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LEGAL PRECEDENT:
A THEORETICAL AND EMPIRICAL ANALYSIS

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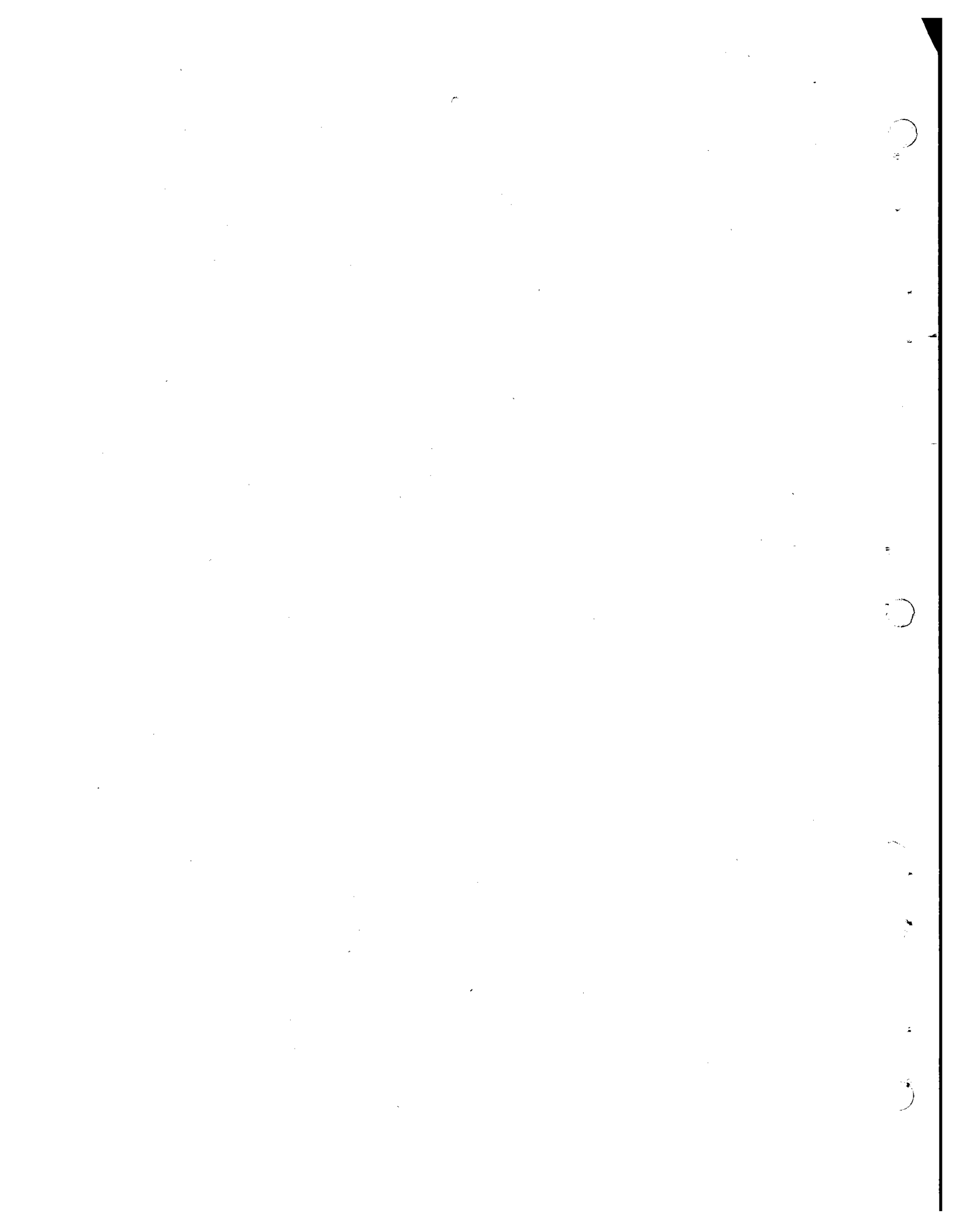
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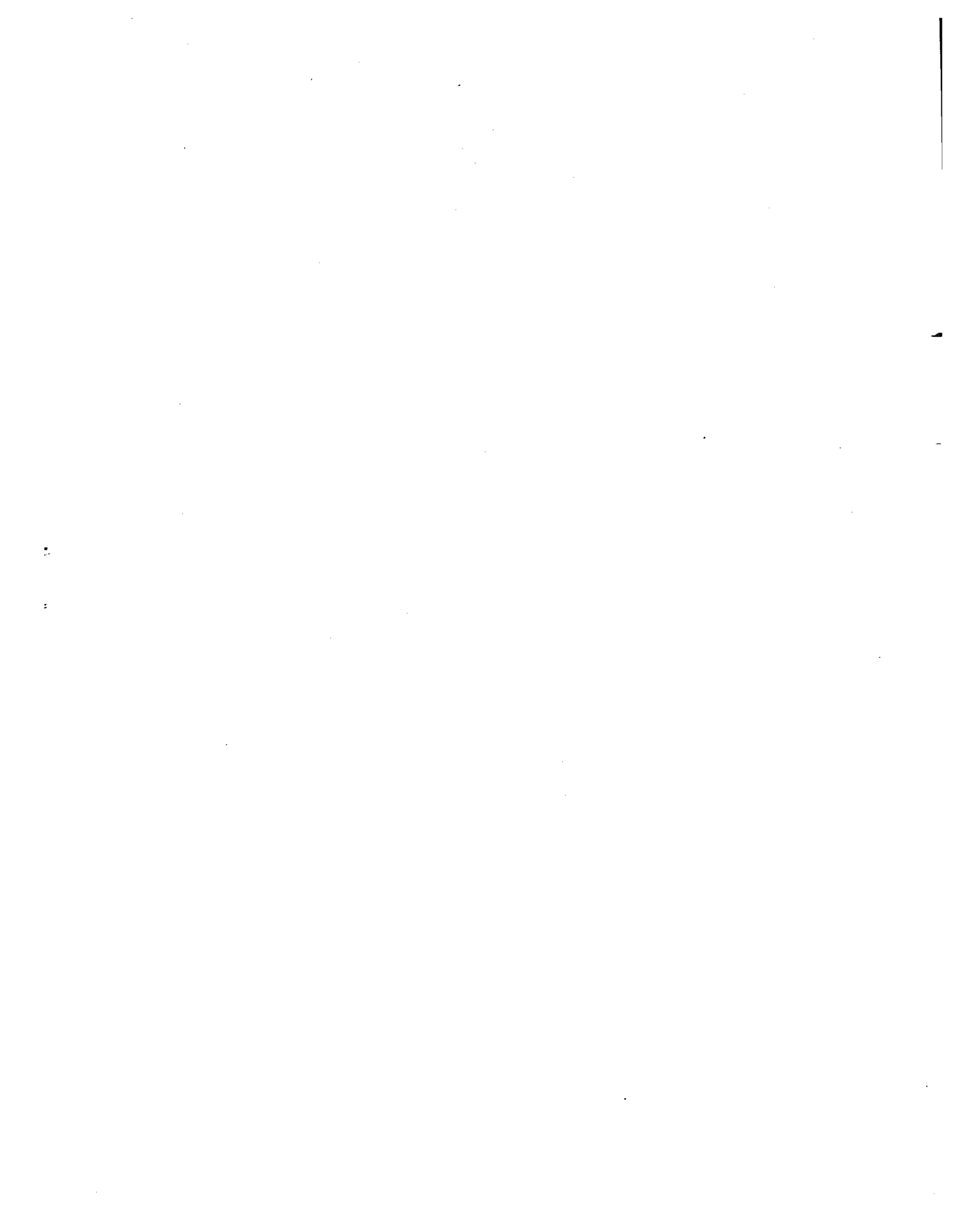
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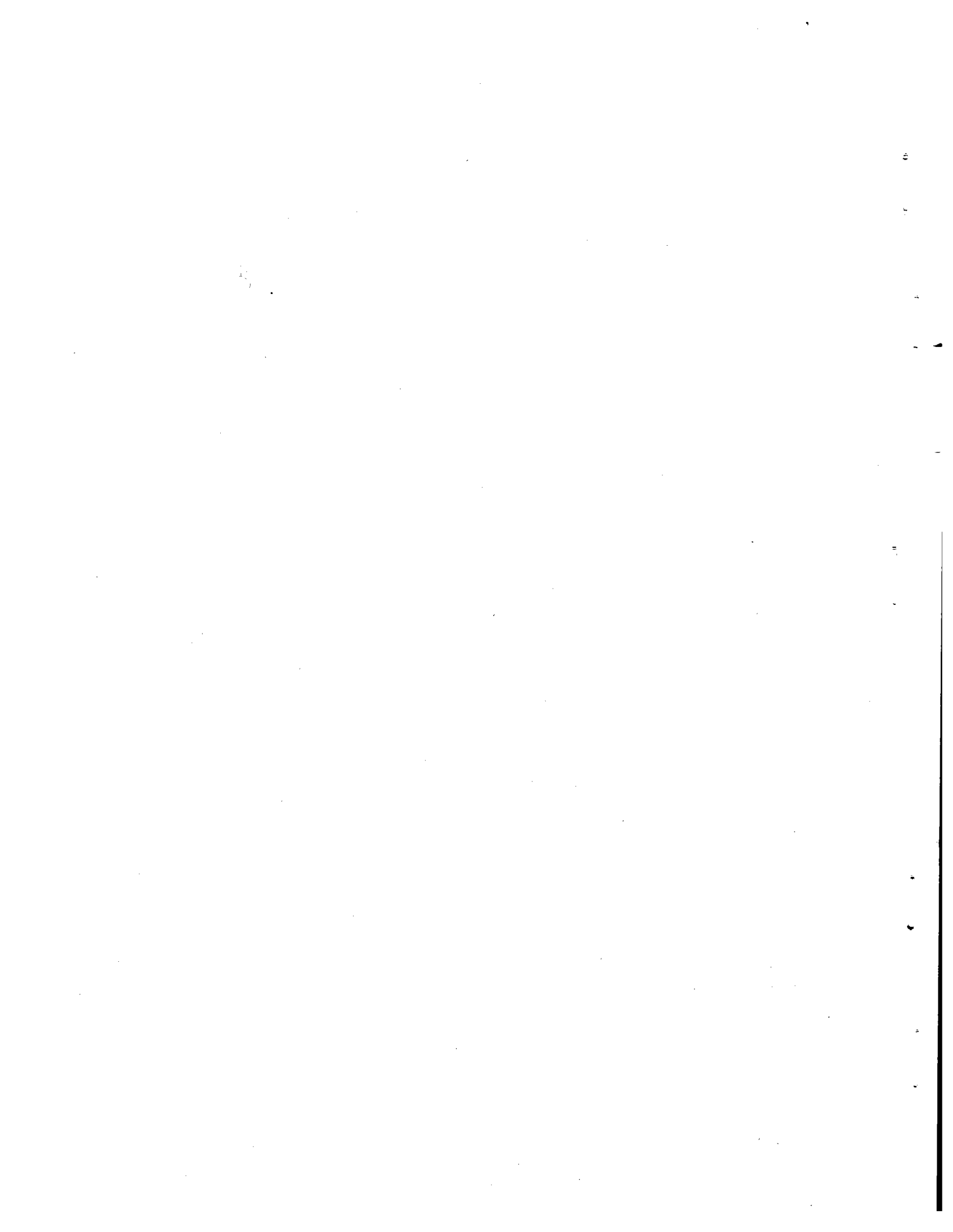
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LEGAL PRECEDENT: A THEORETICAL AND EMPIRICAL ANALYSIS*

William M. Landes** and Richard A. Posner***

I. Introduction

In a legal system such as ours, in which legislative bodies confine themselves for the most part to prescribing general norms of conduct rather than highly specific rules, the published decisions of courts and administrative agencies interpreting and applying the legislative enactments are important sources of the specific rules of law. When the parties to a legal dispute are unable to agree on the meaning of the governing statute as applied to their dispute, litigation may ensue in which that meaning will be an issue for the court to resolve. The court's resolution will define the specific requirements of the statute in the circumstances presented by the case and thus create (subject to a qualification noted below) a specific rule of legal obligation applicable to like circumstances.

