Sequential Adjudication*

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Abstract

Dispute resolution is a ubiquitous responsibility of government, but precious few disputes are "one and done." Dispute resolution often provokes, and is carried out in the shadow of, future disputes. In this article, we offer a general theory of dispute resolution in such settings, the *dynamic resolution framework*, and describe the impact of resolving disputes within a dynamic setting on the incentives of a strategic adjudicator. We apply the theoretical results to the notion of justiciability, and particularly ripeness, in the US federal judiciary. We leverage our theoretical findings to illuminate and better understand key dynamics of a pair of case studies of US Supreme Court doctrine.

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Governance is a perpetual task. New problems continue to arise—sometimes, the very resolution of one issue can instigate another. How should the government behave if it is aware of this? In a vacuum, the government may prefer to resolve disputes as soon as possible—but this preference might be mitigated by the expected downstream consequences of resolving any given dispute. Sometimes action today begets more action tomorrow, potentially making the cure worse than the disease.

In this paper we explore these issues in the context of the federal courts in the United States, which encounter many of the strategic dilemmas associated with dynamic dispute resolution. As with many other appellate courts, the U.S. Supreme Court has a discretionary docket that allows it to decide which cases to hear and when. It therefore faces the complex decision of structuring the sequence of cases it will hear over time. Articulating a guiding principle, offering a more specific definition for a term, establishing or clarifying guidelines—each of these can raise further clarifying questions. For example, how far does the guiding principle extend? Is the term's newly-clarified definition portable to other issues in which the term appears? Can the guidelines be clarified further, or the terms be defined more precisely? In a nutshell, whether one thinks about setting forth guiding principles, defining terms, or clarifying guidelines, it is a simple reality that, in rendering and explicating decisions, the explanation will often touch upon more than the dispute immediately at hand. In many disputes, if not most, the disposition hinges on one or more clarifying questions and definitions that can and do travel to subsequent disputes.[1]

As a step toward a general understanding of these, and related, aspects of sequential adjudication, we introduce the *dynamic resolution framework*. We analyze the dynamic quandary faced by a unitary actor making decisions over a finite period of time. First, our model highlights the cautionary effect of foresight. Oftentimes, courts decline to decide issues that on their own seem easy to solve. However, because resolving that dispute might (or will) raise subsequent disputes, the courts may decline to "wade into the waters." Second, our model provides a framework for understanding "ripeness." In our model, some long-simmering disputes will be resolved because other disputes have arisen. These two findings help provide theoretical microfoundations for empirical patterns in

[1]Patty and Penn (2014) provide a positive model of the importance of explanations in policymaking—their theory investigates the collective implications and importance of the type of path-dependence that the theory presented in this article derives from first principles.

the evolution and development of legal and political "issues." Such patterns have been the subject of considerable interest in legal scholarship and empirical political science: for example, the notion of jurisprudential regimes (*e.g.*, Richards and Kritzer (2002), Kritzer and Richards (2005)) is motivated in part by periods of stability punctuated by rapid changes and the the irregular and rapid shifts in how cases in a given issue area are adjudicated by the Court. Similarly, agenda-setting within the judiciary produces dynamic linkages in the Court's decision-making in which salient cases are subsequently followed by bursts of activity tied to the issues in those cases (e.g., Baird, 2007).

More generally, the model yields theoretical and empirical insights about the path-dependent development of law, case selection, and the connections among cases. The findings reported here have implications for empirical studies concerned with the distributive politics of judicial policy-making, the ways courts and litigation can be used for social change, and strategic dynamics underlying case selection by collegial courts. Outside of the judiciary, though, the theoretical framework we develop also has substantive applications to myriad dispute-based policy-makers, such as administrative dispute resolvers, precedent-based committees, and other institutions.

1 Case Selection and the Evolution of Disputes

American courts make policy by resolving disputes. Because courts must wait for cases to be brought to them, they have limited capacity for setting their own agenda (e.g., Epstein, Segal and Johnson, 1996). Kornhauser (1992, 182) observes, "The problem of agenda control does not plague adjudication because, to a large extent, the courts do not set their own agenda. Litigants determine the flow of cases to the courts and no litigant or group of litigants has sufficient control over an issue to regulate the order in which sub-issues arise in the judicial system." At the same time, scholars have also remarked on the wide discretion given to many peak courts, most notably the US Supreme Court, to pick and choose which cases it will hear (e.g., Pacelle, 1991; McGuire and Palmer, 1995, 1996; Baird, 2007). The practical consequence of these two realities is that the U.S. Supreme Court—like the peak court in many judicial systems—has extensive discretion to set its docket from among a set of questions raised by litigants. Strategic litigants, in turn, may be able to respond to actions taken by the courts indicating which questions they are likely to be able to successfully litigate (Baird, 2004). Three important dynamics therefore interact to drive the sequence of adjudication. First, the resolution of some questions naturally closes off other questions but opens up still others. Second, courts anticipating a dynamic docket that evolves and changes as they resolve disputes must anticipate the downstream implications of their decisions as they triage and sequence their actions. Third, the particular consequences of any given dispute are a function of how litigants react and decide to set future dockets for the courts.

One question begets another. In a famed children's book, Laura Numeroff teaches us that "if you give a mouse a cookie," he's inevitably going to want something else. So, too, for courts answering litigants' questions. Answering one question raises another. Law is complicated, and while any given decision may settle one issue, the consequences of that decision are inevitably that other issues arise or are implied by the first. For example, when the US Supreme Court decided in *Roe v. Wade* (410 U.S. 113 1973) that states could not impose an undue burden on women seeking an abortion before the third trimester, that precedent only raised more questions about what constitutes an undue burden, whether the principle creates a "right to die," and whether a state could prohibit abortions from being performed at state-operated hospitals. Lawyers refer to the sequence of cases that follow from a given precedent as that case's *progeny*, connoting the idea that new questions follow as a *consequence* of the older ones. Some areas of the law are marked by complex progenies in which many diverse questions arise from the resolution of a single issue, whereas others might have simpler progenies in which a few questions emerge to simply "fill in" issues left unresolved (e.g., Clark and Lauderdale, 2012).

Indeed, when deciding which cases to take, the Supreme Court is aware of the complexity of the issues raised in a given case and the extent to which deciding the case will raise additional questions. In his study of the *certiorari* process, Perry (1991, 234-7) describes some cases as having "bad facts" or being "bad vehicles" in the sense that they raise a host of interconnected issues (see also Estreicher and Sexton, 1984). Perry quotes one Supreme Court justice as saying, "Rushing at an issue you might later find that the relevant issue is surrounded by other issues. You must be careful to see that the facts surround the issue in such a way that you can get to it." He goes on to describe how the justices look to the pipeline of cases coming from the lower courts to consider how issues are interconnected and which cases present the right combination of questions to most effectively speak in a given area of law. Our theory, as discussed in Section 2, captures this important and ubiquitous characteristic of the Court's agenda.

The Supreme Court knows that resolving one dispute provokes subsequent litigation. The questions raised during litigation—by judges and litigants alike—demonstrate this concern is often central to one's reasoning. Justice Alito famously asked during the oral arguments in *National Federation of Independent Business v. Sebelius* (132 S. Ct. 2566 2012) whether the Court's approval of the Affordable Care Act's individual mandate would open the door to federal requirements that one eat broccoli. Less tongue-in-cheek, state legislators in Utah filed an amicus brief with the US Supreme Court in *Herbert v. Kitchen* arguing that overturning prohibitions on gay marriage would give rise to questions about the legality of incestuous or polygamous marriages.

These concerns about subsequent questions can be mitigated or aggravated by the legal context in which a decision is made. A decision may give rise to a new set of questions when issued alone, but when issued in conjunction with another decision, the implications for future litigation may be different. One case may generate no subsequent litigation or plentiful subsequent litigation, depending on the accompanying decisions. Concurrent decisions can mitigate or aggravate slippery slopes or confusion caused by any given decision. Therefore, when the Supreme Court chooses which cases to decide in a given year, that set of cases may be evaluated collectively—so the Supreme Court may make take a broad perspective when choosing that set of cases.

We define a "prospectively ripe" dispute as one whose resolution will produce useful subsequent litigation. In this sense, a case is characterized in part by the subsequent questions or disputes that the justices expect to be raised *by* its resolution. While the main way lawyers often talk about ripeness is *retrospective*—focused on whether or not sufficient related disputes have arisen—we show below that there is a sensible interpretation of ripeness in terms of the *downstream* consequences of resolving an issue. The theoretical framework we introduce explicitly models the interconnections among cases and legal issues and so can explain, prospectively, why courts may decline to answer seemingly easy legal questions or may finally decide to weigh in on issues that have been long simmering. Our framework simultaneously incorporates both the prospective and retrospective directions of ripeness. In terms of retrospective ripeness, optimal dispute resolution is conditioned both on the set of disputes that are currently pending (as more disputes arise, resolution of any given pending dispute becomes more likely). At the same time, the role of prospective ripeness emerges as well: as a given dispute becomes linked to (*i.e.*, capable of initiating) a larger set of subsequent disputes, the situations in which the dispute will be resolved decreases. By virtue of the dynamic nature of dispute resolution, the future impact of resolving any given dispute (*i.e.*, the dispute's prospective ripeness) endogenously creates an implicit role for the other pending disputes in determining whether it is optimal at any point in time to resolve that dispute (*i.e.*, the dispute's retrospective ripeness). In other words, the shadow of the future—the downstream effect(s) of resolving a dispute—filters upstream and leads to optimal adjudication decisions that, even on a dispute-by-dispute basis, are sensitive to the entire portfolio of pending disputes.

Anticipating the path of the law. For a court facing a docket of cases and trying to choose which cases to decide, the sequential nature of the questions that arise implies the court must make choices under the shadow of future dockets. Much of the literature on certiorari and "percolation" is backward-looking. Many of the theoretical perspectives adopted in this research are about the Supreme Court—or justices—considering what has come before and whether it is prepared to resolve a current case, especially whether the Court has received sufficient information to confidently resolve the dispute (e.g., Perry, 1991; Grant, Hendrickson and Lynch, 2012; Clark and Kastellec, 2013). There is also a challenging *forward*-looking problem. The court must ask itself, "If I decide case X today, which cases will I have to choose from tomorrow? What issues are likely to arise as a consequence? Will I want to resolve those issues?" In this way, we see the dynamic, evolutionary nature of the law. Early choices set the conditions under which subsequent choices will be made. Those conditions can reinforce past decisions, in the sense of *increasing returns*; they can cause instability in the sense of *negative feedback*; or they can shape the likelihood of possible future events. Because current decisions or choices shape the likelihood of future events happening, the process of dispute resolution is necessarily *path dependent* (Page, 2006).

