The Autonomy of Law from Politics: Evidence from a Network Analysis of US Environmental Law

Abstract

Laws – be they common law, statutes or the constitution – evolve continuously. People make use of them; discovering ambiguities or disagreeing on their proper application, they ask courts throughout the nation to re-interpret them. What are the political drivers of this process? This paper reconstructs the network of citations to legal precedent for a period of forty years for all U.S. environmental court cases, providing full information regarding which precedent is affirmed or undermined by written opinions. The paper introduces multiple statistics that capture dynamic features of this network and significant changes in the legal rules of environmental governance. Using these measures, the paper tests whether legal change is affected by changes in the preferences of pivotal legislators, as proposed by the positive political theory of the courts. Overall, the dynamic properties of this network reveal that laws evolve largely independently from shifts in legislative power.

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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, if any, come into play in this process?

Political economy theory has long been preoccupied with the question of the role played by judicial independence in economic governance and the conditions for the emergence of judicial independence (Rafael la Porta 2008). Both in economics and in positive political theory, strategic models of the interaction of legal and political players predict that the greater the distance between the policy ideals of rival political groups, the more likely it is that political actors will let the judiciary act autonomously (Hanssen 2004; Fox and Stephenson 2011). This paper therefore explores the question at hand by testing whether changes in the ideology of key legislators influences the degree to which case law evolves over time. The paper focuses on environmental case law, an area of the law that is politically contested and is not, at least in the United States, subject to constitutional constraints.

The focus on environmental case law is relevant given that judicial independence has been shown to secure long-term commitments when political actors have no such capacity (Klerman and Mahoney 2005). This capacity to commit is particularly important in the context of environmental governance due to the long-term and dynamic characteristics of environmental problems, often arising from stock externalities (Kolstad 1996). At the same time, few studies examine the trajectories of environmental legislation over time, even though the difficulty of maintaining a policy on the long-term is seen as a major obstacle to effective environmental governance (Rodrik 1996; Hovi, Sprinz, and Underdal 2009; Jacobs 2011). 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

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[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.

for special interests, local associations and local authorities, leading to an uninterrupted flow of decisions over more than four decades. 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 own preferences as possible, but within the "gridlock interval" – the policy interval delineated by pivotal legislative actors, which defines a policy area immune from reversals by legislators (Ferejohn and

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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 to be pivotal by Krehbiel (2010) 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 and legal 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.
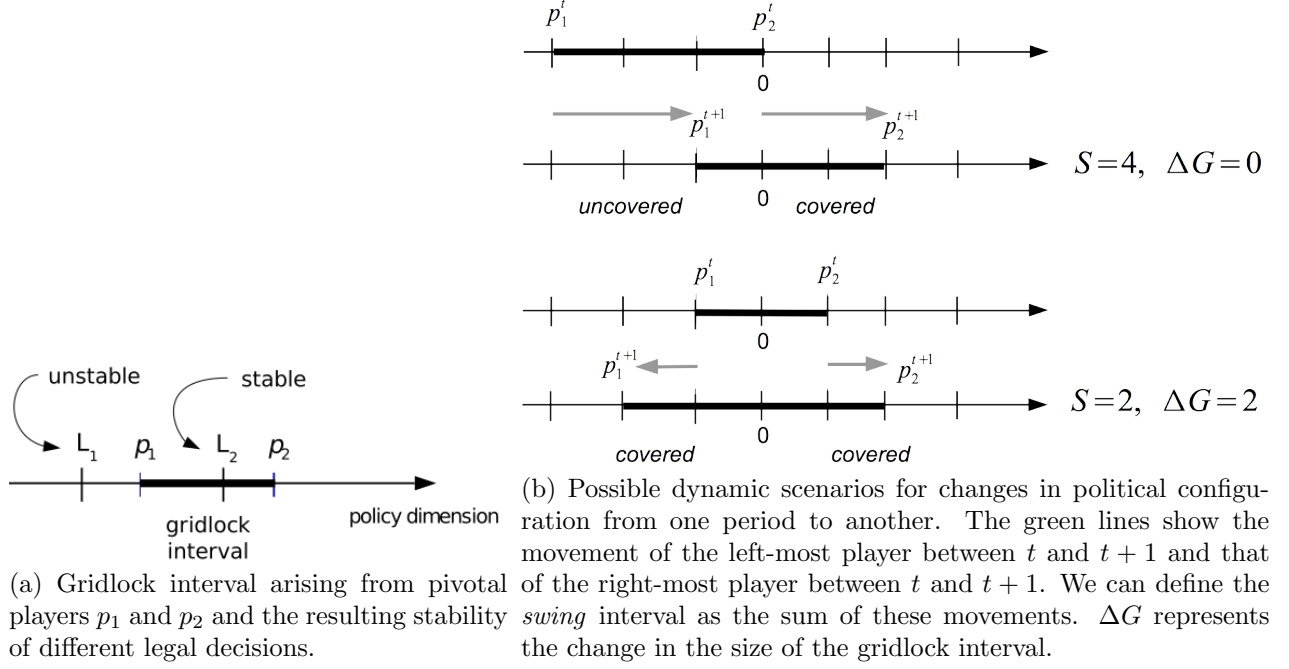
Methodologically, this paper presents a few innovations. First, it attempts to move from political behavior to policy substance, a move that has been called for by several scholars and seems warranted if we are to understand the output of institutions (Lapinski 2008). Second, in order to study changes in policy substance in a large-N framework, I propose measures of legal change from the network of citations to legal precedent. 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). In a pioneering study, Hansford and Spriggs (2006) first made use of network analysis to test theories of the political and legal drivers of legal dynamics, showing in particular the key role of precedent in shaping policy outcomes of the Supreme Court. Here, I consider the entire court system's interaction with pivotal players in the branches.