The rules produced by the process of adjudication are distinctive in being implicit rather than explicit rules.¹ The rule promulgated by a decision is not the court's express statement, if any, of a rule; rather, it is the court's holding, that is, the minimum rule (whether or not expressly articulated) necessary to explain the outcome of the case. The rule created by a single decision will therefore tend to be extremely narrow in scope; a broader judge-made rule will generally require a series of

judicial decisions--a string of holdings--for it is only from a series of decisions, each determining the legal significance of a slightly different set of facts, that a rule applicable to a situation common or general enough to be likely to recur in the future can be inferred.

A factor pushing in the same direction is that the authority of a rule declared in a single decision is limited unless the rule is declared by a higher court for the guidance of a lower one in the same jurisdiction. Especially in appellate litigation, most of the judge-made rules urged on the court are those of a coequal court, or those declared in the earlier decisions of the same court; such rules have persuasive force, but are not binding. Where, however, the rule has been, as it were, solidified in a long line of decisions, the authority of the rule is enhanced. The rule then represents the accumulated experience of many judges responding to the arguments and evidence of many lawyers and is therefore more likely to be followed in subsequent cases.

The distinctive attributes of decisional rules are captured in the term that the legal system uses to describe such rules: "precedents." In ordinary language, a precedent is something done in the past that is appealed to as a reason for doing the same thing again. It is much the same in law. The earlier decision provides a reason for deciding a subsequent similar case the same way, and a series of related precedents may crystallize a rule having much the same force as a statutory rule. Accordingly, legal precedents are more accurately described as

inputs into the production of judge-made rules of law than as the rules themselves; but this refinement will be ignored in this paper to simplify the exposition.

The use of precedents to create rules of legal obligation has, to our knowledge, received little theoretical or empirical analysis.² This paper presents and tests empirically an economic approach to legal precedent that is derived mainly from the analysis of capital formation and investment. We treat the body of legal precedents created by judicial decisions in prior periods as a capital stock that yields a flow of information services which depreciates over time as new conditions arise that were not foreseen by the framers of the existing precedents. New (and replacement) capital is created by investment in the production of precedents.

The basic data for the empirical analysis are case citations appearing in judicial opinions. An initial problem is that a case citation is not the same thing as a precedent. Sometimes a case is not cited as a precedent; an example is a citation of the decision of a lower court (or courts) in the same case. Our samples exclude this obvious nonprecedential citation, and other (less obvious) ones.³ In some instances, counting citations may result in underestimating the true number of precedents by excluding the precedent that is so effective in defining the requirements of the law that it prevents legal disputes from arising in the first place or, if they do arise, induces them to be settled without litigation. In the limit, such a "superprecedent" might never be cited in an appellate opinion yet have greater precedential significance than the most frequently cited cases. But such cases are probably rare. If a case is highly specific, it will hardly qualify as a "superprecedent";

by definition it will control only those infrequent cases that present virtually identical facts to those of the case in which it was originally announced. If it is highly general, and therefore more likely to be an important precedent, it is unlikely to decide so clearly as to prevent disputes or litigation from arising, the specific form of the question presented in subsequent cases.

Citations by scientists and other scholars to scientific and scholarly books and articles (rather than by lawyers and judges to cases) have been studied extensively by historians of science, by sociologists, and by economists.⁴ Scholarly citations, however, are not examples of the use of precedent. The normal function of the scholarly citation is not to adduce authority for a proposition but to give credit for prior original work, to refer the reader to corroborative or collateral findings by other scholars, and as a method of incorporating by reference relevant theorems, proofs, etc. Since the second and third functions of scholarly citation have counterparts in judicial citation, studies of scholarly citation may have relevance to understanding judicial citation, but the present paper does not explore the possible parallels between scholarly and judicial citation.

The idea of analyzing judicial citation practices for regularities that might refute or support hypotheses derived from capital theory will no doubt strike many lawyers, both practicing and academic, as a dubious undertaking. Not only are many lawyers skeptical in general concerning the use of economic models and quantitative methods to study the legal system, but they assume that judges' citation practices are altogether too idiosyncratic to be illuminated by general theory and statistical

aggregation. Whether a judicial opinion cites many cases or few, old cases or new, is, they believe, more a function of the judge's personal style, tastes, erudition, pedantry, etc. than of systematic characteristics of the legal process. Yet this seems improbable. The extensive research and writing that lawyers, judges, and law clerks devote to discovering, marshalling, enumerating, and explaining precedents are not costless undertakings, and would not be undertaken if precedent did not enter systematically into the decision of cases. However, the question whether or not the use of precedents is systematic does not have to be decided on a priori grounds; to the extent that judicial citation practices exhibit regularities explicable within a systematic analytical framework, a statistical analysis of precedent should reveal them.

The paper is organized as follows. Part II describes our case samples and presents tables summarizing the principal characteristics of citations. The theoretical analysis is contained in Part III. There we formalize the capital-investment model, derive hypotheses, and discuss the production of precedents in the absence of an explicit market. Part IV develops techniques for using case citations to study precedents empirically and presents the results of our empirical analysis. The final part of this paper, Part V, suggests some areas of further research utilizing the approach developed here.

II. The Samples

Our first and principal source of data on precedents is a random sample of 658 decisions (an approximately one-in-ten sample) handed down by the federal courts of appeals during an approximately 18-month period beginning in January 1974 and ending in the summer of 1975. Each decision was classified by subject matter, and the number and age of citations to both earlier Supreme Court and other-court decisions were recorded. Two other data sources were also developed for this study: a random sample of 223 decisions (again an approximately one-in-ten sample) by the federal courts of appeals during 1960, and all of the decisions handed down by the Supreme Court during its 1974 term.

Table 1 presents a subject-matter breakdown of the decisions in our three data sets. The subject-matter classifications we employ are gross,⁵ but this is unavoidable because of the limited number of cases included in our samples. Table 1 indicates the close comparability between the subject-matter distributions of our 1960 and 1974-1975 courts of appeals samples and those reported by the Administrative Office of the U.S. Courts for all cases commenced in the courts of appeals in fiscal years 1960 and 1974 respectively.⁶

[Insert Table 1]

TABLE 1
Samples Utilized in Study

Subject-matter Classification	Sample						Total Commenced	
	U.S. Courts of Appeals ¹		U.S. Supreme Court		U.S. Courts of Appeals ⁴		1974 (%)	1960 (%)
	1974-1975 No.	1960 No. (%)	1974 Term ² No.	(%)	1974 (%)	1960 (%)		
Common Law	115	(17.5)	54	(24.2)	13	(8.3)	(12.8)	(23.6)
Torts and contracts	94	(14.3)	48	(21.5)	11	(7.3)		
Admiralty	21	(3.2)	6	(2.7)	2	(1.3)		
Economic Regulation	183	(27.8)	97	(43.5)	48	(30.8)	(20.7)	(33.2)
Tax	36	(5.5)	37	(16.6)	8	(5.1)		
Antitrust	12	(1.8)	4	(1.8)	8	(5.1)		
Labor	53	(8.1)	26	(11.7)	17	(10.9)		
Federal regulatory agencies, n.e.c.	50	(7.6)	10	(4.5)	13	(8.3)		
Patents, copyrights, and trade marks	32	(4.9)	20	(9.0)	2	(1.3)		
Civil Rights	47	(7.1)	2	(0.9)	13	(8.3)	(9.1)	(1.1)
Constitutional ³	65	(9.9)	6	(2.7)	57	(36.5)		
Criminal ³	239	(36.3)	50	(22.4)	37	(23.7)	(31.5)	(21.6)
Criminal (excl. const.)	193	(29.3)	46	(20.6)	42	(7.7)		
Bankruptcy	17	(2.6)	7	(3.1)	5	(3.2)	(1.7)	(3.1)
Military	11	(1.7)	5	(2.2)	2	(1.3)		
Land Condemnation	8	(1.2)	5	(2.2)	3	(1.9)	(1.1)	(2.5)
Not Classified	19	(2.9)	1	(0.4)	3	(1.9)	(23.1)	(14.9)
Total	658		223		156			

1. "Memorandum" opinions--very short per curiam (unsigned) opinions that contain no citations--were omitted. Opinions of the U.S. Court of Claims and Court of Customs and Patent Appeals were included in the courts of appeals samples.

2. Summary affirmances (akin to memorandum opinions in the courts of appeals--see note 1 supra) were omitted.

3. Criminal cases (including postconviction proceedings, which are technically civil proceedings) involving constitutional questions were counted in both the Constitutional and Criminal categories; but the second count was subtracted for purposes of computing the totals in the last row of the table.

Sources: Federal Reporter, 2d; U.S. Reports; 1960, 1974 Ann. Reps., Dir., Adm. Off., U.S. Cts.

To avoid becoming confused later on, the reader should be careful to distinguish between the cases in our three samples (hereafter "sample cases") and our measure of precedents. The sample cases presented in Table 1 are not the precedents that we studied; they are the source of our data on precedents. It is the citations in the sample cases that are the precedents (more precisely, the proxy for the precedents) used in the empirical analysis. Thus, we study Supreme Court precedents by analyzing the citations to Supreme Court decisions contained in both the courts of appeals and the Supreme Court sample cases, and courts of appeals precedents by analyzing citations to courts of appeals decisions in both the courts of appeals and Supreme Court sample cases. This is not the only way to collect and analyze data on precedents. An alternative approach, not used in this study, is to trace the history of a case as a precedent by counting the citations to that case in later judicial opinions.⁷

Table 2 summarizes the data on precedents that we obtained from the three sets of sample cases. The average ages, standard errors, and numbers of citations are presented by subject-matter classes for each data set.⁸ Within each subject-matter classification there is a further breakdown between citations to U.S. Supreme Court decisions and citations to other court decisions. The reason for distinguishing empirically among subject matters, and between Supreme Court and other-court citations, is that theory (developed in the next part of this paper) suggests that precedents will differ systematically both across subject-matter classes and between the Supreme Court and other courts, in particular the U.S. courts of appeals.⁹

Two methods of calculating the age of citations are used in Table 2.