We see in archival evidence from the US Supreme Court a clear sense of path dependence in the law. As our examples from the Affordable Care Act and same-sex marriage cases illustrate, the justices and their clerks often consider what deciding a given case will mean for the likelihood of future questions and issues arising. Our results indicate a fuller picture of the type of concerns that they need to consider when deciding which cases to hear from a docket of pending disputes. Most importantly, whether to resolve a particular case in the docket depends on what other cases are also in the docket.

Scholars often consider the law to be path dependent in the sense that earlier decisions affect future decisions (Kornhauser, 1992; Hathaway, 2001). However, past scholarship on path dependence in the law generally focuses on case results—such as answered gaps in the law (e.g., Cameron, 1993) or the role of stare decisis (e.g., Bueno de Mesquita and Stephenson, 2002). Perhaps more important, though, are the effects of doctrinal constructs shaping future litigation. It is not uncommon to find accounts that claim certain early cases "paved the way" for future cases. In part, what this claim means is that earlier cases answered questions that begot new questions and provided the logical connections necessary for bringing new disputes to the courts.

Taken from this perspective, path dependence in the law can be thought of more broadly than being just about the specific results of individual case outcomes but more generally about the effects of doctrinal moves on the *types of questions* brought to the courts and the sets of issues that relate to one another. Some empirical work on development in the law considers doctrinal evolution (e.g., Kastellec, 2010; Richards and Kritzer, 2002), though that research does not benefit from a theoretical framework for understanding sequential adjudication as the means of constructing a path-dependent body of law. Questions emerge, then, about what case selection strategy leads to optimally efficient doctrine, when judges might reconsider past decisions, and how judges can use related cases to most effectively address a question of law (e.g., Callander and Clark, 2013).

The results we derive show, for example, that legal questions that themselves are raised as matters ancillary to more important questions will be resolved sooner than are otherwise similar issues that are connected to less important questions. Our theoretical framework provides an understanding for why dispute resolution can appear "clumpy" as a result of the court not resolving any seemingly pressing issues in a domain for a significant period of time and then, in one fell swoop, resolves a host of related issues. More specifically, the theory provides an explanation for this behavior that does not depend on the importance of the pending issues varying across time. Rather, the key causal mechanism in our theory is the emergence of a sufficient number of disputes with common "downstream" consequences. One of the key insights from our theory is that a decision-maker who worries about the future may delay making some decision—in effect, let the question(s) at hand "percolate"—because he or she is awaiting a moment when he or she can clear the decks of multiple related disputes at once. This effect emerges in our theory in spite of any explicit assumption of "economies of scale": rather, the appearance of scale economies emerges from the interlinkages between disputes. From this starting point, as we show below, our theory provides an "equilibrium" notion of ripeness, where a dispute is optimally resolved only if there are other related disputes pending, where "related" is based on what future disputes are initiated by their resolution. We now turn to the formal presentation of the model.

2 The Model

We consider a single decision-maker model of dynamic resolution in which a court is faced with choosing which disputes, if any, to resolve from a set of ongoing disputes. We remain agnostic about the nature of the dispute and use the term "court" as a placeholder for any strategic dispute resolver. The court will adjudicate cases across $T \geq 1$ discrete periods, where T is finite (but may be arbitrarily large).

Disputes and Linkages. Each dispute d is characterized by a dispute-specific cost of delay, $c(d) \geq 0$. We omit a more detailed, micro-level representation of the disputes so as to focus on the impact of dynamic linkages between disputes on the abstract incentives of the court to resolve any given dispute. The set of all n possible disputes is denoted by $\mathcal{D}$. The (exogenous) linkages between disputes is represented by a $n \times n$ *linkage matrix*, L. The probability that resolving dispute d will provoke some dispute j is denoted by $L_{dj} \in [0,1]$, with the additional restriction $L_{dd} = 0$: resolving any given dispute does not (immediately) lead to the recurrence of that dispute. Thus, L defines a weighted graph on $\mathcal{D}$. In order to keep presentation as parsimonious as possible, we focus on the case in which linkages are deterministic: $L_{dj} \in \{0, 1\}$ for each distinct pair of disputes d and j. Part of the reason this decision makes the presentation parsimonious is that it allows us to unambiguously refer to the "predecessors" and "successors" for any dispute $d \in \mathcal{D}$, given the linkage matrix L. The *predecessors* of a dispute d, denoted by $P_L(d)$, or simply $P(d)$ when the context is clear, are those disputes that, when resolved, provoke dispute d:

$$P_L(d) = \{j \in \mathcal{D} : L_{jd} = 1\},$$

and the *successors* of a dispute d, denoted by $S_L(d)$, or simply $S(d)$, are those disputes that are provoked when d is resolved:

$$S_L(d) = \{j \in \mathcal{D} : L_{dj} = 1\}.$$

Sequence of Play and The Court's Payoffs. At the beginning of each period t, the court observes the (possibly empty) set of disputes that are available for resolution, $D_t \subseteq \mathcal{D}$. We call D_t the court's *docket*. Following observation of D_t, the court can adjudicate as many available cases as it wants. We assume that the direct cost of adjudication is a linear function of the number of cases adjudicated: if the court adjudicates x cases, it pays a direct cost of kx, for $k \geq 0$.[2] The set of cases the court adjudicates in period t is denoted by $a_t \subseteq D_t$ and the set of cases remaining to be disposed of is denoted by $r_t \equiv D_t \setminus a_t$. The payoff received by the court in period t is

$$U_t(a_t; D_t) = -\left[k|a_t| + \sum_{d \in r_t} c(d)\right]$$

[2]Obviously, one could generalize the framework by allowing the cost of adjudicating a given dispute to depend on the dispute (or more complicated structures that allow the cost to depend on the exact set of disputes is adjudicates). Allowing for this heterogeneity will easily generate the possibility of seemingly counterintuitive optimal adjudication strategies. However, we demonstrate that such counterintuitive results emerge in a smaller, more restricted environment anyway, thereby rendering such additional complications superfluous for our purposes. This is because the actual, equilibrium, cost of optimally resolving different disputes is already heterogeneous in this framework due to the fact that disputes will generally differ with respect to the identities and characteristics of their successors. In a nutshell, optimally resolving a dispute requires accounting for the number of, and costs of not resolving, the disputes that would be initiated by resolving the dispute in question.

The next docket—the set of cases available for resolution in period $t+1$—is constructed iteratively as follows. Initially, the set of cases to be resolved in period $t+1$ is simply those cases that were available for resolution, but not resolved, in period t: $D_{t+1} = r_t$. Then, for each dispute resolved in period t, $d \in a_T$, and each dispute $j \in \mathcal{D}$, dispute j is added to D_{t+1} with probability L_{dj}. Finally, any dispute resolved in period t is removed from the resulting set (*i.e.*, recently resolved disputes do not immediately reoccur). Thus, the probability that dispute j is in D_{t+1}, given D_t and a_t, is denoted and defined by

$$P(j; D_t, a_t) \equiv \begin{cases} 0 & \text{if } j \in a_t, \\ 1 & \text{if } j \in r_t, \\ 1 - \prod_{d \in a_t}(1 - L_{dj}) & \text{otherwise.} \end{cases}$$

Thus, given D_t and a_t, the probability that the next period's docket will equal D is

$$P(D; D_t, a_t) \equiv \prod_{d \in D} P(d; D_t, a_t) \prod_{j \notin D} (1 - P(j; D_t, a_t)),$$

or, given our restriction of attention to deterministic linkage matrices, the next period's docket is with certainty given by the following:

$$D_{t+1}(D_t, a_t) = r_t \cup (\cup_{d \in a_t} S(d)) \setminus a_t.$$

That is, the next period's docket is equal to the unresolved disputes from the current docket, plus all disputes that are initiated by the disputes resolved in this period, minus the disputes resolved in this period.[3]

Then, for any T-period sequence of dockets, $\mathbf{D} = (D_1, \ldots, D_T)$, and adjudications, $\mathbf{a} = (a_1, \ldots, a_T)$, the court's overall payoff is simply

$$U(\mathbf{a}; \mathbf{D}) = \sum_{t=1}^{T} \delta^{t-1} U_t(a_t; D_t), \tag{1}$$

[3] The final step (subtracting the resolved disputes from this period) may seem a bit counterintuitive at first, but merely accounts for the fact that, if one resolve multiple disputes at once, one or more of the resolved disputes might "initiate" one or more of the other disputes. We presume that this initiation is immediately and costlessly resolved in such a situation.

where $\delta \in (0, 1]$ is an exogenous discount factor. Finally, a *setting*, $\sigma = (\mathcal{D}, c, k, L)$, is a combination of a set of $n \geq 1$ potential disputes, $\mathcal{D}$, a vector of costs of delay, $c \in \mathbf{R}^n_{++}$, a cost of adjudication, $k \geq 0$, and a $n \times n$ matrix of linkages, L. The set of all potential settings is denoted by Σ.

Adjudication Strategies. A T-period adjudication strategy is a complete description of which disputes will be resolved, and when they will be resolved. Specifically, for any setting σ and number of time periods T, an adjudication strategy is a mapping, denoted by $\alpha : 2^{\mathcal{D}} \times \{1, \ldots, T\} \to 2^{\mathcal{D}}$, that maps each docket $D \subseteq \mathcal{D}$ and the time period, $t \in \{1, \ldots, T\}$, into a set of disputes to resolve, denoted by $\alpha(D, t)$.[4] The set of all adjudication strategies, given a setting σ and a number of time periods T, is denoted by $\mathcal{A}(\sigma, T)$. For any setting σ, number of time periods T, and initial docket $D_1 \subseteq \mathcal{D}$, an adjudication strategy $\alpha \in \mathcal{A}(\sigma, T)$ induces, for each time period $t \in \{1, \ldots, T\}$, a distribution of dockets and adjudication decisions.