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 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 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 (Rodriguez and McCubbins 2006; Levy and Spiller 1994). 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

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

(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.

change the status quo policy within that interval but for policies outside of that interval, they are constrained by the preferences of pivotal players because they 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 Figure 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.

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 with 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 veto players in SOP models are typically the median voter of each house and the president. The logic easily extends to other sets of pivotal players suggested by theories of congressional politics. This paper uses Krehbiel's (2010) super-majority players[2], the key majority-party and committee players in Cox and McCubbins's (2007) theory of legislative decision-making, as well as changes in the median ideology of Congress, as a measure of the overall support for environmental protection in Congress[3].

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

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[2]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.

[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).

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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; Bartels and O'Geen 2015). 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 federal court cases between 1970 and 2014 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 SI.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. In the case of this corpus, the nodes 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 the citations between headnotes. These citations can be found in the argumentation section of the opinion in which prior decisions are cited. These citations are usually positive (affirming the validity of that decision), while 8 % of citations are

Figure 2: Dynamic properties of the legal citation network.
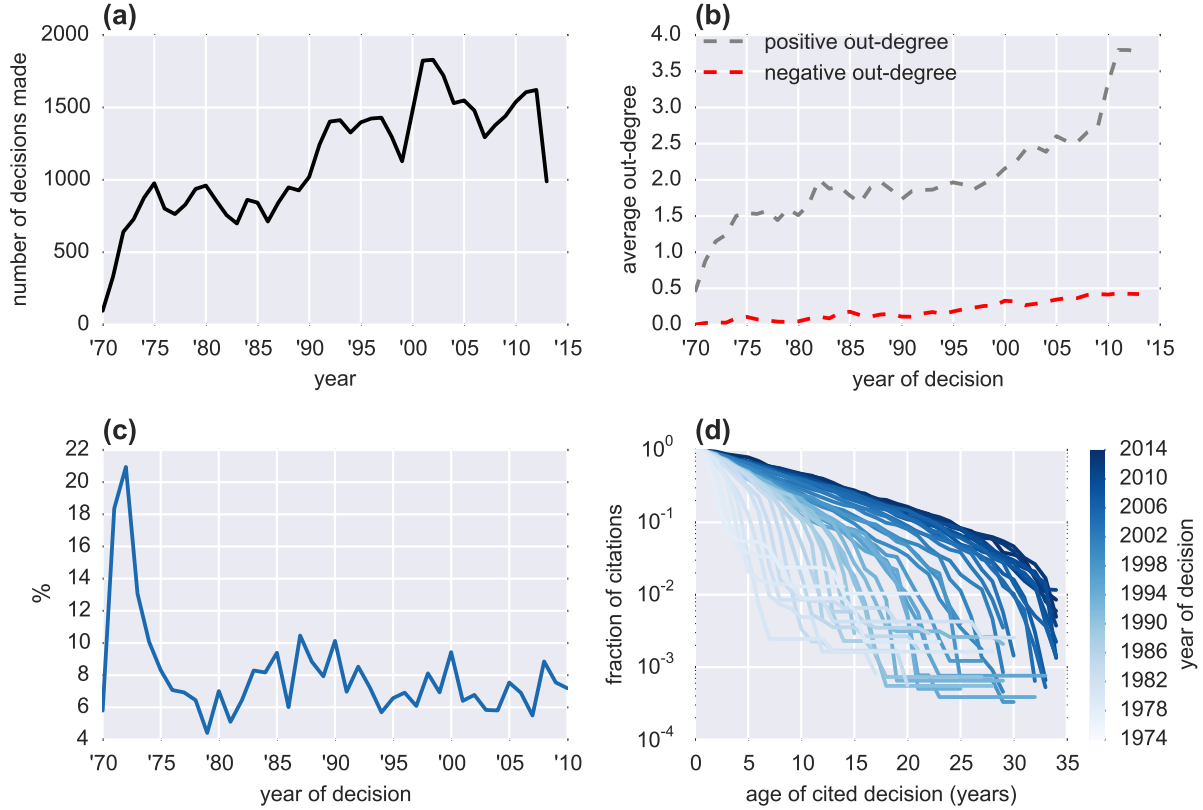
Descriptive statistics portraying dynamic properties of the legal citation network: (a) number of decisions each year, (b) average out-degree of new decisions over time, (c) the percentage of decisions made that accrue at least 5 citations within the 5 subsequent years, (d) the probability distribution of the age of decisions being cited in a given year.

negative (refuting or narrowing the scope of a prior decision)[4]. Since links can only go towards past cases, the network is what is technically called a signed directed acyclic graph – 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. Figure 2(a) shows that the number of decisions has increased over time with fluctuations and stands at about 1700 per year[5]. Figure 2(b) shows the average number of precedents that decisions in a given year cite (this is the out-degree). On average

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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 containing at least one environmental headnote.

each decision cites 2 past decisions and interestingly, this number started increasing in the last decade[6]. We also the rate of negative citations, which is low, but has been increasing over time, targetting decisions ranging from 1970 to 2005 at a rather even rate.