The column labeled "unweighted" is the mean across decisions of the average age of the citations in each decision. The column labeled "weighted" is the average of all of the citations in the subject-matter class (i.e., the average age of the citations in each decision weighted by the number of citations).¹⁰ An example will help to clarify the difference between the unweighted and weighted method. In the 1974-1975 courts of appeals sample, 492 cases cited Supreme Court precedents. For each of these 492 cases we calculated the mean age of citations to Supreme Court citations. The unweighted age (18.5 years in Table 2) is the average of the 492 means (i.e., in effect each of the 492 case means is given a weight of one). The weighted average (19.1 years in Table 2) weights each of the 492 case means by the number of citations contained in that case, and is thus equivalent to the mean age of the 2,278 citations contained in the 492 sample cases.

[Insert Table 2]

Table 2 reveals some interesting regularities in the age of judicial citations. Citations to Supreme Court decisions regularly tend to be twice as old on average as citations to other courts' decisions--roughly, 20 years old compared to 10.¹¹ Of further interest is the similarity of the weighted and unweighted means and of the age distributions across subject-matter classes among the 1960 and 1974-1975 court of appeals samples and the 1974 Supreme Court sample. Another interesting statistic is the "half life" (i.e., median age) of a precedent. In the 1974-1975 courts of appeals sample, half of the citations to Supreme Court and other-court decisions were less than 9.8 and 4.3 years old, respectively (compared to weighted means of 19.1 and 9.9 years). In the 1974 Supreme Court sample,

TABLE 2
Average Age (in Years) of Citations¹

Subject-Matter Classification	U.S. Courts of Appeals, 1974-1975					
	Supreme Court			Other Courts		
	Age		No. per case	Age		No. per case
	w	u		w	u	
Total	19.1 (.3) [2278]	18.5 (.7) [492]	4.630 (.228)	9.9 (.1) [5785]	8.8 (.3) [629]	9.197 (.360)
Common law	33.8 (1.5) [213]	29.9 (2.5) [61]	3.492 (.385)	14.8 (.3) [1061]	13.6 (.9) [114]	9.307 (.667)
Torts and contracts	35.6 (1.9) [137]	30.6 (3.1) [41]	3.341 (.457)	15.7 (.3) [856]	14.3 (1.0) [94]	9.106 (.663)
Admiralty	30.6 (2.2) [76]	28.5 (4.3) [20]	3.800 (.720)	10.9 (.5) [205]	10.5 (1.9) [20]	10.25 (2.319)
Economic regulation	19.5 (.5) [588]	18.7 (1.3) [132]	4.455 (.464)	10.3 (.2) [1660]	9.5 (.5) [176]	9.432 (.720)
Tax	26.1 (1.6) [66]	21.5 (2.7) [26]	2.538 (.494)	15.1 (.4) [324]	12.7 (1.3) [33]	9.818 (1.478)
Antitrust	19.1 (.9) [50]	16.8 (2.9) [10]	5.000 (1.183)	6.5 (.5) [107]	8.6 (1.9) [12]	8.917 (2.506)
Labor	14.9 (.6) [186]	14.3 (1.3) [45]	4.133 (.515)	8.3 (.2) [433]	8.0 (.7) [52]	8.327 (1.079)
Other federal reg. agencies	19.2 (.6) [240]	15.9 (2.0) [34]	7.059 (1.486)	8.0 (.2) [510]	7.0 (.9) [47]	10.851 (1.957)
Patents	30.7 (3.5) [46]	33.1 (6.6) [17]	2.706 (.444)	13.2 (.4) [286]	12.5 (1.5) [32]	8.938 (1.148)
Civil rights	10.1 (.5) [172]	8.0 (1.4) [40]	4.300 (.665)	4.0 (.1) [402]	3.7 (.6) [43]	9.349 (1.637)
Constitutional	12.6 (.5) [136]	10.8 (2.0) [17]	8.000 (1.685)	5.5 (.4) [155]	4.4 (.9) [19]	8.158 (1.532)
Criminal (incl. const.)	16.2 (.3) [999]	16.0 (1.0) [202]	4.946 (.378)	8.0 (.2) [2056]	6.2 (.4) [227]	9.057 (.628)
Criminal (excl. const.)	16.1 (.5) [648]	16.8 (1.2) [157]	4.127 (.382)	8.4 (.2) [1650]	6.3 (.4) [183]	9.016 (.737)
Bankruptcy	37.4 (4.8) [14]	37.9 (7.3) [8]	1.750 (.250)	14.7 (.8) [155]	19.6 (2.8) [17]	9.118 (1.749)
Military	11.1 (1.4) [31]	17.1 (2.9) [6]	5.167 (2.272)	6.0 (.3) [82]	5.3 (.9) [11]	7.455 (1.337)
Land condemnation	50.2 (2.4) [60]	39.2 (8.8) [8]	7.500 (1.832)	22.9 (2.4) [61]	21.4 (7.5) [8]	7.625 (1.224)

Subject-Matter Classification	U.S. Courts of Appeals, 1960					
	Supreme Court			Other Courts		
	Age		No. per case	Age		No. per case
w	u	w		u		
Total	22.5 (.6) [497]	20.3 (1.4) [136]	3.654 (.350)	14.8 (.3) [1765]	11.8 (.7) [208]	8.486 (.627)
Common law	33.3 (2.9) [58]	34.6 (4.8) [26]	2.231 (.256)	16.9 (.4) [552]	18.3 (1.7) [52]	10.615 (1.301)
Torts and contracts	32.8 (3.0) [48]	31.6 (4.9) [21]	2.286 (.302)	17.2 (.4) [504]	18.8 (1.8) [47]	10.723 (1.433)
Admiralty	35.9 (8.6) [10]	47.4 (13.8) [5]	2.000 (.447)	13.7 (.7) [48]	14.1 (2.2) [5]	9.600 (1.503)
Economic regulation	19.8 (.7) [254]	16.1 (1.4) [61]	4.164 (.630)	15.2 (.5) [800]	10.5 (1.0) [88]	9.091 (1.108)
Tax	21.7 (1.1) [103]	17.8 (2.0) [25]	4.120 (.851)	21.7 (1.1) [315]	13.2 (2.0) [32]	9.844 (2.124)
Antitrust	20.0 (.4) [41]	19.2 (2.6) [3]	13.667 (9.207)	15.7 (.8) [46]	14.3 (3.0) [4]	11.500 (4.873)
Labor	15.7 (1.5) [60]	13.1 (2.2) [19]	3.158 (.441)	7.2 (.2) [270]	6.7 (.9) [25]	10.800 (2.134)
Other federal reg. agencies	11.0 (.9) [26]	9.9 (2.1) [8]	3.250 (1.436)	10.6 (1.3) [36]	8.0 (2.8) [8]	4.500 (1.452)
Patents	31.3 (2.4) [24]	25.6 (6.6) [6]	4.000 (.966)	17.1 (.6) [133]	11.4 (2.1) [19]	7.000 (2.036)
Civil rights	19.3 (7.2) [3]	15.8 (10.8) [2]	1.500 (.500)	7.1 (.9) [16]	6.2 (3.7) [2]	8.000 (2.000)
Constitutional	57.7 (0.0) [9]	57.7 (0.0) [1]	9.000 (0.000)	16.7 (7.5) [6]	16.7 (16.7) [2]	3.000 (0.000)
Criminal (incl. const.)	20.5 (1.0) [137]	15.9 (2.1) [36]	3.806 (.675)	10.4 (.4) [273]	7.6 (1.0) [46]	5.935 (.946)
Criminal (excl. const.)	20.2 (1.0) [128]	15.5 (2.1) [32]	4.000 (.749)	10.4 (.4) [261]	7.5 (1.1) [43]	6.070 (1.005)
Bankruptcy	32.7 (2.5) [10]	34.9 (9.7) [3]	3.333 (2.333)	13.6 (.6) [39]	10.8 (2.3) [7]	5.571 (1.510)
Military	8.2 (1.5) [5]	9.4 (2.3) [3]	1.667 (.667)	11.3 (1.0) [34]	6.1 (2.5) [5]	6.800 (3.693)
Land condemnation	24.5 (1.6) [18]	21.6 (6.0) [3]	6.000 (1.528)	17.1 (.8) [41]	16.5 (2.4) [5]	8.200 (1.855)

Table 2 cont.

Subject-Matter Classification	Supreme Court, 1974-1975					
	Supreme Court			Other Courts		
	Age		No. per case	Age		No. per case
w	u	w		u		
Total	25.8 (.3) [2345]	22.7 (1.3) [156]	15.032 (1.012)	15.7 (.6) [938]	12.3 (1.4) [122]	7.689 (.694)
Common law	35.4 (1.2) [156]	27.9 (4.9) [13]	12.000 (2.334)	26.5 (2.2) [115]	20.1 (9.8) [10]	11.500 (4.070)
Torts and contracts	30.2 (1.3) [114]	24.0 (4.8) [11]	10.364 (2.413)	16.8 (3.3) [60]	18.2 (11.8) [8]	7.500 (2.771)
Admiralty	49.5 (.5) [42]	49.9 (3.3) [2]	21.000 (3.000)	37.2 (2.1) [55]	27.5 (18.2) [2]	27.500 (14.500)
Economic regulation	22.9 (.6) [540]	23.2 (2.1) [48]	11.250 (1.029)	13.4 (.4) [345]	10.3 (1.2) [40]	8.625 (1.431)
Tax	40.7 (2.1) [75]	36.2 (6.4) [8]	9.375 (2.42)	12.1 (.3) [69]	10.5 (1.9) [6]	11.5 (3.538)
Antitrust	18.3 (1.1) [96]	22.1 (5.6) [8]	12.000 (2.163)	20.7 (2.6) [35]	13.3 (6.7) [5]	7.000 (2.168)
Labor	15.8 (.6) [177]	15.6 (2.2) [17]	10.412 (1.269)	12.9 (.4) [178]	10.5 (1.5) [15]	11.867 (3.038)
Other federal reg. agencies	23.2 (.7) [172]	23.6 (3.4) [13]	13.231 (2.790)	7.2 (.8) [45]	7.3 (1.8) [12]	3.750 (1.081)
Patents	38.2 (.5) [20]	36.9 (2.5) [2]	10.000 (5.0)	23.8 (.6) [18]	18.7 (5.7) [2]	9.000 (8.000)
Civil rights	22.7 (.5) [285]	23.0 (2.8) [13]	21.923 (3.857)	15.4 (1.8) [74]	15.6 (6.2) [9]	8.222 (1.786)
Constitutional	23.7 (.7) [561]	17.0 (3.0) [32]	17.531 (2.826)	20.5 (2.2) [161]	13.3 (3.9) [24]	6.708 (1.256)
Criminal (incl. const.)	23.1 (.6) [517]	20.4 (2.7) [37]	13.973 (1.943)	10.8 (.7) [185]	9.8 (2.2) [28]	6.607 (1.095)
Criminal (excl. const.)	29.4 (1.8) [90]	20.9 (5.6) [12]	7.500 (2.076)	10.9 (1.2) [86]	8.6 (2.9) [12]	7.167 (1.266)
Bankruptcy	34.2 (.7) [92]	36.6 (5.2) [5]	18.4 (10.829)	9.7 (2.0) [29]	14.6 (6.5) [5]	5.800 (1.530)
Military	30.5 (.1) [46]	30.8 (.4) [2]	23.000 (12.000)	9.8 (.7) [11]	6.8 (3.8) [2]	5.500 (4.500)
Land condemnation	63.7 (2.7) [77]	52.7 (16.2) [3]	25.667 (12.574)	27.8 (10.5) [6]	27.8 (23.5) [2]	3.000 (0.0)

TABLE 2 cont.