Given a setting σ, a time horizon T, a discount factor δ, and an initial docket $D_1 \subseteq \mathcal{D}$, we denote the court's total payoff from an adjudication strategy $\alpha \in \mathcal{A}(\sigma, T)$ by $EU(\alpha; \sigma, T, \delta, D_1)$.[5] With this in hand, an adjudication strategy $\alpha^* \in \mathcal{A}(\sigma, T)$ is *optimal* for any setting σ, number of time periods T, and discount factor δ, if it maximizes $EU(\cdot; \sigma, T, \delta, D_1)$ for each possible initial docket $D_1 \subseteq \mathcal{D}$:

$$\forall D_1 \subseteq \mathcal{D}, \quad \alpha^* \in \underset{\alpha \in \mathcal{A}(\sigma, T)}{\operatorname{argmax}} \; EU(\alpha; \sigma, T, \delta, D_1). \tag{2}$$

We denote the set of all optimal adjudications for a setting-time length pair (σ, T) by $\mathcal{A}^*(\sigma, T, \delta)$. When the setting σ is clear, we denote the set of all t-period optimal adjudications in period $t \leq T$ for any docket $D \subseteq \mathcal{D}$ by $A^*_t(D)$. We show in the appendix that the set of optimal adjudication strategies is nonempty and generically unique (Proposition 3).

While our existence result applies to any finite time horizon, much of our discussion in the article focuses on the two-period setting ($T = 2$). This simplification is sufficient to highlight the court's incentives in a dynamic adjudication setting. In the following subsections, we consider (1)

[4] We could restrict adjudication strategies to adjudicating only disputes currently in the docket ($\alpha(D, t) \subseteq D$ for all (D, t)), but this is unnecessary given our focus on optimal adjudications.

[5] This function encompasses how α will generate dockets in periods $2, \ldots, T$, given L. This is what distinguishes it from its primitive function, $U(\cdot)$, defined in Equation (1).

the characteristics of optimal behavior in a two-period setting, (2) the effect of foresight on optimal behavior, (3) the effect of costs (of adjudication and delay) on optimal behavior, and (4) the effect of the linkages among cases on optimal behavior.

2.1 The Two-Period Setting

In the two-period setting, the court's motivations are based solely on the relative costs of delay and on what "new issues" will emerge as a result of adjudication.

We can solve for the optimal first-period adjudication decision, a_1^*, given an initial docket D_1, by backward induction. In particular, given any second period docket, D_2, deriving the optimal adjudication strategy is straightforward. The optimal second period adjudication decision, given D_2, is any adjudication decision satisfying

$$a_2^*(D_2) \in \underset{a_2 \subseteq D_2}{\text{argmax}}\ U_2(a_2; D_2) = \underset{a_2 \subseteq D_2}{\text{argmin}} \left[\sum_{d \in r_t} c(d) + k|a_2| \right]. \tag{3}$$

The additive separability across disputes of both the costs of resolution and the costs of delay implies that the court should resolve only those disputes that are costlier to allow to linger than to resolve and should always resolve those that are strictly so. If, as in the final period, the court is faced with simply considering whether to leave a dispute unresolved or not, without concern about any further future implications of the resolution of the dispute (*i.e.*, if L is not part of the court's calculus), then the court should a resolve a dispute d only if $c(d) \geq k$.

Moving back from the second period to the first, the question becomes, which cases should be left unresolved in the first period? The court should resolve a dispute d in the first period *only* if $(1 + \delta)c(d) \geq k$. This motivates the next assumption, which simplifies the presentation of our results and requires only setting aside very low cost (*i.e.*, "minor") disputes.[6] In the static setting, the assumption implies that any dispute that has no successors would be resolved by an optimal adjudication strategy if the dispute arises in any period before the final period, but does allow for the possibility that a dispute might not be resolved in the final period.

[6]We assume that the inequality is strict so as to set aside uninteresting knife-edge indifference on the part of the court.

Assumption 1 *Given the discount factor, δ, each dispute $d \in \mathcal{D}$ satisfies the following:*

$$c(d) > \frac{k}{1+\delta}.$$

Assumption 1 establishes a useful baseline: any dispute in the initial docket that is left unresolved by an optimal strategy is left unresolved precisely because of the *dynamic implications* of its resolution. That is, given Assumption 1, an optimal adjudication strategy would resolve all disputes in the first period in a "static" setting, where the linkage matrix, L, contains only zeroes.

2.2 Analysis

Analysis of our model gives rise to a host of rich results and implications across a variety of features of the dynamic resolution framework. Here, we focus attention on three sets of findings: (i) the ways in which the dynamic links among cases create an efficiency in delay, (ii) the static consequences of those dynamics, and (iii) the endogenous emergence of economies of scale in dynamic dispute resolution.

2.2.1 Efficient procrastination

Judicial decisions and interpretations are relevant to the court at least partially because the court will have to revisit them in the future. Accordingly, the court's expectations about what it will (or will not) have to adjudicate in the future will affect its willingness to let even a seemingly pressing issue percolate. Our first result illustrates why the Court may sometimes rationally demur from resolving a seemingly easy or seemingly pressing issue—because the expected consequences of resolution are too costly.

We begin illustration of this result with a simple example.

Example 1 Suppose that there are four potential disputes, $\mathcal{D} = \{1, 2, 3, 4\}$, the cost of delay from each dispute $d \in \mathcal{D}$ is given by $c(d) = d$, and the cost of adjudication is $k < 1$. Furthermore, suppose that set of initially available disputes is $D_1 = \{1, 2\}$ and that the linkages between the disputes are as follows:

$$L = \begin{bmatrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix},$$

so that the linkages are as displayed in Figure 1, where an arrow from one dispute i to another, j indicates that resolving the dispute i in the first period will result in dispute j arising in the second period. Note that dispute 2 is logically connected and ancillary to dispute 1.

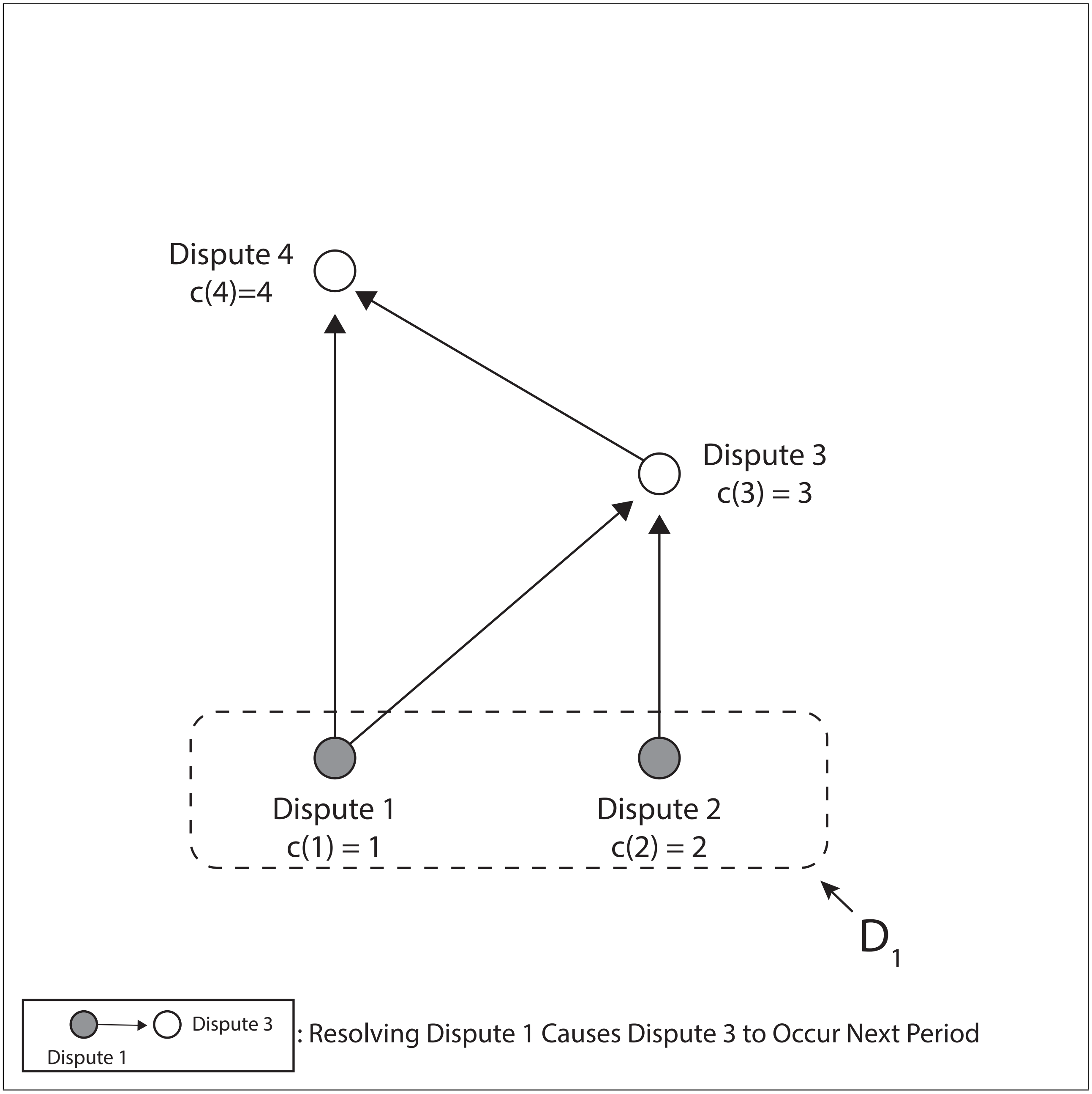

Figure 1: Endogenous Ripeness

There are four potential adjudication decisions for the court in the first period($a_1 \in \{\varnothing, \{1\}, \{2\}, \{1,2\}\}$) and the docket that the court will face in the second period as a function of the first period adjudication is given by the following:

$$\begin{aligned} D_2(\varnothing) &= \{1,2\}, \\ D_2(\{1\}) &= \{2,3,4\}, \\ D_2(\{2\}) &= \{1,3\}, \text{ and} \\ D_2(\{1,2\}) &= \{3,4\}. \end{aligned}$$

The court's optimal adjudication depends on the cost of adjudication, k. Assumption 1 implies that $k < 2$. (For the purposes of this example, it suffices to assume that $k < 1$.) This assumption implies that the optimal second-period adjudication strategy for any docket D_2 is simply D_2: all pending disputes should be resolved in the final period. Accordingly, the court's total payoff from each of the four possible first-period adjudications, given that the court is sequentially rational (*i.e.*, it uses an optimal adjudication strategy in the second period and resolves all pending disputes) are as follows:

$$\begin{aligned} V^*(\varnothing) &= -(3+2k), \\ V^*(\{1\}) &= -(2+4k), \\ V^*(\{2\}) &= -(1+3k), \text{ and} \\ V^*(\{1,2\}) &= -4k. \end{aligned}$$

Note first that, for any $k < 1$, resolving only dispute 1 is dominated by resolving both disputes 1 and 2: $V^*(\{1\}) < V^*(\{1,2\})$. This is consistent with Proposition 2: because dispute 2 is ancillary to dispute 1: it provokes dispute 3, while dispute 1 provokes both disputes 3 and 4. Thus, if $k < 1$, the court's optimal solution is

$$\mathbf{a}^* = (\{1,2\}, \{3,4\}).$$

it should resolve every dispute as it arises.