Figure 2 also shows that both positive and negative citations are made to the full history of decisions, not merely very recent ones or a set of early very foundational ones. Figure 2(d) depicts the distribution of the age of decisions cited and how this distribution shifts over time. The probability of citing a decision declines as a function of its age, but it declines less and less steeply as the corpus matures. Conversely, this means that the probability of citing an older decision has increased steadily over time, indicating that the body of law is cumulative. By now, 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. It is also informative to consider the proportion of decisions arising in a given year that are sufficiently important as to gather at least 5 citations within 5 years, as plotted in Figure 2(c). We see first that the first few years of environmental law were indeed special: for a period of a few years, more than 20% of decisions pass this threshold of importance. It then settles at a fairly stationary rate of 6-10%. This means that every year, new significant decisions are made. Together, these descriptive statistics indicate that corpus of law is dynamic, displaying the continued reliance on older decisions, as well as arrival of new influential decisions.

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].

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[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.

[7]Of course, the Supreme Court or the D.C court of appeals tend to be more highly cited. If we plot instead the distribution of citation counts to a court rather than the number of decisions emanating from each court, we still conclude 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

Figure 3: The distribution of decisions across federal courts.
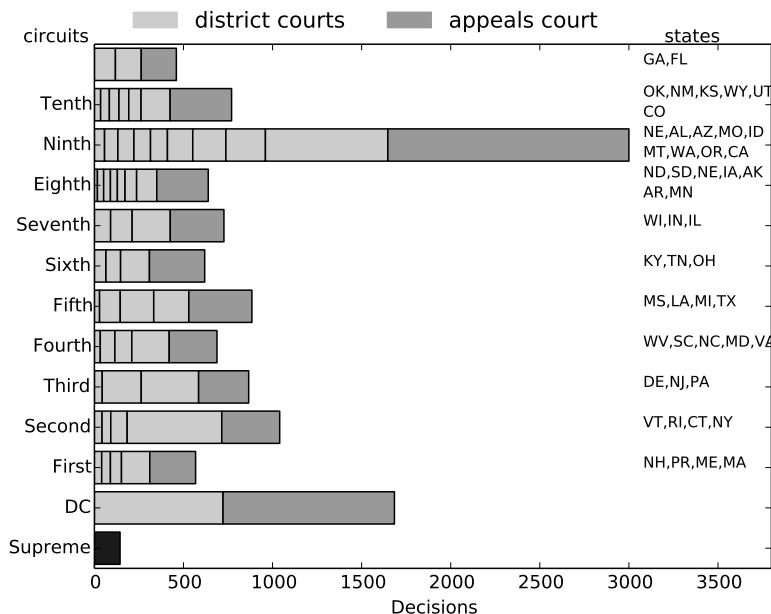
The network is 75% connected, which shows that decisions form a fairly interconnected system. However, not all issues are as closely connected as others: the network is to a strong degree organized in *communities*, i.e. groups of issues that are more likely to cite other issues in the group than issues outside the group[8]. These groups can be identified using community detection algorithms, which try to identify groups of nodes that have a higher probability of citing each other than nodes outside of the group[9]. Using one such algorithm (Newman 2006), the body of environmental law splits into eight thematic groups: 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], as illustrated in the Appendix (Figure SI.2).

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the appeals court of other circuits.

[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.

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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 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.

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 novel 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, or 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. Additionally, the choice of which past opinions to cite also affect the law. Positive citations increase the validity of the precedent (Hansford and Spriggs 2006: say that it increases the "vitality" of the opinion), whereas 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; Knight and Epstein 1996).

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

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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

certain doctrines over others. Doing so can both allow them to justify a specific case outcome, which they prefer, and to re-invigorate a particular policy-bearing doctrine, by signaling 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 become highly cited over time, which I take as evidence that they articulate new principles. *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 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, if the policy area is salient.

- 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 that explicitly overturn older ones, to the swing interval. As we saw earlier, the larger the swing interval the larger the window of opportunity for judges to change aspects of the law, under the theory of the separation-of-powers. This effect should only matter for policy areas that are salient to members of Congress. If an area is not particularly salient, we expect members of Congress to overlook changes in statutory interpretation by judges.

Hypothesis 2 proposes that decisions made in periods of strong congressional support for environmental policy should preferentially cite precedents that also arose in periods of strong

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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).

congressional support. Vice versa, decisions made in periods of congressional opposition to environmental policy should preferentially cite precedents that also arose in periods of congressional opposition.

I shall now explain how to measure novelty, controversy, policy salience, and preferential reinforcement. Recall that the measure of novelty and controversy rely on the importance of a decision in the subsequent sequence of decisions. As we saw in Figure 2(d), citations do not occur instantaneously. Hence, we need a model for how citations accrue as a function of the decision's importance and time. Following (Wang, Song, and Barabási 2013), consider that citations to decision i arise according to a Poisson process, with rate at time t equal to 1:

$$x_i(t) = \lambda_i c_i(t) f(t; \mu, \sigma) \tag{1}$$

$x_i(t)$ is the rate of citation to decision i at time t after its appearance. λ_i is the importance of the decision (which acts as a base rate for the arrival of citations). The rate is amplified by existing number of citations $c_i(t)$, which captures the rich-gets-richer process, whereby citations tend to accrue to decisions that are already highly cited. Finally, $f(t; \mu, \sigma)$ is a relaxation function. This function modifies the rate to capture the fact that a decision takes some time to mature and subsequently loses its relevance over time. To see the relevance and shape of this function, 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 probability function – a common function for decay processes such as this one. 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.