Notes: w = weighted average (see text for explanation).

u = unweighted average (see text for explanation).

No. per case = average number of citations per case.

1. In each subject-matter class there are three numbers per column under the age columns: the top one is the mean age; the middle one (in parentheses) is the standard error of the mean; and the lowest one (in brackets) is either the number of citations (weighted columns) or number of cases with citations (unweighted columns).

2. In the no.-per-case column there are two numbers per column: the top one is the mean number and the second one (in parentheses) is the standard error of the mean number.

the half lives of Supreme Court and other court decisions were 13 and 5.4 years respectively (compared to weighted means of 25.8 and 15.7 years). The substantial skewness in the age distribution of citations is due in part, as we show later, to the growth over time in the production of precedents. But this cannot be the complete explanation, because it does not account for the skewness in citations to the Supreme Court, where the production of precedents has remained relatively constant over time. Other explanatory variables are the obsolescence or depreciation of legal precedents, the generality or specificity of precedents, statutory activity, and other factors explored later.

The half life of citations in scholarly journals appears to be generally shorter than that of citations in judicial decisions--for example, 5.5 years in economic and in sociological articles and about four years in physics and biomedical research.¹² Another basis of comparison to scholarly citations is the number of citations per decision or article. Combining citations to both the Supreme Court and other courts, we find that the average number of citations per decision is 12.3 and 21 in the 1974-1975 courts of appeals and in the Supreme Court samples, respectively. This compares to approximately 11 citations per article in leading economic journals, 18 in chemical journals, and four or five in medical journals.¹³

The data in Table 2 can be used to test a popular explanation of differences in average ages of citations: differences in the individual citation practices of judges. Arguably, whether a judge cites many or few cases is largely a matter of personal preference or taste for citing cases. This implies that the judge with little taste for citing

cases will tend to cite only the most recent cases--because he lacks information on the relevance of earlier decisions, wants to economize on his time, or believes that the more recent ones tend to have greater precedential significance. By the same token, the judge with a taste for citing many cases will cite those same recent cases plus others less recent and hence the average age of his citations will be greater. Thus, if taste is the principal determinant of the number of citations, there should be a strong positive correlation between the number of citations per case and the average age of citations per case. We, of course, question the premise that citation practice is largely a matter of personal preference (and implicitly therefore not capable of being studied scientifically). The economist expects citation practices to be basically uniform across judges, just as he expects different business firms to pursue similar investment policies in the face of similar economic conditions. If a judge cites more cases, it is not because his taste for citations is different but because the case before him is different--perhaps it has more issues, or its issues are less clearly controlled by some precedent. Accordingly, we would not expect to find a strong positive relationship between the number of citations per opinion and their average age.

This issue can be illuminated by empirical analysis. A useful first step is to compare the weighted to the unweighted average ages in Table 2, since a positive correlation between average age and number of citations implies that the weighted method will yield a higher average age than the

unweighted.¹⁴ For all subject-matter categories taken together (the first row of Table 2), the weighted exceeds the unweighted in all six possible comparisons. In our largest sample, however, the 1974-1975 U.S. courts of appeals sample, the differences are slight--.6 years and 1.1 years for citations to Supreme Court and other-court decisions respectively. In the two smaller samples the differences are somewhat greater, averaging about three years.

A more powerful test of the importance of the number of citations on age (and thus a more powerful test of the "taste" hypothesis) is to estimate a regression of the form

$$\bar{A}_i = \alpha + \beta_1 C_i + \beta_j X_{ji} + u_i \quad (1)$$

where \bar{A}_i is the average age of citations in the i th case, C_i the number of citations in the i th case, and X_{ji} a vector of subject-matter dummy variables. Equations (3.1) - (3.6) in Table 3 present the results of simple regressions of \bar{A}_i on C_i for Supreme Court and other-court citations for

[Insert Table 3]

our three data sets. The regressions show that the number of citations does have a positive effect on the age of citations, but the effect is statistically significant in only four of the six equations, and the magnitude of the effect is small. For example, in the 1974-1975 sample of citations to the Supreme Court (I-SC) an approximate doubling in the number of citations in a decision, from the mean of 4.6 to 10, increases the mean age of citations by only about .6 years (from 19.1 to 19.7 years), and an increase in the number of citations to other courts (I-OC) from the mean of 9.2 to 20 increases the average age by only about 1.3 years

TABLE 3
Average-Age Regressions

Equation Number	Sample	n	Constant	C_i	X_{jc}	R^2
3.1	I-SC	492	17.945	.110 (.750)	-	.00
3.2	I-OC	629	7.698	.122 (3.397)	-	.02
3.3	II-SC	156	18.326	.293 (2.905)	-	.05
3.4	II-OC	122	8.823	.450 (2.470)	-	.04
3.5	III-SC	136	18.460	.498 (1.418)	-	.01
3.6	III-OC	208	9.209	.311 (4.092)	-	.07
3.7	I-SC	492	29.430	.342 (2.439)	[8.89]	.18
3.8	I-OC	629	13.192	.123 (3.926)	[14.98]	.25

Notes:

- Sample: I = 1974-1975 Court of Appeals
II = 1974 Supreme Court
III = 1960 Court of Appeals
SC = citations to Supreme Court cases
OC = citations to other-court cases
- n = number of observations in regression.
- t-statistics in parentheses.
- F-statistic on set of dummy variables X_{jc} is in brackets.

(from 9.9 to 11.2 years). Even in the other two samples, the impact of the number of citations on the average age is small; for example, in sample II-SC, increasing the number of citations to Supreme Court cases from the mean of 15 to 30 would increase average age only from 25.8 to 30.2 years.¹⁵ Although these results neither justify nor compel rejection of the "taste" hypothesis, they indicate it is a weak hypothesis.

Not only is the magnitude of the effect of number on age of citations small, but the amount of variation in average age across cases that is explained by differences in the number of citations is negligible; the adjusted R^2 's in Table 3 range from 0 to .07 in equations (3.1) to (3.6).

Equations (3.7) to (3.8) add 14 dummy subject-matter variables to the 1974-1975 courts of appeals regressions. Each variable takes the value 1 if the case involves the particular subject matter and 0 otherwise. This allows us to answer the question whether subject matter has a significant effect on average age if the number of citations is held constant. (Alternatively, equations (3.7) and (3.8) test the partial effect of numbers on age, holding subject-matter constant.) An F-test performed on the entire set of subject-matter variables indicates that differences in subject matter generate significant differences in the average age of citations.¹⁶ This result tends to undermine the "taste" hypothesis, for there is no reason why tastes in citing cases should vary systematically across subject-matter areas. Moreover, the "taste" hypothesis supplies no rationale for separating the samples into citations to the Supreme Court and to other courts and we suspect that if the samples were not separated in this way the observed positive effect of numbers on age would be even weaker than we found it to be. Although we have not estimated regressions based on a combination of these samples, the fact that citations

to the Supreme Court tend to be older, yet the number of citations to the Supreme Court tend to be fewer, than to other courts suggests that the positive effect of numbers on age would be even weaker if citations to the Supreme Court and to other courts were combined in the courts of appeals regressions.

In sum, there appear to be regularities in the citation data (e.g., the difference between citations to the Supreme Court and to other courts, and the effect of subject matter) that are not explained by assumed differences in the individual citation preferences of judges. A more promising approach is to ignore differences in tastes or preferences and instead utilize an economic framework in which precedents are viewed as constituting a stock of legal capital subject to depreciation and the production of precedents is treated as a form of investment

III. The Theoretical Framework: Legal Capital

This part of the paper develops a capital-investment approach for the analysis of legal precedent. We begin by formulating a model of optimal investment in the production of precedents, and then use this model to generate hypotheses concerning the rate of investment, the size of the capital stock and its rate of depreciation, and the interaction among these variables. Finally, we examine certain peculiarities in the precedent-production process that result from the seeming absence of market incentives on the part of participants in that process. Because of the novelty of our approach to legal precedent, we develop the theory in more detail than is necessary for the empirical analysis that follows. In particular, although the determinants of investment and the capital stock are discussed here, these variables are with one exception

treated as exogenous in the empirical analysis. There we largely focus on measuring investment and the capital stock, and combining these measures with data on citations to estimate and test hypotheses concerning the depreciation of legal capital.

A. Some Definitions

Let L_t^i equal the stock of legal capital in a particular substantive area of the law (the i^{th} area) in period t . The stock is defined as the set of precedents that have accumulated from judicial decisions in prior periods ($t-1$, $t-2$, etc.).¹⁷ This stock generates a flow of services in period t that may be defined as bodies of information on the types of behavior that will be subject to civil and criminal sanctions and on the magnitude of these sanctions. One can write the stock of legal capital in period t as

$$L_t^i = I_{t-1}^i + (1-\delta^i)L_{t-1}^i \quad (2)$$

where I_{t-1}^i is the gross investment (assumed to be nonnegative) in legal capital that takes place in period $t-1$, and δ^i is the depreciation rate (assumed to be constant) of legal capital during the interval $t-1$ to t .

For purposes of empirical estimation of legal capital, it is useful to express equation (2) as a function of investment and depreciation rates in all previous periods. By substituting for L_{t-1}^i , L_{t-2}^i , etc. we can rewrite equation (2) as

$$L_t^i = I_{t-1}^i + (1-\delta^i)I_{t-2}^i + (1-\delta^i)^2 I_{t-3}^i + \dots + (1-\delta^i)^{t-1} I_0^i \quad (3)$$

where I_0^i is the investment in legal capital in the base period 0. Equation (3) illustrates the fundamental proposition that an investment in any period increases the stock of legal capital in all future periods, although the increments in the stock diminish with time due to the successive compounding of depreciation rates.

Although a precedent does not "wear out" in a physical sense, it depreciates in an economic sense because the value of its information content declines over time with changing circumstances.¹⁸ Changes in social and economic conditions, in legislation, in judicial personnel, and in other parameters of legal action reduce the value of precedents as a source of legal doctrine. To illustrate, a decision involving a collision between two horse-drawn wagons is bound to lose some of its precedential value when wagons are replaced by cars and trucks, and a decision turning on the difference between "trespass" and "trespass on the case" may lose all of its precedential value when the common-law forms of action are abolished by statute. In general, passage of time reduces the flow of services of a precedent,¹⁹ and this reduction represents the depreciation or obsolescence of legal capital.

The monetary equivalent of the information services generated by the stock of legal capital in the i^{th} area in period t can be written as

$$V_t = V(L_t; N_t) \quad (4)$$

(The subscript i is now suppressed for notational convenience.) We assume positive (i.e., the greater the stock, the greater the total value of the information services) and diminishing returns to legal capital at each moment in time.²⁰ The services from a given stock will also be greater the greater is the number of users (N_t) of this type of legal capital.