In order to capture the notion of ripeness, consider first the situation when the docket contains only dispute 1: $D_1 = \{1\}$. In this case, the court's total payoff from each of the two possible first-period adjudication strategies, given that the court is sequentially rational (*i.e.*, it uses an optimal adjudication strategy in the second period) are as follows:

$$\begin{aligned} V^*(\varnothing) &= -(1+k), \\ V^*(\{1\}) &= -3k. \end{aligned}$$

Accordingly, the court should resolve the first dispute in the first period only if $k \leq {}^1\!/_2$. If $k \in ({}^1\!/_2, 1]$, the court will dispose of the first dispute in the first period *only if* if the second dispute is also pending.

Considering the complementary case of the initial docket containing only dispute 2, $D_1 = \{2\}$, the court's total payoff from each of the two possible first-period adjudications, given that the court is sequentially rational (*i.e.*, it uses an optimal adjudication strategy in the second period) are as follows:

$$\begin{aligned} V^*(\varnothing) &= -(2+k), \\ V^*(\{2\}) &= -2k. \end{aligned}$$

Accordingly, the court should resolve dispute 2 in the first period if $k < 2$, as we have assumed. Thus, the court should dispose of dispute 2 regardless of whether dispute 1 is on the docket, but it should dispose of dispute 1 only if either the cost of adjudication is sufficiently small ($k \leq {}^1\!/_2$) or if dispute 2 is also on the docket. △

Example 1 illustrates the core intuition underlying our equilibrium notion of "ripeness." In particular, whereas the standard notion of ripeness is *retrospective*—have the necessary procedural and legal processes and hurdles been met in order to justify adjudication?—our model suggests a complementary, and broader, notion of *prospective* ripeness. In this view, courts ask not whether a given case is sufficiently prepared for resolution but instead whether the effects of resolution will be beneficial or detrimental. An integral part of that calculation is whether the resolution of a dispute will trigger a host of new disputes that otherwise would not require resolution.

We formalize this notion of prospective ripeness by defining "percolable" disputes—these are disputes that the Court will sometimes leave unresolved. Our assumption about costs (Assumption 1) ensures that every dispute would be resolved immediately if there were sufficiently many other pending disputes, so our focus here is on discriminating between two sets of disputes: (1) those that will never be allowed to percolate and (2) those that are allowed to percolate in some, but not all situations. The following formally defines the disputes falling into this second group.

Definition 1 *For any setting $\sigma = (\mathcal{D}, c, k, L) \in \Sigma$, and any discount factor $\delta \in (0,1]$, a dispute $d \in \mathcal{D}$ is said to be* percolable *if, for every 2-period optimal adjudication strategy $a^* \in \mathcal{A}^*(\sigma, T, \delta)$, there exists a docket $D \subseteq \mathcal{D}$ with $d \in D$ such that $d \notin a^*(D,1)$ and a docket $D' \subseteq \mathcal{D}$ such that $d \in a^*(D',1)$.*

Proposition 1 *For any setting $\sigma = (\mathcal{D}, c, k, L) \in \Sigma$, any discount factor $\delta \in (0,1]$, a dispute $d \in \mathcal{D}$ is* *percolable if and only if*

$$c(d) < k\left(1 + \frac{\delta|S_L(d)|}{2}\right) - \delta \min[k, c(d)]. \tag{4}$$

The condition in Proposition 1 (Inequality (4)) yields a few immediate conclusions. First, it is optimal to allow a costly dispute to percolate only if it has successors. This conclusion validates our notion of ripeness as capturing a *dynamic* property of dispute resolution. If a dispute has no successors, then *the optimality of its resolution is independent of both when it emerges and what other disputes are pending when it emerges*. Second, a dispute will be allowed to percolate only if it is not too costly to leave unresolved for a period (*i.e.*, $c(d)$ is not too large). If a dispute is sufficiently costly to endure, then it will be optimally resolved whenever it emerges. Finally, and most interestingly, disputes that have more successors are more likely to be allowed to percolate. Put another way, the condition expressed in Inequality (4) is a necessary condition for the Court to consider what other disputes are pending when deciding whether to resolve a given dispute d. That is, if Inequality (4) is not satisfied for a given dispute d, then the dispute is sufficiently costly to endure and has sufficiently few downstream consequences (*i.e.*, $|S_L(d)|$ is small) that the Court should resolve the dispute whenever it arises.

It is when Inequality (4) *is* satisfied that illustrates how the downstream consequences of a dispute affect whether a Court is willing to resolve that dispute in any period. Costly downstream disputes discourage resolution—even if the dispute in question would be easy to resolve. However, the adverse side of those downstream consequences can be mitigated when there are other pending disputes that have the same downstream consequences. As our example illustrates, the cost-benefit balance is shifted as more cases with the same downstream consequences are presented, therefore not affecting appreciably the "cost" of resolving a dispute (i.e., triggering new disputes) which increasing the cost of demurring (i.e., leaving even more pending disputes unresolved).

Result 1 *Expectations about what an adjudicator will (or will not) have to adjudicate in the future will affect its willingness to let a dispute percolate.*

Thinking about the US Supreme Court, this captures one aspect of a case's justiciability. Ripeness—a key but nebulous aspect of justiciability—refers to whether the Court "needs" or "is able" to make a decision regarding the case at hand. Accordingly, it can arguably be best thought of a practical guideline toward restraint. The ripeness requirement is meant to "ensure that judicial decision making is carried on with the requisite factual foundation, or under a time frame that avoids premature interference with the regulatory actions of other government bodies" (Nichol, 1987, p. 155).

Ripeness encourages not only slow action but also infrequent action, attempting to ensure that the court doesn't provoke or become embroiled in more disputes than it absolutely must:

> its function is to prevent premature judicial interference with government action and *to avoid entanglement in abstract, poorly defined disputes.* The mature, focused conflict not only affords the Court an informing perspective on the actual working or impact of laws, . . ., but also provides the Court with greater choice among the grounds for decision, an opportunity thus to decide in the narrowest compass.[7]

Interpreting ripeness as an implicit canon of avoidance is in line with the incentives identified above in the dynamic resolution framework. As more logically-connected disputes are included in the docket, the net cost of (optimally) provoking those future disputes concomitantly declines. This leads to our next result: dynamic relationships impact static settings.

2.2.2 Static Consequences of Dynamic Effects

Our model demonstrates that the dynamic relationships among cases create interdependence among cases being considered by the Court at the same time. This result, as we show below, has direct implications for theoretical and empirical models of case selection and agenda-setting.

We begin by defining connectedness among cases. One such notion is similar to covering or domination (Fishburn, 1977; Miller, 1980; McKelvey, 1986) and emerges when one dispute initiates a strict superset of the disputes initiated by another dispute to which it is logically connected. In this case, resolution of the first dispute renders mute the dynamic implications of resolving the second dispute. Formally, when one dispute's successors are contained within those of another dispute with which it is logically connected, the first dispute is said to *ancillary* to the second.

[7] Albert (1977), p. 1155.

Definition 2 *Given a setting $\sigma = (\mathcal{D}, c, k, L)$, and any pair of disputes $d_1, d_2 \in \mathcal{D}$ that are share a common successor, d_1 is* ancillary *to d_2 if $S_L(d_1) \subseteq S_L(d_2)$.*

The relationship is referred to as ancillary because, if d_1 is ancillary to d_2, then resolving dispute d_2 initiates *every* dispute that resolution of d_1 would initiate. Note that two disputes can be ancillary to each other: this occurs when the two disputes have identical successors.[8]

With our definition of ancillary disputes, our next result provides further insight into the static interdependence created by disputes' dynamic relationships. In particular, Proposition 2 states that if it is optimal to resolve a dispute d in any given initial docket, then it is also optimal to simultaneously resolve any disputes ancillary to d. This is a dominance argument, but it also establishes a specific monotonicity result: when one adds an ancillary dispute, it remains optimal to resolve the original dispute *and* it is optimal to resolve the ancillary dispute as well.

Proposition 2 *For any setting $\sigma = (\mathcal{D}, c, k, L) \in \Sigma$, any positive integer T, any discount factor δ, and any T-period optimal adjudication $a^* \in \mathcal{A}^*(\sigma, T, \delta)$, if $d \in \mathcal{D}$ is ancillary to $d' \in \mathcal{D}$, then for any $D \subseteq \mathcal{D}$ with $\{d, d'\} \subseteq D$, $d' \in a^*(D, 1)$ implies $d \in a^*(D, 1)$.*

It is straightforward to see that the converse of Proposition 2 does not hold: if resolving a dispute is optimal in a docket and one adds a dispute to which that dispute is ancillary, it is not necessarily the case that resolving the newly added dispute is optimal, too—the newly added dispute might initiate an arbitrarily large number of disputes above and beyond those that the original dispute initiates.