Given a Poisson process with rate function given by Equation 1, the number of citations to decision i after t years have elapsed is:

$$c_i(t) = m(e^{\lambda_i \Phi(\frac{ln(t)-\mu}{\sigma})} - 1) \tag{2}$$

where Φ is the cumulative standard normal and m is the average number of citations in the corpus, here equal to $m = 2$. The Appendix discusses the maximum likelihood estimation of λ_i given this model[13].

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[13]The proposed measure of importance only takes into account local connections. Measures that fully exploit the

Figure 4: Probability distribution of delay between decision and its citation.
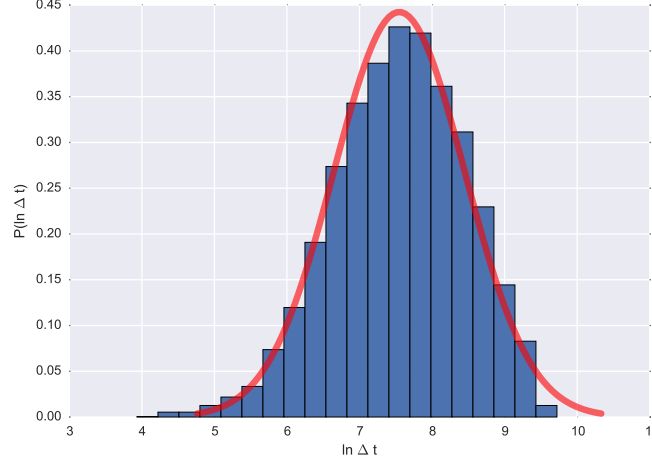
Time here is in days. The best fit curve gives $\mu = 7.42$ and $\sigma = 1.13$, indicating that immediacy is on average close to 5 years.

Given the importance λ_i of a decision, I then 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). Thus, 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 $\mathcal{C}_{j,T}$:

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

The measure of controversy is the sum of the importance of the nodes in $L_{j,T}^-$, where $L_{j,T}^-$

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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 (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.

represents the set of nodes in topic j that are negatively cited in period T.

To build the measure of policy salience to members of Congress of an environmental issue area, I first counted the number of times the statute(s) relevant to the policy area was mentioned in the *Congressional Record* in a given month. I then computed the z-score for each monthly count for each policy area. To get a measure of the policy area's salience for a policy area in a given Congress, I then average the z-scores for all months in that Congress. The resulting variation in policy salience for each policy area, denoted $sa_{j,T}$ for each topic j and congressional period T, is shown in panel c) of Figure 5. We see in particular that there is a spike in the salience of all environmental topics during the 104th Congress (1995-1996), which is the first Congress in which both chambers obtained a Republican majority since the 1950s and a time when environmental laws came under intense scrutiny.

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 increasing need to modify laws over time to fit changing circumstances. Finally, there is variation in these measures for all topics except for the topic of historical preservation, which will be dropped in subsequent analyses.

To formalize the idea of preferential reinforcement, we will consider the probability of a decision today citing a decision Δ_t years in the past, and estimate whether the similarity between the political environment today and Δ_t years ago is associated with different probabilities of citation. For example, do judges making a decision during a Republican majority Congress preferentially draw on precedent that was decided during another Republican majority Congress? Denote $E(t)$ the political environment in year t. I consider several aspects of the political environment to define similarity: the majority party in Congress, the majority attitude towards environmental policy in Congress ($E(t) = 1$ if the median preference in Congress is pro-environmental in year t and $E(t) = 0$ otherwise), the party of the executive, and, finally, the overlap in the FV-gridlock interval between the two periods. Hence we seek to estimate