Since most activities involving two or more persons or firms are guided, in part, by the legal consequences of the activity, one might approximate N_t by the community's population, income, number of business transactions, number of firms, etc.²¹ Our term "monetary equivalent" is simply a convenient index for measuring the value of the services (previously defined as information on the types of behavior subject to sanctions and on the magnitude of these sanctions) generated by legal capital.²²

The source of investment in legal capital in period $t-1$ is the set of judicial decisions in that period that create precedents--mainly published appellate decisions. Although most legal disputes are terminated by out-of-court settlements, we ignore the contribution of settlements to legal capital since it is small: settlements, even when their terms are publicly disclosed, provide little information about the content of legal rules. Similarly, trials that occur only because of a disagreement over facts do not generate significant legal capital since the outcome of such a trial does not provide information about the content of legal rules. Since any legal issue decided on appeal--and any legal issues in cases that are not appealed--will have been decided either initially or finally at the trial level, trial decisions can be a source of legal capital, but the fraction of trials that generates precedents is small, so we are justified in limiting our empirical analysis to a sample of appellate decisions. (Of course, even at the appellate level, not all decisions contribute significantly to legal capital; an example would be the decision of an appeal that involved only issues of the sufficiency of evidence.)

The creation of precedents through appellate decision-making consumes the (valuable) time of judges, attorneys, law clerks, court clerks, jurors,

witnesses, and litigants, plus resources associated with the construction and maintenance of court houses, plus other scarce resources. Ignoring for the moment the underlying investment production function (discussed in subpart D), we can write investments costs in period t as

$$C_t = C(I_t) \quad (5)$$

where the marginal cost of I_t is both positive (since increases in I_t require greater inputs) and nondecreasing.

B. Optimal Production of Precedents

An optimal investment policy would be one that maximized the present value (π) of the difference between the value of the flow of services and the costs of investment with respect to investment in each period, subject to the earlier conditions that $L_t - I_{t-1} = (1-\delta)L_{t-1}$, δ is constant and I_t is nonnegative.²³ This yields T first-order conditions (from $t=0$ to $T-1$) of the form

$$\begin{aligned} \frac{\partial \pi}{\partial I_t} = & R_{t+1}V'_{t+1} + R_{t+2}V'_{t+2}(1-\delta) + R_{t+3}V'_{t+3}(1-\delta)^2 + \dots \\ & + R_TV'_T(1-\delta)^{T-t-1} - R_tC'_t = 0 \end{aligned} \quad (6)$$

where R_{t+j} is the value (dollar equivalent) at the beginning of period 0 of the services of legal capital in periods $t+j$ (i.e., $R_{t+j} = 1/(1+r)^{t+j}$, where the per-period discount rate, r , is assumed constant); V'_{t+j} is the value of the marginal product of the service of legal capital in $t+j$, and C'_t is the marginal costs of investment. The optimality condition in (6) represents the usual equality of marginal returns with marginal costs.

It is more convenient to represent the equilibrium condition in terms of the optimal stock of legal capital in period $t+1$. This is given by

$$V'_{t+1} = C'_t(r+\delta-\tilde{C}_t) \quad (7)$$

where \tilde{C}_t is the percentage change in the marginal costs of investment from period t to $t+1$.²⁴ Equation (7), which states that in each period the capital stock is expanded until the undiscounted value of the marginal product in that period equals the marginal user cost of capital, has the advantage of allowing us to convert the multi-period flow equilibrium (equation (6)) into a single-period stock equilibrium. This is illustrated in Figure 1, where we assume that the marginal cost of investment is constant and equal in each period (i.e., $\tilde{C}_t = 0$), implying a single-period adjustment to any discrepancy between actual and desired capital stock. To illustrate, if the stock in t is below the equilibrium (or desired) stock in $t+1$ because, for example, a new statute is passed creating a demand for new legal capital or destroying old legal capital, then investment in period t will be sufficient to bring the stock up to its desired level in $t+1$. And if the variables in equation (7) remain constant thereafter, future investment will just offset depreciation and the capital stock will remain at its stationary desired level.

[Insert Figure 1]

A fundamental implication of equation (7) and Figure 1 is that the stock of legal capital in any period will be greater, the greater the value of its marginal product and the lower its marginal user cost (i.e., the lower $C'_t(r+\delta)$). Thus in areas of the law that affect more people, legal capital should be relatively more valuable

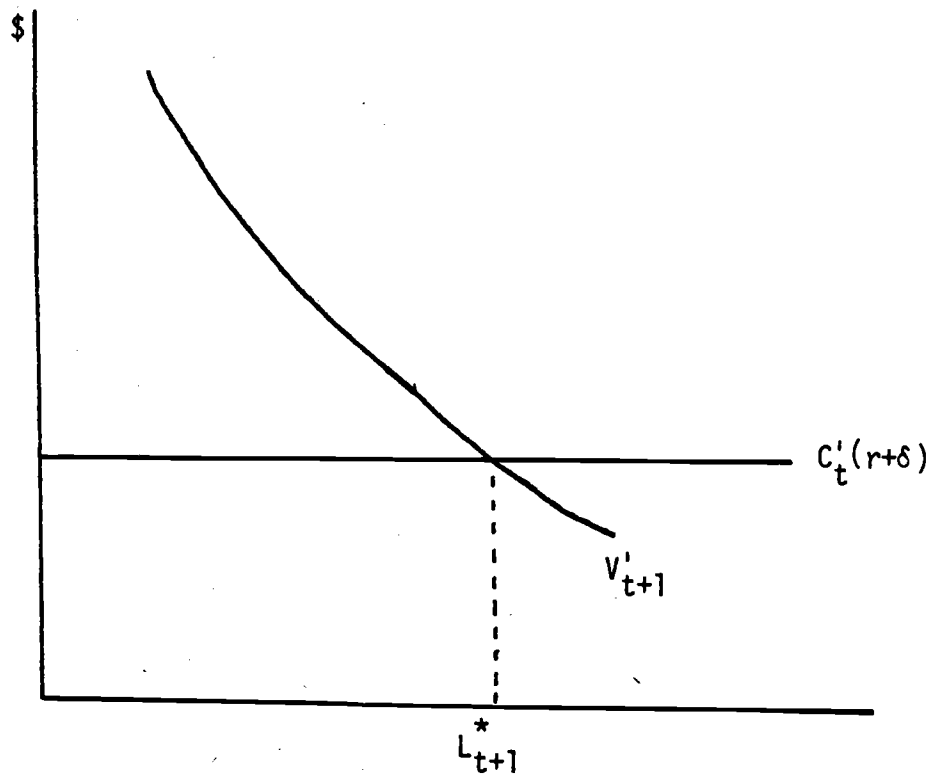


Figure 1

and hence the optimal stock larger. However, the number of users of the legal capital (N_t in equation (4)) must be weighted by the value that users attach to the capital. Thus, a form of legal capital that has narrow applicability and hence a few users may still be relatively large if the users attach a high value to this capital. Similarly, in larger communities, the per capita amount of legal capital should be greater. This follows from the public-good aspect of legal capital. In the limiting case, the entire capital stock is received by each member of the community. Hence a larger community induces a shift in the demand curve in Figure 1 and a greater aggregate and per capita capital stock. To take another example developed later, suppose that legislative activity depreciates legal capital; one would then expect that in those areas of the law where there was relatively greater statutory activity depreciation rates of legal capital would be greater and the optimal stock of legal capital smaller.²⁵ The effect on gross investment, however, is uncertain. Although a higher depreciation rate lowers the optimal stock, it also implies faster replacement of the (smaller) stock.²⁶ As a final example, the stock of legal capital would tend to grow over time if, for example N_t was growing secularly. Thus, the demand curve in Figure 1 would be shifting to the right (provided V'_{t+1} was a positive function of N_t), leading to a secular increase in the capital stock. And assuming a constant rate of growth of the capital stock and a constant δ , gross investment would grow at a rate equal to that of the capital stock.²⁷

C. Depreciation of Legal Capital

In the previous subpart we considered the effect of different depreciation rates on investment and the capital stock. We did not, however, explore the forces that affect the depreciation rate itself. It is useful to extend our analysis in this direction since, as indicated earlier, it is possible to integrate data on investment and citations for the purpose

of estimating depreciation rates on legal precedents by subject matter--estimates that we believe are interesting in themselves as well as necessary in order to test hypotheses derived from the capital-theory approach to legal precedent. What follows therefore, is both the development of some testable hypotheses on depreciation and some further discussion of the interrelationship among depreciation, investment, and capital. We do not, however, explicitly incorporate depreciation as a decision variable in the formal model developed in the previous subpart and attempt to derive optimal depreciation rates. A preliminary attempt to do so indicated that such a modification would be exceedingly complicated and would not alter substantively the capital-investment framework used in the empirical analysis.

1. General Versus Specific Legal Capital. Other things being equal, a precedent can be expected to depreciate more rapidly the narrower (more specific) it is in terms of the span of facts and issues that it covers. Conversely, the broader (more general) a precedent is, the slower should be its rate of depreciation. A general precedent is less likely to be rendered obsolete by a change in the social or legal environment in which the precedent is applied; for example, a decision laying down a broad principle of tort liability should retain its precedential force--be cited--for a longer period of time than one holding that railroads must station flagmen at certain crossings. A general precedent is like a machine that, being adaptable to a number of different uses, is less subject to technological obsolescence than one specialized to a particular industrial task, or like general human capital (e.g., schooling), which tends to depreciate over the life cycle of an individual more slowly than investment in specific capital (e.g., training specialized to a particular employer).

The distinction between general and specific legal capital implies that Supreme Court precedents will depreciate more slowly than those of other courts such as the federal courts of appeals. The Supreme Court

is more selective than any other court in its choice of cases to review, due in major part to its more limited capacity (which is due in turn to society's evident reluctance to increase the number of Supreme Court Justices or take other measures that would enable the Supreme Court to increase its production of precedents) compared to other courts. Thus, while the Supreme Court's output of precedents has remained constant for many years despite the enormous secular increase in the number of legal disputes within the Court's jurisdiction,²⁸ the appointment of additional judges to the federal courts of appeals has enabled those courts greatly to increase their output of precedents.²⁹ The more limited capacity of the Supreme Court compared to that of the courts of appeals has made the opportunity cost of developing new precedents and modifying old ones increase faster in the Supreme Court. That is why the Supreme Court has had to become relatively more selective over time in its choice of cases to review, and one might expect this selection to favor cases of greater generality³⁰ and hence more durability as precedents. This implies, incidentally, that, other things being equal, the depreciation rate of Supreme Court precedents should have declined over time relative to that of the courts of appeals.

In relying on the greater generality of Supreme Court precedents to predict that they will depreciate more slowly than courts of appeals precedents, we may seem to be overlooking the obvious: Supreme Court precedents depreciate less rapidly than courts of appeals precedents because, being more authoritative, they are more valuable. However, neither economic nor any other theory predicts that a capital good will depreciate more slowly because it is more valuable: modern weapons systems and computers are examples of expensive capital goods that depreciate rapidly (compared, say, to lathes). The value of a good does not dictate when it is replaced.