The monotonicity established in Proposition 2 reveals a crucial source of static interdependence that arises from dynamic linkages. Two disputes that seem unrelated today may be connected by shared offspring. As a result, the decisions to resolve seemingly independent disputes may not be independent. In particular, judicial decisions and interpretations are relevant to the court at least partially because the court will have to revisit them in the future. Accordingly, the court's consideration of what future cases will or will not arise can affect its willingness to let even a seemingly pressing issue percolate. Put more directly, our analysis illustrates the interdependence (or, "joint dependence") of the court's optimal adjudication strategy on the combination of various disputes eligible for resolution.

[8]We might also define a weaker notion of connectedness, logical interdependence, as when two disputes share at least one common successor—i.e., when $S_L(d_1) \cap S_L(d_2) \neq \varnothing$.

Result 2 *A strategic adjudicator will resolve (weakly) more disputes as the number of pending disputes increases.*

2.2.3 Prospective Ripeness and Endogenous Economies of Scale

As we saw above in our discussion of Proposition 1, prospective ripeness is a function of how much overlap there is in the downstream consequences of logically related disputes. Proposition 2 demonstrates a strong result, that if a disputes's downstream consequences are totally subsumed by another dispute—i.e., if a dispute is ancillary to another pending dispute—then it is optimal to resolve that ancillary dispute whenever it is optimal to resolve the dispute to which it is ancillary.

One of the richer results that arises from that relationship is a form of endogenous economy of scale. Even while we assume constant, linear costs to adjudicating disputes, economies of scale arise endogenously in the dynamic resolution framework. This may produce episodic- or burst-style adjudication, in which the court decides related cases in clusters. These economies arise because of the common downstream consequences that follow from resolving any given collection of disputes. To see this, consider another illustrative example.

Example 2 Let $\{d, e, f\}$ be three distinct disputes satisfying the following: d is logically connected to e through f and only through f: $(S_L(d) \cap S_L(e) = \{f\}$. Suppose that $c(d) \leq c(e) < k$ and $k \leq c(f)$. Then it is simple to show that, if f is not active in the first period, the optimal adjudication strategy will not resolve either d or e in the first period unless *both* d and e are active in the first period.[9] With these presumptions in hand, the optimal adjudication for $D_1 = \{d, e\}$ is described by the following:

$$a^*(\{d,e\}) = \begin{cases} (\{d,e\},\{f\}) & \text{if } c(d) + c(e) > \frac{3k}{2}, \\ (\varnothing, \varnothing) & \text{otherwise.} \end{cases}$$

Thus, holding $c(d)$ fixed at (say) $\frac{3}{4}k$, the d will be resolved only if $c(e) \geq c(d)$. That is, the resolution of d is dependent upon the cost of a different dispute to which d is logically connected. △

Example 2 highlights the potential importance not only of what disputes are logically connected to each other—a point that follows from the discussion of ripeness—but also the costliness of allowing each of the logically connected disputes to remain unresolved. In the end, if a given dispute

[9] Suppose that d is active in the first period but e is not. Then resolving d will initiate f in the second period, which will then cost k to resolve in the second period, so that the payoff would be $-2k$, whereas not resolving d at all will yield a payoff of $-2c(d) > -2k$.

is logically connected to urgent or pressing disputes, that dispute will be resolved more quickly (or may be more likely to resolved) than if it is logically connected to less important disputes. Herein lies a crucial source of endogenous economies of scale. There may exist two disputes that, independently, are not worth resolving. However, because one dispute's downstream consequences that follow from being resolved are completely subsumed by another's, there are no costs to resolving the ancillary dispute as long as the other is resolved, and in effect the two disputes' costs of delay are combined. This results in an apparent economy of scale that arises endogenously as a consequence of the logical connections among disputes.

It is straightforward to show that, holding fixed the number of disputes that a given dispute d would initiate, resolution of that dispute d becomes more likely as the set of disputes to which it is logically connected grows. Indeed, a fundamental feature of endogenous ripeness within our theory is that *enlarging the number of logical connections of a given dispute will increase the court's incentive to resolve that dispute*.

Result 3 *Logical connections among cases affect their prospective ripeness. As a case becomes logically connected to a larger set of cases, the Court will become more likely to resolve that dispute, endogenously creating the appearance of an economy of scale in adjudication.*

2.3 Summary of Theoretical Predictions

Our model yields a variety of insights into structuring a docket when cases have downstream consequences. We make two main substantive points. The first is an immediate result of the nature of sequential decision-making: the court may prefer not to resolve a dispute today if resolution would raise too many costly subsequent disputes. The second is more subtle. If two seemingly unrelated disputes would initiate similar subsequent disputes—even if they share just one successor dispute—the Court may prefer to resolve those disputes together, *even if* that means letting one dispute simmer unresolved until the other arises. Therefore, it may be beneficial to resolve seemingly unrelated disputes together, if they would raise similar subsequent issues for resolution. In fact, even though we assume a linear cost of adjudication, there is an economy to resolving multiple disputes together. Substantively, even if the Court does not formally consolidate cases for resolution and hears each on its own, there is still cost-savings by resolving multiple disputes together.

3 Illustrating Endogenous Ripeness: Constitutional Rights v. Evidence of Discrimination

We now illustrate the key result from our theoretical analysis, using case studies from the US Supreme Court. Individual cases are often thought of as “ripe” when background conditions have been met that justify judicial resolution—such as the exhaustion of administrative remedies or the resolution of preliminary issues that may change the legal question at hand. Our model suggests an alternative form of ripeness that is often at play but is concerned more with the percolation of questions or issues connected to a given dispute rather than questions internal to the individual case itself. In this sense, the form of ripeness we study can be seen as a system-level ripeness, rather than a case-level ripeness. Two legal questions in particular illustrate how this system-level ripeness emerges.

3.1 Monetary Damages for Violation of Constitutional Rights

During Reconstruction, Congress enacted the Civil Rights Act of 1871, which provided, in part, that any state official who violates an individuals’ constitutional rights will be liable for monetary damages. However, what remained unclear was whether the principle articulated in the Civil Rights Act extended to all government officials—specifically, federal officials. That question, however, came to the US Supreme Court in a case known as *Bell v. Hood*. In 1942, a group of FBI agents entered Bell’s house, arrested him, and took a considerable amount of his property, allegedly motivated by his affiliation with a group known as Mankind United. Bell was held without access to his lawyer for a long period of time. Bell ultimately sued the FBI agents for violating his constitutional rights under the Fourth and Fifth Amendments. However, because neither the Constitution nor the Civil Rights Act creates a cause of action for such a violation by federal officials, there was a preliminary question about whether federal courts can—or, must—take jurisdiction in a case seeking monetary damages for constitutional rights violations even if the case does not identify a particular cause of action.

The US Supreme Court decided that federal courts do in fact have jurisdiction over claims in which individuals sue government officials for violating their rights and seek monetary damages. However, the Court explicitly avoided answering the question whether the Constitution supports such a claim. During subsequent years, the Supreme Court repeatedly avoided answering the question whether the Constitution gives rise to claims against federal officials who violate individuals' rights. Notable questions that arose in this are include questions about whether federal officials can be sued for illegally detaining foreign aliens and ordering deportation (e.g., *Gregoire v. Biddle* (1949) and whether inmates can sue prison officials for violating their rights (e.g., *Hatfield v. Bailleaux* (1961)).

Finally, in *Bivens v. Six Unknown Named Agents* (1971) the US Supreme Court directly addressed the question of whether there is a right to sue federal agents for violation of constitutional rights. In that case, the Federal Bureau of Narcotics searched Bivens' home and then arrested him, all without a warrant. The case was dismissed by a federal judge, and Bivens sued for violation of his Fourth Amendment rights. This time, the Supreme Court ultimately decided to weigh in on the question that had remained unanswered since *Bell*—the Court held that when an individual's constitutional rights are violated by federal agents, and no other remedy exists, there is an implied right of action for monetary damages. That is, when a federal official violates one's rights, the Constitution implies the aggrieved person can sue for money if there is no other mechanism for being compensated. Thus, 25 years after *Bell*, and after the emergence of myriad situations in which individuals' rights were clearly violated but despite the spirit of the Civil Rights Act of 1871 there was no means of compensating those individuals, the Court finally agreed to take up *and resolve* the question whether the Constitution entails a right of action—the ability to sue—against those officials.

Of course, *Bivens* was not the end of the matter (for a discussion of these developments, see Frampton, 2012). The Court, in that case, only held that the Fourth Amendment implies a right of action—in the following years, the Court would have to answer whether other constitutional provisions also implied such a right. These cases arose in the context of equal protection claims under the Fifth Amendment (*Davis v. Passman* (1979)) and claims of cruel and unusual punishment under the Eighth Amendment (*Carlson v. Green* (1980)). In 1983, though, the Court first held that there is a limit to Bivens actions, in a case involving a NASA employee who claimed violation of his First Amendment rights when he was demoted for having criticized publicly the agency (*Bush v. Lucas*). The reason the Court declined to extend Bivens to this situation is that there was an administrative appeal process the employee could use, thereby invoking the component of the Bivens holding that the Constitution implies such a right of action only when there does not exist another course of remedy. Ever since, the general pattern has been of the Court declining to extend the Bivens rule to other types of claims.

The example of monetary damages against federal officials illustrates one of the central dynamics our model uncovers. The Civil Rights Act of 1871 demonstrated a commitment to holding accountable officials abusing their authority and acting outside of the law, providing for monetary damages. However, because of the circumstances under which the law was written, a question remained whether the principle applies to federal officials, as well as state officials. Initially, as in *Bell*, individuals seeking to sue had a hard time articulating the law that justified their claims. While the Supreme Court acknowledged the courts should hear these cases, it declined to decide whether the Constitution actually allows one to win such a case. For more than two decades, the issue continued to emerge, arising in an increasing number of contexts until, in 1971, the Court decided in Bivens to answer the question. In the context of our model, the question went from being a dispute provoked by a single prior dispute to one that is provoked by many disputes.

Once the Court agreed to resolve the dispute, though, a whole new set of disputes was immediately provoked, adding to the Court's docket. Claims of Fifth and Eighth Amendment violations arrived in rapid succession. Within 10 years, the Court finally appreciated the deluge of new disputes that its resolution of the question in *Bivens* had provoked and began seeking ways to eliminate new disputes. Today, the stream of new disputes continues, even if a bit abated, as the Court wrestles with the landslide of questions that have arisen as a consequence of its decision to resolve *Bivens*.