$P(i$ cites j published at date $t_i - \Delta_t | E(t_i), E(t_j))$

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Figure 5: Variation in the measures of novelty, controversy and salience
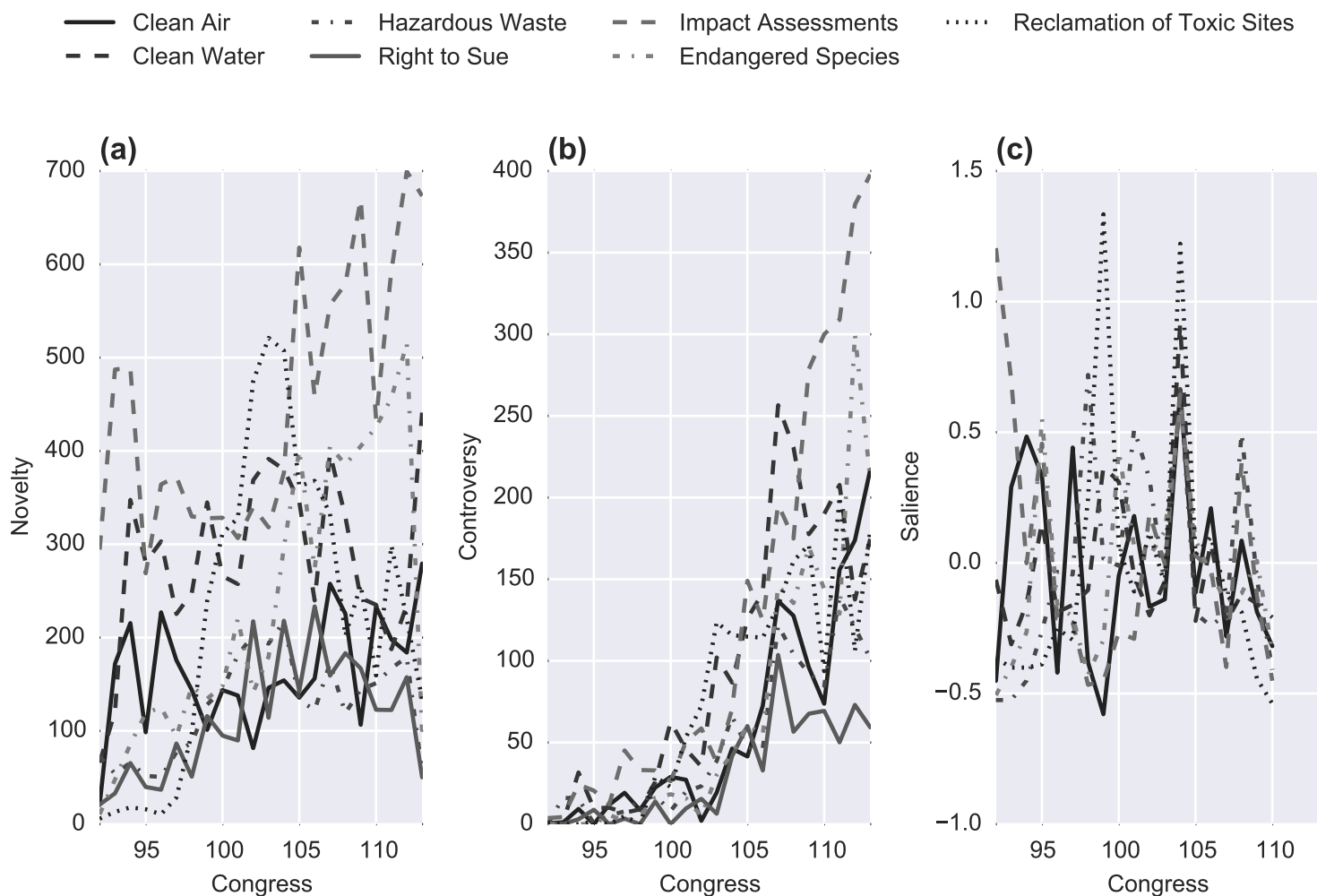
a) Novelty, b) Controversy, c) Salience, from the 92nd to the 113th Congress, broken down by major topics of environmental law.

where t_i is the year in which decision i appeared and $t_j = t_i - \Delta_t$ is the year in which decision j appeared. If these probabilities do not differ appreciably as a function of $E(t_i), E(t_j)$, we can reject the hypothesis that precedents are cited preferentially in response to the political environment.

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 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 by Clinton, Jackman, and Rivers (2004) is then used to infer ideal points from these votes[14]. 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. Here, the gridlock interval is 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:

$$S_T = |G_T^- - G_{T-1}^-| + |G_T^+ - G_{T-1}^+|$$

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[14]The R package pcsl implements the model.

Figure 6: The FV gridlock interval and chamber medians for each Congress on a one-dimensional pro-environment to anti-environment regulation policy space, and the resulting swing measure.
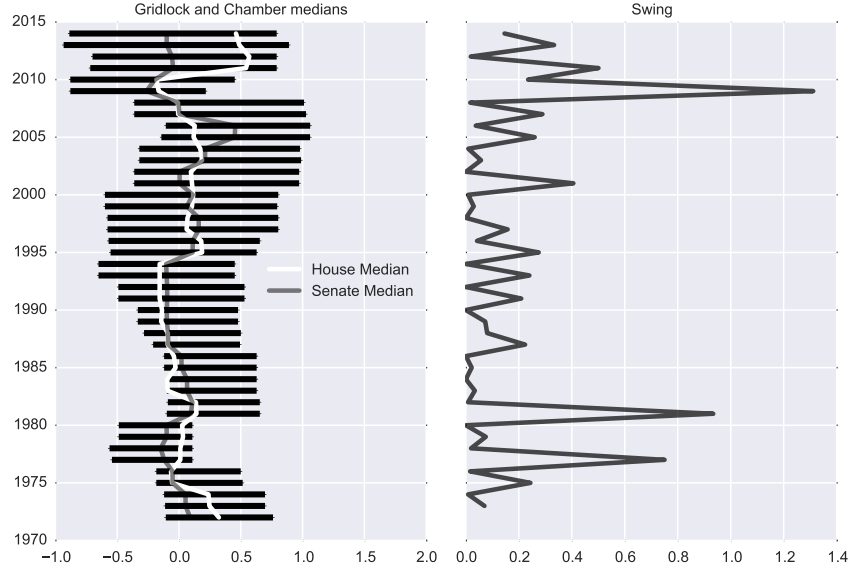
where $G_T^-(G_T^+)$ designates the lower (upper) bound of the Gridlock interval at period T. In Figure 6, the gridlock interval used to compute the swing measure is G^{FV}. But the same expression applies if we define the gridlock interval by other pivotal players. In the case of the committee gatekeeping model, following Spiller and Gely (1992), the measure of gridlock is defined as: $G^{CG} = [min(H_c, S_c, H_M, S_M), max(H_c, S_c, H_M, S_M)]$. where H_c and S_c are the median preferences of the relevant gatekeeping committees in the House and Senate and H_M and S_M are the median preferences of the House and Senate floors[15].