2. Statutory Activity and Depreciation. Precedents can be expected to depreciate more rapidly in areas of law in which there is considerable statutory activity, since a change in statutory law will tend to make precedents based on earlier statutory language obsolete. If we could reliably measure the levels of statutory activity across the various subject-matter areas in our sample, we could test this hypothesis rigorously. At this stage, only a casual empirical analysis of the hypothesis appears feasible. A further difficulty in testing this hypothesis arises from the possibility that the legal system will anticipate statutory activity. If statutory activity is anticipated in area A but not B, the courts may adapt by making their precedents in A more general and hence more adaptable, in which event the observed depreciation rate might not differ across areas that differed in statutory activity. Still another difficulty is that legislatures may pass statutes in areas where legal capital depreciates at a high rate precisely in order to compensate for the relative uncertainty in those areas. In such a case, statutory activity and depreciation would be positively correlated but the direction of causality would be reversed.

3. Substantive Versus Procedural Citations. We have attempted to disaggregate our 1974-1975 courts of appeals sample into citations to substantive and to procedural issues by subject-matter classes. Since identical procedural issues can arise in different substantive areas, cases in different areas might cite many of the same cases on procedural questions. If so, one would expect less variation in depreciation rates of procedural precedents across subject-matter classes than of substantive precedents. The testing of this hypothesis, however, is hampered by the conceptual difficulty of distinguishing between "substantive" and "pro-

cedural" citations--for example, is the issue of damages in an antitrust case a substantive or a procedural question?

4. Uncertainty, Litigation, and the Production of Precedents. Suppose that the stock of legal capital, and hence the flow of information on the likely outcomes of potential legal disputes, were temporarily below the desired (long-run equilibrium) level. This might be due to new legislation or other unanticipated changes in economic or social conditions that rendered part of the existing capital stock obsolete. With the resulting increase in uncertainty, more disputes would arise, parties to a dispute would find it more difficult to forecast the outcome of litigation, and litigation would increase. The result would be a temporary increase in the production of precedents (investment) until the discrepancy between actual and desired capital was eliminated.³¹ (This process is described in greater detail in the next subpart.) Alternatively, suppose depreciation were permanently higher in one subject-matter area of the law compared to another, with other factors held constant. Although the capital stock (and possibly gross investment) would be smaller in the area with higher depreciation, the ratio of investment to capital should be greater.³² Thus, a higher observed depreciation rate, whether caused by temporary or permanent forces, should be associated with a greater investment-capital ratio.

This hypothesis can be tested in two possible ways. From estimates of depreciation, investment, and the capital stock by subject matter, the relationship between depreciation and the investment-capital ratio can readily be determined. A difficulty with this test is the limited number of subject-matter classes in our sample. A more powerful test (not

performed in this paper, however) would be to apply the depreciation rates calculated in this paper to other data sets containing more observations. Specifically, we could examine the trial-settlement ratios and appeal rates across the more than 90 U.S. district courts as a function of the depreciation rates in each subject-matter class weighted by the proportion of cases in the district in each class and other variables such as the length of trial queues. Since higher depreciation is a measure of relative uncertainty, we should observe that, other things being equal, the higher is the weighted depreciation rate of a district, the greater will be the proportion of trials in the district.

D. The Production Function of Legal Precedents

The actual production of legal precedents combines two basic inputs: (1) the resource inputs of the parties to legal disputes in litigating their disputes in the courts and (2) the inputs of judges in writing judicial opinions that will operate as precedents in future cases. A mysterious aspect of the production process is the apparent absence of market incentives. Consider first the production of precedents from the point of view of the disputants. The individual or firm that brings a case that becomes an important precedent--a Hadley v. Baxendale or a Marbury v. Madison--receives no "royalty" or other compensation from use of the case to decide subsequent cases. To be sure, some litigants (e.g., railroads defending tort suits or the government prosecuting antitrust violations) anticipate the recurrence, in future litigation to which they will be parties, of the issues involved in the current litigation, and such

litigants have an interest in the precedent produced by the litigation. But most litigants do not anticipate a recurrence of the same or even of similar issues in future litigation to which they will be parties, and from their standpoint the precedent produced by the current litigation is a worthless by-product of dispute resolution. This raises the question how the demand for precedents shown in Figure 1, a good that accrues primarily to the community as a whole rather than to individuals or firms in the community, can be translated into a private demand which will induce the private production of precedents.

The answer lies in an understanding of why litigation, as distinct from out-of-court settlement, ever occurs, given that normally it is costlier than settlement. Economic analysis suggests that, in general, litigation will occur only when the parties are unable to agree on the likely outcome of the litigation, and more particularly when one party (or both) significantly exaggerates the probability that it will prevail.³³ Thus the ratio of lawsuits to settlements is mainly a function of the amount of uncertainty, which leads to divergent estimates by the parties of the probable outcome of litigation. The amount of legal uncertainty³⁴ is, in turn, a function of the stock of legal rules, a stock in most areas of the law composed largely of precedents.

The ultimate dependence of the litigation rate on the stock of legal knowledge assures that at least one of the critical inputs into production of precedents--the litigants' research and advocacy--will respond in a manner at least roughly congruent with the social need for them. Absence

or depletion of the relevant legal capital incites litigation, which produces precedents as a by-product and thereby builds up the stock. Suppose, for example, that a completely new statute has just been enacted. There are no precedents indicating how the statute is to be applied to a variety of specific disputes (we can assume that like most statutes this one is ambiguously or at least generally worded). Initially, therefore, there will be great uncertainty as to the practical meaning of the statute. The uncertainty will increase the private costs of negotiating out-of-court settlements of disputes resulting from attempts to apply the statute, because the outcomes of litigation over the meaning of the statute will be difficult to predict. Hence a good deal of litigation can be expected to occur and, as a by-product, precedents defining the precise meaning of the statute will be generated. As the stock of legal knowledge relating to the statute is built up, uncertainty will fall, and with it the amount of litigation and hence the production of additional precedents. But uncertainty will not be eliminated; as changing social or economic conditions generate new kinds of disputes over the application of the statute the stock of prior legal knowledge will depreciate, inducing litigation that will produce fresh precedents.

This analysis suggests how it has been possible for the Anglo-American legal system to rely, for almost a thousand years, on the uncompensated efforts of litigants to create most of the legal rules administered by the legal system. There are, to be sure, alternative methods of inducing the production of precedents. One is government subsidy--and since the end

of the fee system of defraying judicial expenses, litigation has been (modestly) subsidized by having the expense of judicial personnel, court facilities, etc. defrayed by the taxpayer rather than by the litigants. Another possibility would be to give the litigants property rights in the precedents generated in any lawsuit to which they were parties. Just as a composer receives a royalty every time a song he has written is played on a radio station, so--in principle anyway--a litigant could be given a royalty every time that a case he had brought (or defended³⁵) was cited in the brief or oral argument of a subsequent case.

Before appraising these alternatives, we must consider the incentives of the judges, the other critical input into the production of legal precedents, to participate in that production. The independence of the judiciary (especially of the federal judiciary, the focus of our attention in this paper) from the political branches of the government³⁶ makes it extremely difficult to model judicial behavior in economic terms; the outcome of a case seems unrelated to the judge's welfare. One approach is to posit that the independent judge derives welfare by imposing his policy preferences on the community. This approach, which is broadly consistent with the ordinary assumptions of self-interested behavior employed in economic analysis, is helpful in explaining why a judge might want to create precedents rather than just resolve disputes: to the extent it is followed in subsequent decisions, the precedent will affect more behavior. Indeed, dispute resolution as such affects no behavior; it merely redistributes the losses created by some past incident, and those are sunk costs.

Less obviously perhaps, this approach may also explain why judges

follow precedents. It is the practice of deciding in accordance with precedent that makes decisions operate as precedents. No matter how wilful a judge is, he is likely to follow precedent to some extent, for if he did not the practice of decision according to precedent ("stare decisis," the lawyers call it) would be undermined and the precedential significance of his own decisions thereby reduced. To be sure, there is a potentially serious free-rider problem. The judge who disregards all precedents but his own may gain more utility in increased freedom to impose his personal preferences on the community than he loses by contributing to a general erosion of the principle of adherence to precedent. But the free-rider problem is held in check by the structure of appellate review. Usually there is one court, with relatively few members, who are supreme within any given jurisdiction. Their power to reverse the decisions of lower courts checks any tendencies on the part of lower-court judges to disregard precedent, and their own position in the judicial hierarchy checks their own tendencies in that direction. If the U.S. Supreme Court refuses to accord precedential weight to earlier Supreme Court decisions, it thereby undermines the precedential weight of its own decisions. To be sure, the trade-off is a complicated one, and we would not expect--nor do we find--that the balance is always in favor of adherence to precedent. Our argument, however, is not that precedent is always adhered to, but that decision according to precedent will often represent rational self-interested behavior to judges who personally disagree with the precedent in question.

If there is a judicial demand for legal advocacy that will assist courts in adhering to old and formulating new precedents, the litigants will supply such assistance even though their only interest is in resolving a

dispute. However, although this point might seem to imply that the provision of subsidy or ASCAP-type royalties may not be necessary to prevent under-production of precedents, it ignores the availability of substitute modes of dispute resolution--such as private arbitration--that do not involve the production of precedents and hence are less costly to the disputants. To avoid inefficient substitution away from the courts, a public subsidy of court litigation may be justified after all. (An alternative would be to tax private arbitration.) And since the identification of a case that will be an important precedent may be difficult or impossible to make in advance, a general subsidy of litigation may be more efficient than an attempt to subsidize just those litigants who in fact contribute to the production of precedents.

The question whether judges indeed follow the principle of stare decisis or decision according to precedent can be approached empirically by asking what a refusal to decide cases according to precedent would imply with regard to the citation practices of judges. (A preliminary question might be, if judges do not follow precedent why do they cite cases at all? The answer might be, to fool people into thinking they were following precedent. But we distrust explanations that assume persistent gullibility on the part of the community.) Such a practice would imply that the observed depreciation rate of precedents was zero: the judge who is indifferent to the precedential significance of the cases will tend to pick cases to cite from past years roughly in proportion to the amount of gross investment, implying (as we show in the next section) zero depreciation.³⁷

A more plausible rival to the hypothesis that judges decide in accordance with precedent, giving due weight to depreciation, is that judges, in some courts and some periods, disregard the precedents established by their predecessors; they try to change the law to

make it conform to their own views of public policy. This practice, sometimes called "judicial activism" and frequently associated with the "Warren Court" of the 1960s, does not imply an indifference to precedent as such, and hence does not imply a zero depreciation rate. Rather, it implies a desire on the part of the judges to replace the precedents of an earlier period with new, contrary precedents. Precisely what the citation practice of an activist court would be is unclear. The court might cite few cases; or it might reach back into the distant past for precedents, in which event the observed depreciation rate of the precedents cited by it might be low. Presumably, as the activist court produced more and more of its own precedents (i.e., by deciding cases), the measured depreciation rate of precedents cited by it would rise, for it would tend to cite its own precedents, which would be recent, and not to cite (many) precedents of earlier judges. What seems unambiguous, however, is the impact of judicial activism on the depreciation rate indeed of precedents in the decisions of a lower court. If the Warren Court was indeed an unusually activist one, then the depreciation rates of Supreme Court precedents should be lower in our sample of 1960 court of appeals cases (prior to the heyday of the Warren Court) than in our 1974-1975 court of appeals sample. The courts of appeals are bound by the precedents created by the Supreme Court and if the Warren Court destroyed much existing legal capital, replacing it with its own (necessarily recent) precedents, this would show up in an increase in the depreciation rate of Supreme Court precedents in the courts of appeals.