3.2 Can statistics prove discrimination?

A complementary dynamic can be seen in the example of the use of statistics as evidence in judicial proceedings. While lawyers have offered statistical evidence in litigation since at least the mid-19th century, only very recently have courts established doctrine on using social science and statistical evidence—when statistics are valid evidence and when they are not. Before then, lawyers often presented statistical evidence, but it was never established whether or not such findings constituted evidence. As early as 1868, in *Robinson v. Mandell*, (20 F. Cas. 1027)—a case concerning handwriting analysis that is regarded as the first attempt to present statistical evidence in court (Barnes and Conley, 1986, 5), Circuit Justice Clifford wrote, "Some of the questions discussed were new, and it must be admitted that they are highly important as affecting the rules of evidence." But it was almost 100 years before these questions regarding the use of statistics as evidence were answered. Despite the frequent opportunities to announce such doctrine regarding the use of mathematics, statistics, and social scientific evidence, the Court produced no such doctrine until the 1970s. Use of statistics in court was increasingly frequent but suspect, and very little law governed its use (Fienberg, 1989, 6-7).

In the 1950s and 1960s, social scientific and statistical approaches slowly entered the courts—for example, social science experiments were famously presented in *Brown v. Board of Education*. However, beginning in the 1970s, there was a "sharp increase" in the use of statistics in court (Fienberg, 1989, 211). Specifically, the Supreme Court held in 1971 in *Griggs v. Duke Power Co.* (401 U.S. 424) that a plaintiff "need only make a numerical demonstration that the protected group fared less well than the majority under the suspect procedure" (p. 11) —in other words, the Court "opened the door to statistical proof" (Barnes and Conley, 1986, 10).

This invited further disputes to identify exactly when statistical evidence is admissible, exactly when it is proof of discrimination, and how it should be treated by the various actors in the judicial process. The Court foresaw the interconnected disputes and waited until it could answer many disputes at once. One particularly clear example of delaying the problem concerns the use of statistics to show employment discrimination. If the Court decides statistics are valid evidence in these kinds of cases, subsequent disputes naturally arise—what the appropriate reference group is, whether such evidence is fully supportive on its own or whether it should be buttressed with evidence specific to the case at hand. But these questions also arise for other kinds of discrimination—jury selection, school composition, and so on. In 1977, the Court addressed the admissibility of statistical evidence in three decisions on discrimination: *Castaneda v. Partida*, *Teamsters v. United States*, and *Hazelwood School District v. United States*. These cases established the principles for using statistics to demonstrate discrimination in jury selection, employment and union practices, and hiring practices, respectively. By corralling these cases, the court was able to adjudicate clarifying and subsequent questions efficiently in the following years.

Today, the use of quantitative inference is so common that the Federal Judicial Center's Reference Manual on Scientific Evidence contains two chapters on how to use and interpret these tools. Statistics and quantitative evidence are employed in a variety of fields, and the specific doctrine relating to their admissibility has developed in separate but related paths. Among the many areas of law that rely on statistical evidence to show discrimination, statistics are often referenced in employment discrimination cases (to show disparities between groups), and in criminal cases (most famously, to show that black defendants who kill white victims are more likely to be sentenced to death than other race combinations, an analysis the Court rejected as evidence of discrimination in *McCleskey v. Kemp*.) The acceptability of statistics in the courtroom opened a number of questions in these diverse areas.[10]

The Court had many opportunities to address the use of extra-legal argument, and the use of statistical evidence specifically. But it waited until the issue was "ripe," *not* in the retrospective sense that the question had percolated sufficiently, but in the prospective sense that subsequent disputes were ready to be brought. When this stage was reached, the Court issued an invitation in *Griggs* in 1971, then resolved three disputes that were created in 1977.

[10]Of course, statistical and quantitative evidence is used in areas of law outside discrimination as well. For example, in tort cases, evidence of the counterfactual earnings a plaintiff would have received had he not been injured is often statistical in nature.

3.3 When is a dispute properly linked?

The two examples of endogenously-emerging ripeness illustrate complementary dynamics elucidated by our model. In both instances, we see that cases were allowed to percolate and await ripeness until a sufficient number of logically connected disputes emerged onto the docket. Remark 3 and Example 1 above formally show the cautionary effect of foresight. In the example of monetary damages for constitutional rights violations, the Court was hesitant to open the floodgates to the downstream consequences of recognizing a cause of action for monetary damages. However, as the density of logically connected disputes all provoking those downstream consequences increased, the Court reached a point where it made sense to resolve the pending disputes, initiating the subsequent flow of cases. Further, as the example of the use of statistics demonstrates, once the Court decides to resolve a dispute, it will "sweep up" many logically connected, ancillary disputes. Indeed, this is one of the more general predictions of our model, and as we see in this example, once the Court decided to set a standard for using statistics, it collected all of the then-pending questions (jury discrimination, employment discrimination, and jury selection) and resolved them virtually at the same time. In both instances, addressing the central question was likely to have significant downstream consequences, as resolving the dispute was likely to generate lots of litigation. But in each instance the case seems to have reach a critical threshold at which it was ripe for resolution because of the many questions that were simultaneously being "held up" by the desire to avoid the more complicated subsidiary dispute.

4 Discussion and Conclusion

Policy making is a strategic, dynamic, path-dependent process. Scholars have written extensively on the nuances of the policy process. That research has documented both the sequential strategic steps take in the crafting of individual policies and the long-run sequential nature of political movements that encompass multiple individual policy achievements. However, this literature does not include a robust theory of the general, predictive, systematic features of dynamic policy making. We have proposed one such theory, tailored in particular to the setting in which policy is made through the adjudication of individual disputes. The model yields implications about how a strategic policy-maker will sequence various questions posed in light of the salience or import of the questions and especially the inter-linkages among the various questions.

While we focus on the U.S. Supreme Court as the sequential decision-maker, our model's insights are applicable more broadly. Executive agencies in the bureaucracy face the same dynamic issues. For example, the National Resource Defense Council (NRDC) has often sued the Environmental Protection Agency (EPA) over its enforcement of the Clean Water and Safe Drinking Water Acts. In doing so, it has often entered into consent decrees—agreements between the EPA and NRDC to settle the dispute without any admitting to being wrong. (Golden, 2003, pp. 10) describes this process: "The EPA promulgates rules to fulfill provisions in its authorizing statutes (and their amendments) and to comply with court orders and consent decrees. These two factors even impact agenda items that do not appear to be directly directed by legislation or court order. For example, the EPAs Water Office issues a surprising number of rules regulating test procedures and methods to be used by point sources to measure water emissions, etc. These too are driven by the consent decree. Each time the EPA issues a rule to comply with the consent decree it must then promulgate rules regulating methods and test procedures for that type of point source or emission."

Connected disputes and strategic dilemmas. Courts make policy through the adjudication of individual cases, establishing rules emerge through those individual cases and analogy among them (e.g., Fox and Vanberg, 2014; Callander and Clark, 2013). Administrative agencies engage in much the same analogical process, often establishing procedures and rules in the course of their adjudicatory responsibilities. However, this simple fact about the way in which major institutions of government work raises a fundamental, perplexing question: What makes a good case for a court, or agency, to use to articulate a doctrine or rule? Much work has been done on agenda-setting in legislative, administrative, and judicial settings, but that work typically focuses on case-level, static factors that make individual questions warrant resolution. Our analysis reveals that dynamic considerations—specifically the sequential path of disputes—can make seemingly equal disputes more or less attractive vehicles for policy-making. The consequence is that any theory of agenda-setting is necessarily incomplete if it does not model the dynamic linkages among disputes.

Questions presented. Our analysis focuses on a particular dynamic problem—how an adjudicator compares the downstream consequences of resolving problems against the cost of delaying resolution—to the exclusion of a number of other dynamics that might complicate the logic we study. For example, questions left unresolved by a court or bureaucracy might create political incentives for a legislature to take up the issue, thereby creating an alternative set of dynamic costs associated with delay. Complementarily, resolving a dispute might "take the wind out" of a politically salient policy debate. Resolving a dispute may remove future disputes from the docket. These possibilities are intriguing and present promising future extensions to the model; our framework can naturally handle them.

Strategic litigation. Another potential dynamic that we do not consider here is the role of litigants in setting the docket. Research on purposefully-driven agenda-setting usually considers how signals sent by litigants can communicate to the Court the importance of a given case (e.g., McGuire and Caldeira, 1993; McGuire, 1994; Boucher and Segal, 1995; Spriggs and Wahlbeck, 1997). Our framework has implications for how interested, potentially strategic, litigants can influence the mix of issues available for resolution at any given time. While our theory is deliberately stark and omits consideration of strategic litigants and other actors—the theory considers only the incentives of a court facing a set of disputes with exogenous linkages—it provides the theoretical underpinnings for a fuller consideration of the incentives such actors would face.

If the Court is sensitive to the anticipated consequences of resolution—even of resolution of *another* dispute—then there is a chance litigants can increase the likelihood their case is heard by manipulating the whole docket over time. A variety of questions in political science concerning distributive politics are implicitly motivated by this concern, most notably in the study of the development of rights through litigation (e.g., Epp, 1998; Kersch, 2004; Sanders, 1999).

Moreover, this type of strategy is not just a feature of long trends in special interest litigation. Administrative agencies specifically identify the links among cases as a component of their strategic calculus. An OECD report on competition between the US Federal Trade Commission and the

Department of Justice notes, "The Commission sometimes brings cases not only because of the immediate market impact, but also because the case may help clarify the law.. . . [T]he value of enforcement action goes beyond the specific case by clarifying the law and in turn guiding the broader business community" (*Roundtable on Competition Authorities' Enforcement Priorities*, 1999).