To test the hypotheses that novelty and controversy increase with the measure of swing, the following time-series cross-sectional linear regressions is estimated on the panel of the six areas

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[15]I use the House committee on natural resources, the House judiciary committee, the Senate committee on environment and public works and the Senate judiciary committee as key committees.

of the law:

$$\mathcal{N}_{j,T} \sim N(n_{j,T}|\mu_{j,T}^N, \Sigma^N) \tag{3}$$

$$\text{where } \mu_{j,T}^N = \gamma_j^N + \beta_1^N log(S_T) + \beta_2^N log(S_T) * sa_{j,T} + \beta_3^N G_T + \beta_4^N \mathcal{N}_{j,T-1} \tag{4}$$

and $\tag{5}$

$$\mathcal{C}_{j,T} \sim N(c_{j,T}|\mu_{j,T}^C, \Sigma^C) \tag{6}$$

$$\text{where } \mu_{j,T}^C = \gamma_j^C + \beta_1^C log(S_T) + \beta_2^C log(S_T) * sa_{j,T} + \beta_3^C G_T + \beta_4^C \mathcal{C}_{j,T-1} + \beta_5 T \tag{7}$$

where γ_j is a vector of fixed effects, for each sub-network j (representing a distinct area of environmental law). The swing measure is logged due to its skewed distribution. The unit of time T here is an individual Congress (2 year interval). A lag is included since past legal change could possibly affect both current legal change and the distribution of congressional preferences.

These equations are 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.

Table 2: Regression results

	Novelty - FV	Novelty - CG	Controversy - FV	Controversy - CG
log(Swing)	−0.01	−7.04	3.66	−2.37
	(7.47)	(4.66)	(3.42)	(1.88)
Gridlock	55.10	56.50	32.89	36.29
	(34.70)	(22.56)	(28.42)	(10.36)
log(Swing):Salience	−23.76	−20.73	−0.42	0.56
	(8.93)	(9.22)	(2.87)	(2.76)
Lag	60.33	63.90	0.70	0.77
	(8.87)	(7.45)	(0.10)	(0.09)
Congress			1.90	1.40
			(1.80)	(1.17)
N	108	108	108	108
R^2	0.94	0.94	0.92	0.93
adj. R^2	0.93	0.94	0.91	0.92
Resid. sd	72.77	71.73	27.17	25.55

Robust standard errors in parentheses

The results of the analysis are shown in Table 2. First, they indicate that the hypotheses are rejected: the interaction term between salience and swing is negatively associated with novelty and is unrelated to controversy. This holds whether we look at the filibuster-presidential veto set of players or the committee gatekeeping set of veto players. The only coefficient whose sign and statistical significance is consistent with the SOP theory of statutory interpretation[16] is that representing the effect of G^{CG} on controversy: periods with more gridlock (as defined by gatekeeping committees and floor medians) see a greater rate of rebuttal of past opinions, modifying the statutory interpretation of courts. Yet, this effect is not robust to variation in the way the gridlock interval is defined.

The largest and most robust pattern revealed by Table 2 is that illustrated in Figure 7, which plots the expected level of novelty as the logged measure of Swing goes from its minimum to maximum value, for topics having high salience and those having low salience. We see that legal novelty is highest when a topic is salient to members of Congress, but congressional preferences are stable. Hence, instead of larger change in the distribution of preferences in Congress triggering or at least being associated with significantly new statutory interpretation by the courts in salient policy areas, we see that courts are more likely to hold their ground in such periods of political change. I come back to the interpretation of this pattern in the Discussion. Suffice to say here that it is not consistent with the SOP theory of statutory interpretation.

I now turn to the hypothesis of preferential reinforcement. To estimate Equation 3.2, we need to estimate the probabilities $P(j$ cites $i)$, the probability of a citation from j to i. Karrer and Newman (2009) developed a model for directed acyclic graphs that gives us an exact analytical 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. Now consider the quantity f_{ij}, which is m times the probability that a single in-stub at node j is connected to a single out-stub at vertex i[17]. With these quantities in hand, we have

$$P(j \text{ cites } i) = \frac{f_{ij} k_i^{out} k_j^{in}}{m}$$

where k_i^{out} is the out-degree of i (equivalently, number of outgoing stubs) and $k_j in$ is the in-

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[16]I say that it is consistent although I have argued that Swing should be more significant than Gridlock if congressional preferences were acting as a constraint on the courts over time.

[17]The probability itself has more meaning but it vanishes in the limit of a large network but the inclusion of the factor of m yields a quantity that tends to a nonzero limit.