IV. Empirical Analysis

A. Specification of the Model

There are two basic techniques for using the age distribution of citations to estimate rates of depreciation or obsolescence of legal capital. The first makes exclusive use of the mean of the age distribution. In its crudest form, the rate of depreciation is inferred solely from the reciprocal of the average age of citations; thus, the older the average age, the lower the depreciation rate. This procedure has a counterpart in the citation analyses of sociologists of science, where the age of citations to scholarly works is used to develop measures of the relative "hardness" of different scientific disciplines, the rate at which scientific knowledge diffuses, its rate of obsolescence, and other phenomena. The second technique we employ, a far more efficient one (as we show below), makes use of the entire frequency distribution of citations to earlier decisions, not just the mean. Using regression analysis, we are able to estimate depreciation rates and extend the empirical analysis to the determination of the forces affecting investment, depreciation, and capital, and the interrelationship among these variables.

1. Average Age of Citations. The reader will recall our earlier derivation of the stock of legal capital in equation (3). By utilizing the assumption of a constant nonnegative rate of growth of legal capital, equal to θ , which implies an identical constant rate of growth of gross investment,³⁸ we can transform equation (3) into

$$L_t = I_{t-1} \left[\frac{1}{(\delta + \gamma - \delta\gamma)} \right] \quad (8)$$

where $\gamma = \theta/(1+\theta)$ and the number of periods is sufficiently large so that $[(1-\delta)(1-\gamma)]^t \approx 0$. The proportion of precedents in this stock that are exactly one year old (I_{t-1}/L_t) equals $(\delta+\gamma-\delta\gamma)$; the proportion of two-year-old precedents (I_{t-2}/L_t) equals $(\delta+\gamma-\delta\gamma)(1-\delta)(1-\gamma)$; and, more generally, the proportion of precedents that are A_j year old is given by

$$f(A_j) = (\delta+\gamma-\delta\gamma)[(1-\delta)(1-\gamma)]^{j-1} \quad (9)$$

Now assume that we have a random sample of type i cases to be decided in period t and the stock of precedents relevant to these cases is given by equation (8). Since each proportion $f(A_j)$ can be interpreted as the probability of selecting a precedent that is A_j years old, the mathematical expectation or mean age of A_j is given by

$$E(A_j) = \sum_j f(A_j)A_j = (\delta+\gamma-\delta\gamma)\left[\sum_j A_j [(1-\delta)(1-\gamma)]^{j-1}\right], \quad (10)$$

which simplifies to

$$E(A_j) = \frac{1}{(\delta+\gamma-\delta\gamma)}, \quad (11)$$

assuming again that t is sufficiently large.

This result can be made clearer by an example. If today's capital stock contained some precedents that were one year old, some two years old, etc., and these precedents had been produced over time at a constant (nonnegative) growth rate of θ and had in turn depreciated at a constant rate of δ , then the mean age of precedents (citations) would be given by equation (11). Therefore, if one were able to estimate the growth rate and the average age, equation (11) could be used to calculate the depreciation rate. For example, a 10-year mean age and a growth rate of five per cent per year would

yield in the limit a 5.5 per cent depreciation rate. Finally, if either the depreciation rate or the growth rate were zero, equation (11) would simplify to $1/\gamma$ or $1/\delta$ respectively.

There are two drawbacks to this procedure for estimating depreciation rates. First, the assumption of a constant growth rate of investment--a convenient mathematical simplification--depends on the assumption that the legal system is on a long-run equilibrium growth path. For certain substantive areas of the law, the evidence strongly contradicts this assumption. Civil rights is the most obvious example. We have estimated that the production of precedents in the U.S. courts of appeals in the civil-rights area has been growing at an annual rate of 15.6 per cent since 1953 (the first year that civil rights cases were separately classified by the Administrative Office of the U.S. Courts). This is more than three times the average rate of precedent production in the courts of appeals.³⁹ Similarly, the civil-rights growth rate has been 7.3 per cent in the U.S. Supreme Court since 1948, compared to an overall (i.e., all our subject-matter classes taken together) growth rate of 1.2 per cent. Changing social and economic conditions and their interaction with legislation over the last 25 years have induced a rapid increase in the demand for civil-rights precedents, but it would be highly questionable to assume that this is the long-run equilibrium growth in the demand for civil-rights precedents. Probably the growth in civil-rights precedents prior to the 1950's was closer to the overall growth rate of precedents in the courts of appeals and Supreme Court.⁴⁰

A second drawback of this procedure is the absence of a measure of the standard error of the calculated depreciation rates. Although one can

test the significance of differences in average ages of citations across subject-matter classes and between the Supreme Court and the courts of appeals, there is no readily available technique for testing the significance of differences in the depreciation rates themselves.

2. The Age Distribution of Citations. Let P_t^0 denote the number of precedents produced t years ago ($t = 0, 1, 2, \dots, T$) that have survived to the current period 0, and C_t^0 the number of citations in period 0 to judicial decisions t years ago. Assume that citations and precedents are related as follows:

$$P_t^0 = kC_t^0 \exp(u_t) \quad (12)$$

where k is a proportionality factor between citations and precedents⁴¹ and u_t is a random error term (for example, due to sampling errors in data collection). The proportionality condition--the key assumption that allows one to use citations to study precedents--states that if, for example, we observe twice as many citations to decisions of X than $2X$ years ago, then twice as many precedents have survived into the present from the former than from the latter period. This example is also helpful in illustrating the implicit weighting scheme built into our empirical analysis. In recording the number of citations, our case readers made no distinction between two citations to a single case from t years ago and the citation of two such cases; in both instances the number of citations to t -years-old decisions would be two.⁴² Thus, it is possible (though unlikely) that one would observe twice as many citations to decisions of X than to those of $2X$ years ago, yet the number of decisions actually cited in the two periods would be identical. Even so, one would not want to assign equal

precedential significance to the surviving precedents from the two different time periods, and our method of counting citations weights decisions more heavily the more often they are cited. In our hypothetical example twice as many equivalent decisions (i.e., decisions of equivalent precedential significance) would have survived from X than from 2X years old decisions even though an equal number of cases from both periods were still being cited.⁴³ More generally, estimates of depreciation in our study are based on decisions of equal precedential significance where significance is assumed to be proportional to citations.

Let I_t^* equal the annual investment in precedent production that occurred t years ago, and assume that

$$I_t^* = mI_t \exp(v_t) , \quad (13)$$

where I_t equals our estimate of I_t^* based on a count of written opinions t years ago, m is a proportionality factor applicable to investment, and v_t is a random error term. The number of precedents that have survived from t years ago to period 0 equals investment in that earlier period discounted by the depreciation rate,⁴⁴ as in

$$P_t^0 = I_t^* \exp(-\delta t) . \quad (14)$$

By making the appropriate substitutions, taking logs, and rearranging terms, our estimating equation becomes

$$\ln (C_t^0/I_t) = \alpha + \beta t + \varepsilon_t \quad (15)$$

where α is a constant (equal to $\ln(m/k)$), β equals $-\delta$, and ε_t is a disturbance term assumed to be subject to first-order serial correlation (i.e.,

$\epsilon_t = \rho\epsilon_{t-1} + e_t$ where ρ equals the serial correlation coefficient). Since we have data on both the age distribution of citations and the annual number of written opinions, a simple regression (with an adjustment for serial correlation) of the log of the citation-investment ratio on time will yield an estimate of the depreciation rate.⁴⁵

The regression method of estimating depreciation has several important advantages compared to that of the mean age. First, it enables a measure of the statistical significance of δ ; this facilitates the testing of hypotheses. Second, there is no need to assume a steady-state equilibrium in which the capital stock and investment are growing at a constant rate. Third, equation (15) is the foundation of a more complete estimation system for the determinants of depreciation and investment. A possible specification of this system in addition to equation (15) would include

$$\delta_t = \psi_1 + \psi_2 X_t + \epsilon'_t \quad (16)$$

$$I_t = \phi_1 + \phi_2 \bar{\delta}_t + \phi_3 Y_t + \epsilon''_t \quad (17)$$

where X_t is a vector of variables determining the depreciation rate in period t (possibly, turnover in judicial personnel and new legislation); Y_t is a vector of variables affecting the level of gross investment (possibly, changes in population, national income, legislation and the stock of legal capital); and $\bar{\delta}_t$ is an average of depreciation rates prior to t (since depreciation is expected to influence investment). We mention this more complete equation system, which is not estimated here but will

be utilized in subsequent work on a more comprehensive sample, because it shows clearly the interesting extensions that are possible when one integrates citation data into a regression framework.

B. Depreciation-Rate and Capital-Stock Estimates

1. The Problem of Measuring Investment. Before presenting our estimates of depreciation and of the capital stock of precedents we discuss briefly how we measured investment. It might appear straightforward to measure the annual investment in the production of precedents--all one needs to know is the number of cases decided each year in the relevant court and subject-matter category. In fact, there are serious estimation problems.⁴⁶ The first is the problem of what to count as a precedent--all terminations, only contested terminations, all terminations in which an opinion is written, or only signed majority opinions (as distinct from per curiam and memorandum opinions)? Since only a decision in which an opinion is issued is likely to be cited in a subsequent decision, it is clearly appropriate to limit the pool of precedents to such decisions. Unfortunately, data on the number of written opinions are not published for the courts of appeals, but must be tabulated by counting the opinions contained in the more than 800 volumes of the Federal Reporter.

Second, the available statistical data on subject matter are inadequate, and increasingly so the further back in time one goes. Subject-matter data are available for the Supreme Court back to 1930 but for the courts of

appeals only since 1947 and only for cases commenced and not for cases terminated or for written opinions. If we assume that the distribution by subject matter of cases commenced in the courts of appeals is proportional to that of written opinions in those courts, then the distribution of written opinions by subject-matter can be computed by multiplying the relevant proportion by our estimate of the total number of written opinions. But to obtain estimates of investment by subject matter in both the courts of appeals and the Supreme Court for years in which such data are not available, a more arbitrary assumption must be made: that the distribution of opinions by subject matter in those years is equal to that of the earliest years for which such data are available. However, this assumption is not likely to create serious errors in our regressions estimates of depreciation even though those estimates are generally based on a 100-year period: since our citation data have been aggregated for the early years, the number of observations for years prior to 1948 or 1930 is far fewer than the number of years between 1847 and 1930 or 1948.⁴⁷

A further problem with our estimation procedure is the difficulty of matching citation and investment data by subject-matter classes. For example, our estimate of annual investment in civil-rights precedents is restricted to opinions in civil-rights cases, yet some citations in a sample civil-rights case may not be to prior civil-rights decisions but to decisions in other fields of law. Although this error is likely to understate actual investment within a subject-matter

area, we have no reason to believe that it is systematically related to time. Hence the error would enter the residual term in equation (15), reducing the estimated R^2 . The error is also likely to be relatively more important (and the R^2 lower), the more narrowly the subject-matter class is defined. This is generally consistent with our findings in the empirical analysis.