In this paper we assume that the initial docket is exogenous, and that subsequent dockets are a function of strategic choices made only by the Court. In reality, the probabilistic connections among cases in our model are a rich strategic game involving litigants, courts, and special interests, among other actors. Future extensions to the modeling framework could consider how actors such as interest groups, lower courts, executives, and legislatures might use their various tools (*e.g.*, lawsuits, interpretation of precedent, prosecutions, and legislation) to create and alter links between current and future disputes. In a sense, while our theory is merely one of many ways in which issue linkages can be conceptualized, a framework such as the one we provide is arguably necessary for any full theoretical treatment of how phenomena such as issue networks (Heclo, 1978) emerge, as well as understanding more generally how and why interest groups attempt to tie issues together when lobbying legislatures and the public (Baumgartner and Leech, 1998, 2001; Hurwitz, Moiles and Rohde, 2001; Baumgartner and Jones, 1993, 2009).

Non-informational percolation. Much has been written about why courts, especially the US Supreme Court, demur from resolving seemingly pressing questions. Normative theorists (e.g., Bickel, 1962; Ely, 1980; Sunstein, 1999), for example, contend courts should avoid answering too many questions, in order to leave as much authority as possible in the hands of more directly democratically-accountable institutions. Others have argued that courts need to allow issues to percolate in order to observe how disputes play out and thereby learn what resolution is best suited to the problem (e.g., Tiberi, 1993; Clark and Kastellec, 2013). Still others claim that it is too demanding to select which disputes to resolve and how much effort to put into any given question, so courts must rely on cues from the political world to navigate the mass of disputes that come before them (e.g., Caldeira and Wright, 1988). Our model provides an alternative account for why courts might allow issues to percolate and remain unresolved, which is grounded in the dynamic nature of dispute resolution. By enduring an unresolved dispute, a court might forestall significant downstream consequences, such as a flood of new questions or issues. Indeed, it is a common understanding in the literature on litigation—especially concerning the definition of rights—that once the Supreme Court wades into an issue area, it often provokes a massive flood of new questions implied by its resolution of the initial dispute. The legal world has a term for this flood of cases, the "progeny." From the perspective of our analysis, delay can be interpreted not as a dispute resolver *qua* turtle stretching its head out to see what it can learn but instead as a dispute resolver *qua* ostrich sticking its head into the sand to hide from what is coming.

The Punctuated Nature of Policymaking. By incorporating dynamic linkages between issues, our theory is relevant to a set of questions that extends far beyond judicial agenda-setting and decision-making. In particular, the theory provides an endogenous prediction of policy changes and decisions that are clustered (or, perhaps, "clumpy") across time. The confluence of two ubiquitous, but seemingly contradictory, attributes of political processes within mature institutions—"a plethora of small accommodations and a significant number of radical departures from the past"—have led scholars to search for a theoretical explanation. *Punctuated Equilibrium Theory* is a broad description of such processes. Punctuated equilibrium theory explains the coexistence of these phenomena by emphasizing issue definition and agenda setting, and by arguing that "reinforcement creates great obstacles to anything but modest change, whereas questioning policies at the most fundamental levels creates opportunities for major reversals" (Baumgartner, Jones and Mortensen, 2014). Our theory complements this tradition. In particular, our theory explains both stasis and "punctuations" in a single framework, but it does so without relying on ancillary concepts such as bounded rationality or limited attention.[11] Our theory's complementary perspective is based on the interactive effect of both foresight—some disputes or decisions should be delayed while awaiting others to "play out," and the very real possibility that multiple decisions might have common dynamic effects—these dynamic interconnections are the key to our theory's prediction of periods of relative quiet being interrupted intermittently by bursts of multiple decisions at once.

[11]Our theory is not inconsistent with these concepts, and indeed one could utilize such concepts to build a model of where the linkage matrix—the connections between disputes—comes from. But we leave that for future work.

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A Technical Results and Proofs

For presenting the proofs of the numbered results in the body of the article, two additional results are useful. The following simple proposition states that the set of optimal adjudication strategies is nonempty and, for generic cost vectors c, contains a unique element. That is, there exists a unique optimal adjudication strategy for any setting, time horizon and discount factor.

Proposition 3 *For any set of $n > 1$ disputes, $\mathcal{D}$, adjudication cost $k > 0$, and binary $n \times n$ linkage matrix L,*

1. *for any $\delta \in (0, 1]$, any integer $T \geq 1$, and n-dimensional vector of costs, $c > 0$, the set of optimal adjudications for $\sigma = (\mathcal{D}, c, k, L)$, given δ and T, is nonempty: $\mathcal{A}^*(\sigma, T, \delta) \neq \emptyset$, and*
2. *the set of cost vectors $c > 0$ such that $\mathcal{A}^*(\sigma, T, \delta)$ contains more than one element possesses Lebesgue measure zero in $\mathbf{R}^n_{++}$.*

Proof: Fix an integer $n > 1$, a set of n disputes, $\mathcal{D}$, an adjudication cost $k > 0$, and a binary $n \times n$ linkage matrix L. We prove the two conclusions of the proposition in turn.

Existence of an Optimal Adjudication Strategy. Fixing a discount factor $\delta \in (0, 1]$, a positive integer $T \geq 1$, and an n-dimensional vector of costs, c, each adjudication strategy $\alpha \in \mathcal{A}(\sigma, T)$ yields a finite payoff, $EU(\alpha; \sigma, T, \delta, D_1)$, so that the set of these feasible payoffs is nonempty. Furthermore, the set of adjudication strategies, $\mathcal{A}(\sigma, T)$ is finite so that the set of feasible payoffs from these strategies is also finite. Accordingly, at least one adjudication strategy $a^* \in \mathcal{A}(\sigma, T)$ achieves the maximum of the set of the feasible payoffs and accordingly $a^* \in \mathcal{A}^*(\sigma, T, \delta) \neq \emptyset$, as was to be shown.

Generic Uniqueness of the Optimal Adjudication Strategy. The proof proceeds by induction on T. Fixing a discount factor $\delta \in (0, 1]$ and an n-dimensional vector of costs, c. Fix the time horizon at $T = 1$. The set of adjudication strategies $\mathcal{A}(\sigma, 1)$ consists of every mapping from $2^{\mathcal{D}}$ into itself. For each docket $D \subseteq \mathcal{D}$, the court's payoff from a strategy $a \in \mathcal{A}(\sigma, 1)$ is

$$U_1(a(D, 1), D) = -k|a(D, 1)| - \sum_{d \in r(a, D, 1)} c(d),$$

where $r(a,D,1) \equiv D \setminus a(D,1)$. To keep the presentation simple, note that by the assumption that $k > 0$, an adjudication strategy a can be optimal only if $a(D,1) \subseteq D$ for every $D \subseteq \mathcal{D}$. Accordingly, we consider only such strategies in what follows.

For two strategies a and a' in $\mathcal{A}(\sigma,1)$ with $a(D,1) \neq a'(D,1)$, $U_1(a(D,1),D) = U_1(a'(D,1),D)$ implies that

$$\begin{aligned}
k|a(D,1)| + \sum_{d \in r(a,D,1)} c(d) &= k|a'(D,1)| + \sum_{d \in r(a',D,1)} c(d), \\
k(|a(D,1)| - |a'(D,1)|) &= \sum_{d \in r(a',D,1)} c(d) - \sum_{d \in r(a,D,1)} c(d), \\
k(|a(D,1)| - |a'(D,1)|) &= \sum_{d \in r(a',D,1) \setminus r(a,D,1)} c(d) - \sum_{d \in r(a,D,1) \setminus r(a',D,1)} c(d). \qquad (5)
\end{aligned}$$

Without loss of generality, suppose that $r(a',D,1) \setminus r(a,D,1) \neq \varnothing$.[12] Then let e denote a dispute in $r(a',D,1) \setminus r(a,D,1)$. Then we can rewrite Equation (5) as

$$c(e) = k(|a'(D,1)| - |a(D,1)|) + \sum_{d \in r(a',D,1) \setminus r(a,D,1) \setminus \{e\}} c(d) - \sum_{d \in r(a,D,1) \setminus r(a',D,1)} c(d). \qquad (6)$$

Note that the left hand side of Equation (6) is exactly identified by the right hand side, implying that the space of n-dimensional vectors c that satisfy Equation (6), given k, possesses a dimensionality of no greater than $n-1$. Any space of dimension strictly less than n is assigned measure zero by n-dimensional Lebesgue measure. This establishes the second conclusion of the proposition for $T = 1$.

Now let T be an arbitrary positive integer and presume that $\mathcal{A}^*(\sigma, T-1, \delta)$ contains a single strategy for all cost vectors c except a set assigned measure zero by possessing n-dimensional Lebesgue measure (*i.e.*, for a generic set of cost vectors c). Then, for a generic set of cost vectors c, any pair of T-optimal strategies, a and a' in $\mathcal{A}^*(\sigma, T, \delta)$, must be identical for periods 2 through T, so that to be distinct, they must differ in the first period: there must be some docket $D \in \mathcal{D}$ such that $a(D,1) \neq a'(D,1)$. This argument above can be readily applied to show that the equality of the total

[12] This is without loss of generality because it amounts to a simple choice of labeling, because either $r(a',D,1) \setminus r(a,D,1)$ or $r(a,D,1) \setminus r(a',D,1)$ or both must be nonempty by the supposition that $a(D,1) \subseteq D$ for every $D \subseteq \mathcal{D}$ and $a(D,1) \neq a'(D,1)$.

payoffs from a and a' must uniquely identify the cost of not resolving some dispute $d \in D$, implying that the equality holds on a set of cost vectors possessing dimensionality less than n, yielding the desired result. ∎

The next result shows that any dispute resolved in an optimal adjudication strategy for a given docket is also resolved in an optimal adjudication strategy for a docket that is a superset of that docket.