Figure 7: Expected novelty as a function of the logarithm of the swing measure, for high salience and for low salience, with 95% confidence intervals.
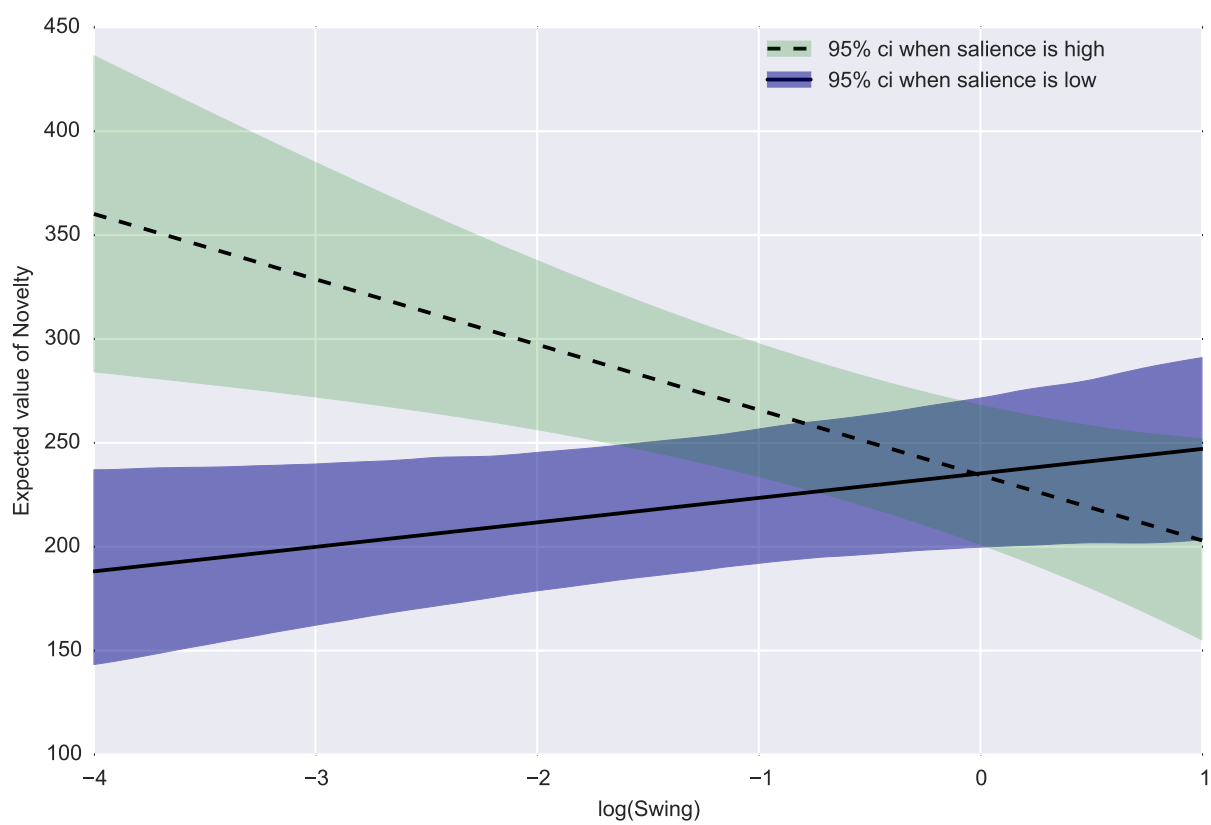
degree of j (equivalently, the number of incoming stubs).

Instead of estimating $P(j$ cites i published at date $t_i - \Delta_t)$, I will simply estimate $f_{ij}(\Delta_t)$ for node i and j separated by Δ_t years, for different values of $E(t_i)$ and $E(t_j)$, the political environments. There are two reasons for focusing on f_{ij} instead of the absolute probabilities of citation. First, the estimate of $P(j$ cites $i)$ are highly sensitive to k_i^{out} and k_j^{in} and are therefore very noisy, whereas f_{ij} are more stable (Karrer and Newman 2009). Second, doing this controls for each node's in-degree (k_i^{in}) and out-degree (k_i^{out}), which better formalizes the hypothesis. Indeed, the variation in the in-degrees is already captured by the novelty measure and modeled by the previous regressions. In this hypothesis, we are interested instead in the pattern of where the citations *go*, taking as a given the appearance of nodes and their respective out-degree and in-degree over time. To estimate the stub probabilities, I follow the technique described in (Karrer and Newman 2009), as explained in the Appendix.

Figure 8(a) shows the distribution of $f_{ij}(\Delta_t)$ for $\Delta_t \in (0, 20)$, for three political conditions: 1) decisions i and j are both made under Congressional majorities that support environmental policies, 2) decisions i and j are both made under Congressional majorities that oppose environmental policies, 3) decision i and j are made under Congresses with majorities that have opposite attitudes towards environmental policy. These distributions were obtained by selecting a large number of node pairs separated by Δ_t years from the sequence of decisions in the legal network and estimating f_{ij} for each node pair. Each node pair falls within one of these three mutually exclusive political conditions, which yields three distributions for $f_{ij}(\Delta_t)$.

We see first that $f_{ij}(\Delta_t)$ declines very quickly with time because newer decisions are more likely to be cited. Second, we note that these distributions are very similar. In particular, if preferential reinforcement was at play in this network, we would expect that node pairs with similar political conditions would have a higher distribution of f_{ij} than node pairs whose political conditions differ. Visual inspection of Figure 8(a) suggests that this is not the case, and indeed, Figure 8(b) shows that the correlation ratio remains very low for the whole Δ_t range. In other words, we see no evidence of preferential reinforcement of precedent in response to the majority party in Congress. The Appendix provides equivalent Figures for the other aspects of the political environment (party of the executive, majority support for environmental policy and FV-gridlock overlap).

To test the hypothesis more rigorously, I simulated 1000 null networks. The simulation of the null networks takes as input the empirical sequence of degrees $(k_0^{in}, k_1^{in}, k_1^{out}, ..., k_N^{out})$.

