congressional politics. Eskridge and Ferejohn (2010) elaborate a theory of "super-statutes" to understand the evolution of some pieces of legislation. Super-statutes, they contend, are laws that penetrate public normative and institutional culture in a deep way, amending the constitutional order[14]. They arise when broad parts of society wish to commit to a great principle. Such statutes generate intense disagreement and continuous deliberation. This deliberation in turn resolves differences in a pluralistic way and eventually creates a strong public commitment to the statute. This commitment gives the statute the same power to shape policies and the behavior of decision-makers as does the constitution, elevating it above short-term politics. Among the examples they give of super-statutes figure the Sherman Act of 1890, the Civil Rights Act of 1964, and the environmental statutes of the 1970s.

Eskridge and Ferejohn's (2010) theory echoes a larger set of theories that argue that the articulation of legal rules helps citizens forge a common understanding of norms of social control (Hadfield and Weingast, 2012), and in doing so can build long-lived and supple governance structures (Stone Sweet, 1999) that enjoy great levels of legitimacy (Gibson, Caldeira, and Baird, 1998; Tyler, 2001) – as long as these legal rules reflect society's pluralism (Eskridge, 2005; Sunstein, 1996). The mechanisms invoked by these theories involve the courts, where actors interpret the statute in a purposive rather than a simple text-bounded way. This generates a dynamic common law, implementing the great principle and adapting it to meet the challenges posed to that principle by a complex society. Intense disagreement generates back and forths between the agencies, courts and elected branches. But it is of a different nature than the back and forth described in rational choice theory, where the ideal points of actors are fixed and where actors strategically push policy closer to their ideal point in anticipation of others' reaction. If the role of public institutions, instead, is to deliberatively contribute to the formation of new societal norms by shaping preferences, then institutional actors must clearly voice their reasoning and preferences, instead of strategically concealing them.

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[14]Constitutional in the sense that "a government is constitutional when its ordinary laws and regulations are regulated by higher order norms and not merely by the will of government officials."

What is the implication of these mechanisms for courts' autonomy and the dynamics of legal change? Eskridge and Ferejohn's (2010) theory suggests that courts and agencies gain autonomy from elected officials by being responsive to a wide range of constituencies[15]. In doing so, they can forge compromises and ensure that new important laws are interpreted in ways that are compatible with other fundamental commitments of society. The autonomous behavior of courts allows for the deliberation, which in turn gradually entrenches the law, further buttressing autonomy, as well as the institution's legitimacy. Through such a process, law comes to supersede short-term partisan struggle and shape current policy debates, rather than being subject to them. The evolution of public laws, then, should not mechanically follow changes in the preferences of elected officials, but follow an autonomous course.

To ground this argument in a concrete example, consider the evolution of the Clean Water Act's interpretation. The Clean Water Act proposed a broad mandate to protect the waters of the United States. Ensued a thirty-year long debate regarding which waters the federal government could have constitutional authority over without violating States' powers. More specifically, which waters would satisfy the Commerce Clause of the Constitution, the clause that justifies the federal government's regulation of intrastate activities? In particular, could isolated bodies of waters, such as wetlands, be included, although they did not explicitly fall under the category of "navigable waters", which are the waters that unambiguously satisfy the Commerce Clause? In 1977, the Army Corps of Engineers and the EPA, with the acquiescence of the courts, expanded the meaning of the term to include wetlands that "are in reasonable proximity to other waters of the United States, as these wetlands are part of this aquatic system."[16]. The meaning of the term was gradually expanded to include more and more bodies of water and private properties impacting them[17]. Eventually, this regulatory movement generated a backlash from the property rights movement. Court battles ensued, forging a compromise between the government's duty to protect private property and the realization that most properties impact the water system due to its interconnectedness. Although a compromise, Eskridge and Ferejohn (2010) note that the extent of waters protected by the Act had by then far exceeded what was initially envisioned by legislators in 1970. Over the course of this public deliberation, the authors contend, the norm that property includes civic obligations and that the government has a duty to protect environmental systems had become part of the society's fundamental commitments. This commitment is of course to be continuously articulated in light of what is feasible in different contexts, a task performed by the public, agencies and the courts

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[15]Hamilton quote

[16](1977 regulation of the Corps, cited on page 267 of the book)

[17]In 1986 the term was expanded to mean waters "which are or would be used as habitat by migratory birds"(Migratory bird rule, page 268 of the book) and, in 2000, to include "ephemeral streams and drainage ditches" as long as they have a perceptible "high water mark".

on an on-going basis.

Few studies investigate the trajectories of environmental legislation (see Baumgartner, 2006), even though in most industrialized countries, these laws have now been in existence long enough to warrant such an investigation. The fact that one legislature cannot bind future legislatures might suggest that environmental policy might suffer from "electoral cycles", just as budgetary and macroeconomic policy seem to. This time inconsistency, always a lurking possibility for democratic political institutions is often blamed for the failure to tackle long-term problems that affect diffuse interests, such as environmental degradation (e.g. Hovi, Sprinz, and Underdal, 2009). This study is a first step towards characterizing the trajectory of environmental statutes in the United States. It suggests that these statutes give rise to a dynamic body of law, but that the time inconsistency that might arise due to shifts in the preferences of legislators over time is not an important factor explaining these dynamics.

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