Proposition 4 For any setting $\sigma = (\mathcal{D}, c, k, L) \in \Sigma$ and any pair of dockets, D and D' with

$$D \subset D' \subseteq \mathcal{D},$$

any 2-period optimal adjudication in D is contained within a 2-period optimal adjudication in D', and every 2-period optimal adjudication in D' contains a 2-period optimal adjudication in D. Formally, for both $t \in \{1, 2\}$,

$$\begin{aligned} a \in A_t^*(D) \quad &\Rightarrow \quad \exists a'_a \in A_t^*(D') \text{ such that } a \subseteq a'_a, \text{ and} \\ a' \in A_t^*(D') \quad &\Rightarrow \quad \exists a_{a'} \in A_t^*(D) \text{ such that } a_{a'} \subseteq a'. \end{aligned}$$

Proof: For any docket D, any adjudication a, and any pair of disputes d, e with $\{d, e\} \subseteq D$, $d \in a$, and $e \notin a$, the net value of resolving d in the first period when $T = 2$ is

$$W(d; D, a) = V_2(a; D) - V_2(a_{-d}; D) = c(d) - V_1(d) - k + \sum_{\delta \notin D} (P(\delta; D, a) - P(\delta; D, a_{-d}))\, V_1(\delta).$$

Note that, if a is an optimal 2-period adjudication, then $W(d; a) \geq 0$ for each $d \in a$. Thus, because $V_1(\delta) \leq 0$ and $P(\delta; D, a) > P(\delta; D, a_{-d})$ for any dispute δ, note that

$$c(d) - V_1(d) - k \geq 0$$

is a necessary condition for d to be part of an optimal 2-period adjudication. Now consider any D'

with $D \subset D'$. Then

$$W(d;D',a) = V_2(a;D') - V_2(a_{-d};D') = c(d) - V_1(d) - k + \sum_{\delta \notin D'} \left(P(\delta;D',a) - P(\delta;D',a_{-d})\right) V_1(\delta).$$

Note that $P(\delta;D',a) = P(\delta;D,a)$ and $P(\delta;D',a_{-d}) = P(\delta;D,a_{-d})$ for all $\delta \notin D \cup D'$. Thus, because $D \subset D'$,

$$\sum_{\delta \notin D'} \left(P(\delta;D',a) - P(\delta;D',a_{-d})\right) V_1(\delta) \geq \sum_{\delta \notin D} \left(P(\delta;D,a) - P(\delta;D,a_{-d})\right) V_1(\delta),$$

so that $W(d;D,a) \geq 0$ implies $W(d;D',a) \geq 0$. Accordingly, for any 2-period optimal adjudication $a^* \in A^*(D)$, there is a 2-period optimal adjudication $a^{**} \in A^*(D')$ such that $a^* \subseteq a^{**}$.

To show the converse (that a 2-period optimal adjudication in $D' \supset D$ must contain a 2-period optimal adjudication in D), the inequalities above can be applied to any 2-period optimal adjudication in D', a^{**}, as follows. Beginning with $a^1 \equiv a^{**} \cap D$, eliminate any dispute $d \in$ for which $W(d;D,a^1) < 0$. If there is no such dispute, then a^1 is a 2-period optimal adjudication in D. If there is such a dispute $d^1 \in a^1$ (if there are multiple disputes that satisfy this, the choice of which dispute to eliminate is irrelevant for our purposes), then let $a^2 \equiv a^1 \setminus \{d^1\}$ and eliminate any dispute d^2 for which $W(d^2;D,a^1) < 0$ (again, choosing arbitrarily if necessary), and let $a^3 \equiv a^2 \setminus \{d^2\}$. If there is no such dispute d^2, then a^1 is a 2-period optimal adjudication in D. Iteration of this process will ultimately conclude, because D is finite. ∎

Proposition 1 *For any setting $\sigma = (\mathcal{D}, c, k, L) \in \Sigma$, any discount factor $\delta \in (0,1]$, a dispute $d \in \mathcal{D}$ is percolable if and only if*

$$c(d) < k\left(1 + \frac{\delta |S_L(d)|}{2}\right) - \delta \min[k, c(d)].$$

Proof: Fix a setting $\sigma = (\mathcal{D}, c, k, L) \in \Sigma$ and a discount factor $\delta \in (0,1]$. The proof proceeds in two steps, establishing sufficiency of Equation (4) and then establishing its necessity. Note that Assumption 1 ensures that, for any T-optimal adjudication strategy (for any integer $T > 1$), $a_t^*(\mathcal{D}) = \mathcal{D}$ for all $t < T$.

Sufficiency of Equation (4). Consider any dispute d satisfying Equation (4). Then consider the docket $D = \{d\}$. Then, by Assumption 1, the maximum payoff from resolving dispute d, $a_1 = \{d\}$, is no greater than

$$-k - \delta\frac{k}{2}|S_L(d)|,$$

which obtains only if every dispute $e \in S_L(d)$ is left unresolved at cost $c(e) = \frac{k}{2}$ (the minimal costliness ensured by Assumption 1), and the maximum payoff from not resolving the dispute, $a_1 = \{\}$, is equal to

$$U(\{\}) = -c(d) - \delta \min[k, c(d)].$$

Thus, leaving d unresolved is optimal only if

$$\begin{aligned} -c(d) - \delta \min[k, c(d)] &\geq -k - \delta\frac{k}{2}|S_L(d)|, \\ c(d) &\leq k\left(1 + \frac{\delta|S_L(d)|}{2}\right) - \delta \min[k, c(d)], \end{aligned}$$

as stated in the proposition. This demonstrates the sufficiency of Inequality 4 for a dispute d to be percolable.

Necessity of Equation (4). To see the necessity of Inequality 4, note that if not resolving d is 2-period optimal for any docket D, it is optimal to leave it unresolved for $D' = \{d\}$, by Proposition 4. Accordingly, if a dispute d is percolable, it must satisfy Inequality 4, as was to be shown. ∎

Proposition 2 *For any setting $\sigma = (\mathcal{D}, c, k, L) \in \Sigma$, any positive integer T, any discount factor δ, and any T-period optimal adjudication $a^* \in \mathcal{A}^*(\sigma, T, \delta)$, if $d \in \mathcal{D}$ is ancillary to $d' \in \mathcal{D}$, then for any $D \subseteq \mathcal{D}$ with $\{d, d'\} \subseteq D$, $d' \in a^*(D, 1)$ implies $d \in a^*(D, 1)$.*

Proof: Fix a setting $\sigma = (\mathcal{D}, c, k, L) \in \Sigma$, a positive integer T, and a discount factor δ. Then let $a^* \in \mathcal{A}^*(\sigma, T, \delta)$ be a T-period optimal adjudication for σ and consider a docket $D \subseteq \mathcal{D}$ with a pair of disputes d and d' such that d is ancillary to d'.

For the purpose of obtaining a contradiction, suppose—contrary to the conclusion of the proposition—

that $d' \in a^*(D,1)$ but $d \notin a^*(D,1)$. Let t_d^* denote the time period that a^* resolves d:

$$t_d^* = \begin{cases} \{t \in \{1,\dots,T\} : d \in a_t^*\} & \text{if } \exists t : d' \in a_t^* \\ T+1 & \text{otherwise.} \end{cases}$$

(Note that t_d^* is uniquely defined if a^* is a T-period optimal adjudication.) Then let a' be a T-period adjudication identical to a^* except that $a_1' = a_1^* \cup \{d\}$ and $a'_{t_d^*} = a^*_{t_d^*} \setminus \{d\}$. The proof proceeds in two cases: $T = 2$ and $T > 2$.

$T = 2$. In the two-period setting, if $c(d) > k$, then the 2-period optimality of a^* implies that $d \in a_2^*$, so that $t_d^* = 2$. Then the net payoff of a' relative to the 2-period optimal strategy a^* is

$$U(a'; D_1) - U(a^*; D_1) = -\left[k(1-\delta) - c(d)\right]. \tag{7}$$

In order for a^* to be a 2-optimal adjudication strategy, it must be the case that the left hand side of Equation (7) is nonpositive, which reduces to

$$\begin{aligned} \left[k(1-\delta) - c(d)\right] &\geq 0, \\ c(d) &\leq k(1-\delta), \end{aligned}$$

which contradicts the supposition that $c(d) > k$. Thus, it must be the case that $c(d) \leq k(1-\delta)$, so that the 2-period optimality of a^* implies that $d \notin a_2^*$ and $t_d^* = 3$.

$$U(a'; D_1) - U(a^*; D_1) = -\left[k - (1+\delta)c(d)\right]. \tag{8}$$

In order for a^* to be a 2-optimal adjudication strategy, it must be the case that the left hand side of Equation (8) is nonpositive, which reduces to

$$\begin{aligned} \left[k - (1+\delta)c(d)\right] &\geq 0, \\ c(d) &\leq \frac{k}{1+\delta}. \end{aligned}$$

Assumption 1 implies that $c(d) > \frac{k}{1+\delta}$. Accordingly, a^* being a 2-optimal adjudication strategy with $d \notin a_1^*$ implies that Assumption 1 is not satisfied, resulting in a contradiction. Thus, if a^* is a 2-optimal adjudication strategy, $d' \in a_1^*$ implies that $d \in a_1^*$, as was to be shown.

$T > 2$**.** For $T > 2$, the same two sub-cases as in the consideration of $T = 2$ above, $k < c(d)$ and $k \geq c(d)$ emerge. It is simple to show that if $k < c(d)$, then $t_d^* < T + 1$ and the logic for the 2 period case applies, because a^* is dominated by any strategy a'' that is identical to a^* except that d is resolved in period $t_d^* - 1$ instead of period t_d^*. Given the finite time horizon, this then leads by induction to an analogous contradiction as in the $T = 2$ case, so that the desired result is obtained.

Accordingly, suppose that $k \geq c(d)$ and, further, that $t_d^* = T + 1$, because otherwise the inductive argument above could be applied based on the presumption that a^* is optimally not deferring resolution of d farther into the future.

The net payoff of the modified strategy a' relative to the T-period optimal adjudication strategy a^* is then:

$$U(a'; D_1) - U(a^*; D_1) = -\left[k - \sum_{t=0}^{T-1} \delta^t c(d)\right]. \tag{9}$$

Then, a^* being T-optimal implies that

$$\begin{aligned} k - \sum_{t=0}^{T-1} \delta^t c(d) &\geq 0, \\ c(d) &\leq \frac{k}{\sum_{t=0}^{T-1} \delta^t}. \end{aligned}$$

Note that

$$\sum_{t=0}^{T-1} \delta^t > (1 + \delta),$$

so that a^* being T-optimal implies that Assumption 1 is violated, resulting in a contradiction. Thus, if a^* is a T-optimal adjudication strategy, it must be the case that $d' \in a_1^*$ implies that $d \in a_1^*$, as was to be shown. ∎