Figure 8: Testing patterns of preferential reinforcement
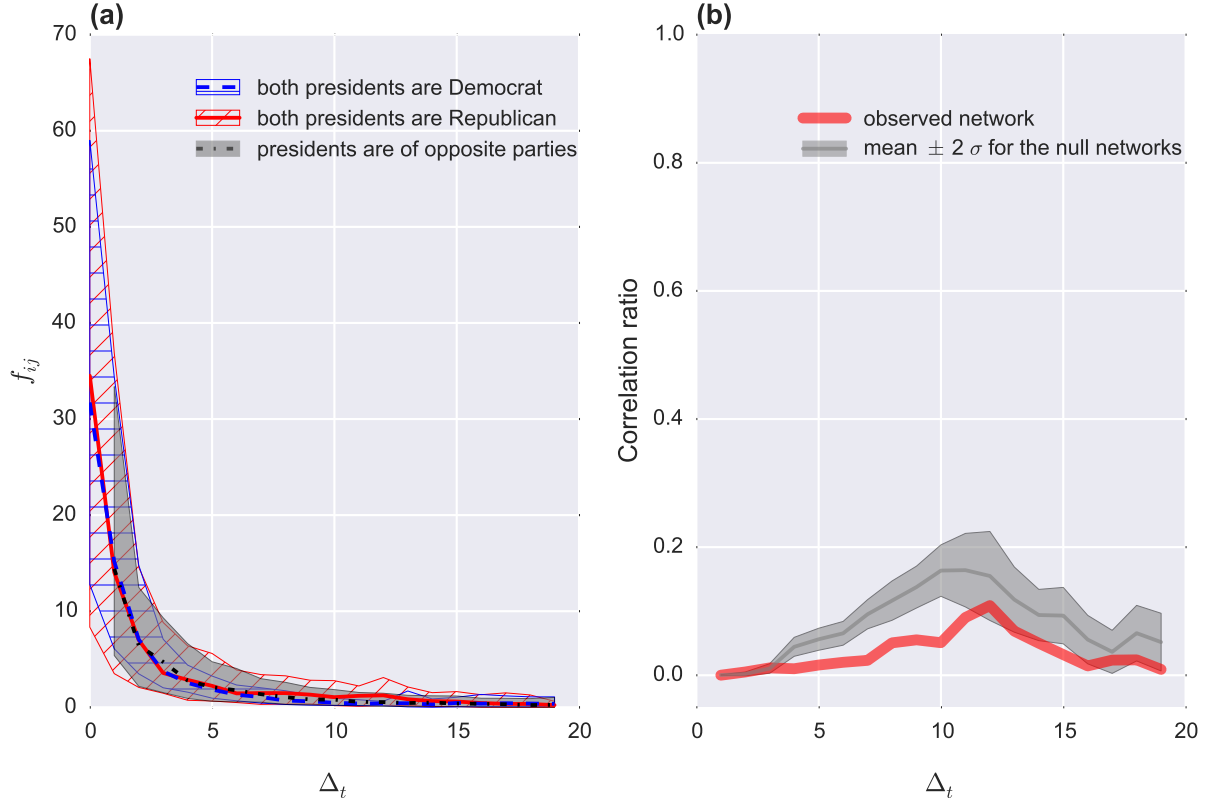
a) The distribution of f_{ij} in the observed citation network as a function of Δ_t, for pairs of decisions that arose under the same pro-environmental political environment, the same anti-environmental political environment, or under differing political environments. b) The correlation ratio quantifying the co-variation between f_{ij} and the political conditions, for the observed networks, and for the null networks.

It then "rewires" the stubs at random, but respecting the empirically observed number of edges between different types of courts (district, appeals, supreme). The random rewiring guarantees that even if the empirical network exhibits a pattern of preferential reinforcement (i.e. a tendency for citations to reinforce past opinions in a way that is congruent with the preferences of politicians), the null networks will not. Yet, they will preserve any pattern due to the order of appearance of nodes and their associated in- and out-degree and the court hierarchy. This provides a bootstrapped distribution of the $f_{ij}(\Delta_t)$ distributions under the null hypothesis of no preferential reinforcement, while keeping all other features of the empirical network constant.

Figure 8(b) shows the distribution of the correlation ratios for these null networks. Just as in the observed network, they are low. They further allow us to reject the hypothesis of preferential reinforcement, since they are on average higher than in the observed network. The opposite should be true if the hypothesis was correct. Similar Figures in the Appendix show equivalent results for the other political environments, allowing us to reject the hypothesis of preferential reinforcement of precedent in response to either Congressional majority party, executive party, Congressional majority policy preferences and the degree of congruence in the FV-gridlock between two political years.

5   Discussion

I have argued that if courts felt constrained by Congress in the interpretation of statutes (at least those salient at a given point in time to members of Congress), 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, overall, 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. Changes in the distribution of

these preferences from one Congress to another is not associated with the appearance of novel decisions, or the overruling of past important decisions. Furthermore, legal decisions made during one particular Congress did not tend to preferentially cite legal decisions made during a period characterized by similar congressional preferences. Overall, this suggests a certain degree of autonomy of the courts from Congress, allowing the courts to avoid mirroring by legal changes the short-term shifts in the preferences of elected officials. However, when congressional preferences are stable and an issue is salient, it was found that the courts are more likely to react and make novel decisions on that issue. This result also suggests that courts are able to resist the pressure of short-term political changes but are sensitive to longer term changes in policy attitudes.

The results 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; Gennaioli and Shleifer 2007) – 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[18]. 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.

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. 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

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[18]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."

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."[19]. The meaning of the term was gradually expanded to include more and more bodies of water and private properties impacting them[20]. 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 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

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[19](1977 regulation of the Corps, cited on page 267 of the book)

[20]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".

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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