2. Depreciation-Rate Estimates. Tables 4 and 5 present regression estimates derived from equation (15) of the depreciation rates by subject-matter classes of the precedents cited in our 1974-1975 courts of appeals (Table 4) and Supreme Court (Table 5) samples.⁴⁸ Both ordinary-least-squares (OLS) and Cochrane-Orcutt generalized-least-squares (GLS) estimates are presented--the GLS method to deal with the assumed first-order serial correlation of the disturbance term. The estimated depreciation rates are nearly always positive, generally within a range of two to seven per cent per year, and most are statistically significant.⁴⁹ Several of our estimates, however, are based on a small number of cases, and though statistically significant are nevertheless unreliable.⁵⁰

[Insert Tables 4 and 5]

In our earlier discussion of the production function of precedents, we hypothesized that a court that gave no weight whatever to precedential significance in deciding a case and writing the opinion would act as if its choice of citations depended solely on the relative number of past opinions, and the citations by such a court would tend, therefore, to have a zero depreciation rate. Tables 4 and 5 enable us to reject this hypothesis and the theory of judicial decision-making that underlies it. We also suggested, however, as part of

TABLE 4

Depreciation Rates, Courts of Appeals, 1974-1975

Subject-Matter Classification	Citations to Other-Court Cases				Citations to Supreme Court Cases			
	Depreciation Rate Estimates		Depreciation Rate Estimates		Depreciation Rate Estimates		Depreciation Rate Estimates	
	S	n	OLS	GLS	S	n	OLS	GLS
All Classes	629	33	.052***	.042***	492	35	.042***	.038***
Common Law	114	33	.043***	.042***	61	35	.026**	.025**
Torts and Contracts	94	33	.040***	.040***	41	35	.018	.016
Admiralty	20	33	.065***	.063***	20	35	.031**	.030*
Economic Regulation	176	33	.067***	.062***	132	35	.055***	.055***
Tax	33	33	.054***	.052***	26	35	.059***	.059***
Antitrust	12	22	.157**	.142**	10	33	.021	.018
Labor	52	33	.118***	.118***	45	35	.053***	.053***
Other federal regulatory agencies	47	33	.086***	.085***	34	35	.029***	.036***
Patents	32	33	.033***	-.061*	17	34	.050***	.047***
Civil Rights	43	22	.320***	.331***	40	32	.029*	.036*
Constitutional (excl. criminal)								
Criminal (All)	227	33	.050***	.043***	17	35	.049***	.049***
Criminal (const.)	44	33	.079***	.073***	202	35	.026***	.024***
Criminal (nonconst.)	183	33	.048***	.043***	45	35	.029**	.026*
Bankruptcy	17	33	.015	-.005	157	35	.028***	.028***
Land	8	33	.050***	.048	8	35	.022*	.024**

Notes:

1. *** - significant at .01 level in two-tail tests
- ** - significant at .05 level in two-tail tests
- * - significant at .10 level in two-tail tests
2. OLS: ordinary least squares.
3. GLS: Cochrane-Orcutt method of generalized least squares.
4. S: number of sample cases.
5. n: number of observations in OLS regression analysis.
6. For the complete regressions see Appendix A, *infra*.

TABLE 5

Depreciation Rates, Supreme Court, 1974 Term

	<u>Citations to Other-Court Cases</u>				<u>Citations to Supreme Court Cases</u>			
	Depreciation Rate Estimates		Depreciation Rate Estimates		Depreciation Rate Estimates		Depreciation Rate Estimates	
	S	n	OLS	GLS	S	n	OLS	GLS
All Classes	122	33	.039***	.030***	156	35	.033***	.030***
Common Law	10	33	.035*	.027	13	35	.024*	.021
Economic Regulation	40	33	.052***	.050***	48	35	.038***	.037***
Civil Rights	9	22	.186***	.191***	13	35	.022***	.022***
Constitutional (excl. crim.)								
Criminal	28	33	.048**	.046**	32	35	.033***	.031***
					37	35	.017***	.016**

Notes. See Table 4.

the rudimentary theory of judicial decision-making sketched in that discussion, that judges not constrained by the threat of reversal of their decisions by a higher court would tend to depart more frequently from deciding according to precedent than courts that were so constrained, and that this would show up in a lower depreciation rate of their citations (because they would be giving less weight to the recency of the precedents cited). Some evidence for this hypothesis is provided by a comparison between the depreciation rates in Tables 4 and 5. The depreciation rates of cases cited by the Supreme Court are almost uniformly lower than those of cases cited by the courts of appeals. Of the ten possible comparisons from the GLS regressions (holding court and subject matter constant), nine depreciation rates are lower in the Supreme Court sample (Table 5) than the courts of appeals sample (Table 4). This suggests that the Supreme Court pays less attention to recency (authority) in its citations than the courts of appeals--as we would expect since Supreme Court decisions cannot be reversed by a higher court.

3. Capital-Stock Estimates. Table 6 presents estimates of the stock of legal capital for precedents produced in the Supreme Court and in the courts of appeals (see equation (3)). Two estimates are given for each court. One is the capital stock of precedents produced in the period 1949 to 1973; the other is the stock produced in the longer period from 1874 (1894 for the courts of appeals) to 1973. The second estimate is the more comprehensive but is subject to substantially greater error because of the difficulty, noted earlier, of classifying very old cases by subject matter.

[Insert Table 6]

The precise interpretation of these numerical estimates is

TABLE 6
Capital-Stock Estimates

Subject-Matter	Depreciation Rate	1949-1973			1894-1973		
		L	ΣI	Ratio	L	ΣI	Ratio
All	.042	53,680	80,349	.67	63,839	141,188	.45
Common Law	.042	11,673	18,495	.63	14,402	34,902	.41
Economic Regulation	.062	12,794	24,620	.52	14,629	48,414	.30
Tax	.052	3,533	6,773	.52	4,560	15,859	.29
Antitrust	.142	366	971	.38	n.a.	n.a.	n.a.
Labor	.118	681	1,675	.41	708	3,999	.18
Other federal reg. agencies	.085	5,869	13,239	.44	6,212	23,540	.26
Patents	.033	1,307	1,963	.67	1,801	4,047	.45
Civil Rights	.331	769	2,783	.28	n.a.	n.a.	n.a.
Constitutional		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Criminal	.043	21,792	30,805	.71	24,380	47,025	.52
Bankruptcy	.015	2,151	2,571	.84	4,104	6,343	.65
Land	.048	366	617	.59	479	1,472	.33

Notes:

1. The depreciation rates used in computing capital stock estimates are from the GLS regressions in Table 4, except for the patent and bankruptcy classes, where we used the OLS estimates because of the negative depreciation rates generated by the GLS method.
2. L = capital stock in the beginning of 1974.
3. ΣI = summation of investment unadjusted for depreciation.
4. n.a. = not available because no subject-matter breakdown was possible.
5. Antitrust and civil rights estimates for the court of appeals is for the period 1952-1973.

Table 6 cont.

Subject-Matter	Supreme Court Precedents						
	1949-1973			1874-1973			
	Depreciation Rate	L	ΣI	Ratio	L	ΣI	Ratio
All	.038	1,373	2,104	.65	2,026	7,127	.28
Common Law	.025	163	234	.69	389	1,217	.32
Economic Regulation	.055	498	926	.54	658	3,596	.18
Tax	.059	75	153	.49	145	1,826	.08
Antitrust	.018	128	160	.80	180	290	.62
Labor	.053	129	240	.54	141	411	.34
Other federal							
reg. agencies	.036	229	345	.66	285	605	.46
Patents	.049	19	32	.59	51	481	.11
Civil Rights	.038	71	95	.75	78	150	.52
Constitutional	.049	709	1,106	.64	900	3,871	.23
Criminal	.024	618	801	.77	815	1,495	.55
Bankruptcy	.024	23	31	.75	130	478	.27
Land	.013	20	24	.83	122	249	.49

somewhat unclear. Since cases differ in their precedential significance, a pure count of cases or even one adjusted for depreciation does not reveal whether the capital stock of precedents is really larger in one subject-matter area than in another, or larger in the Supreme Court than in the courts of appeals. A more illuminating statistic, also shown in Table 6, is the ratio of the capital stock to accumulated investment (unadjusted for depreciation). This ratio tells us the proportion of precedents produced over a given period that have survived to 1974. For example, the ratio .63 for court of appeals common law precedents indicates that 63 per cent of these precedents produced in the period 1949-1973 have survived into 1974. This ratio can be meaningfully compared both across subject-matter classes and between courts. (For example, 67 per cent of common law precedents produced in the Supreme Court have survived into 1974 compared to 63 per cent for the courts of appeals.) Usually (but not always) a high depreciation rate will be associated with a low rate of survival of precedents.⁵¹ To take an extreme example, a 33 per cent depreciation rate of civil rights precedents produced in the courts of appeals yields a 28 per cent survival rate of precedents produced between 1949 and 1973. As one might expect from the generally lower depreciation rates in the Supreme Court, the precedents produced in that court between 1949 and 1973 usually have a higher survival rate than those produced in the courts of appeals.⁵² The differences in survival rates, however, are generally of relatively smaller magnitude than the differences in depreciation rates because of the more rapid growth in investment in recent years in the courts of appeals than in the Supreme Court.

C. Tests of Other Hypotheses

In this section, we present results of empirical tests of the remaining hypotheses developed earlier. These hypotheses concern (1) generality versus specificity of precedents, (2) effect of statutory activity, (3) procedural versus substantive precedents, (4) effects of uncertainty, and (5) Warren Court activism.

1. General Versus Specific Legal Capital. We hypothesized that Supreme Court precedents were more general than those of other courts (particularly the federal courts of appeals), and hence would depreciate more slowly. The results for the 1974-1975 courts of appeals sample in Table 4 are consistent with this hypothesis. The depreciation rate of Supreme Court citations is lower than that of other courts in 13 of the 16 possible comparisons using the GLS method. The major exception is federal taxation. The two other exceptions are the patent and bankruptcy classes, where we estimate negative depreciation rates from the GLS regressions (though a 95 per cent confidence interval includes positive depreciation rates for both classes) and positive rates from the OLS regressions. Incidentally, these are the only two negative depreciation estimates in our entire set of regressions.

The results from our sample of Supreme Court decisions are similar, but less marked--indeed, for all classes together, the Supreme Court and other-court depreciation rates are the same, using the GLS method. The explanation for the difference in this regard between the Supreme Court and court of appeals samples may be that, in general, decisions of other courts do not have substantial precedential significance in the Supreme

Court and the Court may therefore be less concerned with their recency, which is an important attribute of a citation viewed as a precedent. This is consistent with our earlier attempt to explain the lower depreciation rates generally in the Supreme Court sample.

The hypothesis that Supreme Court precedents tend to be more general compared to other-court precedents can be tested indirectly by examining the number of citations per case to Supreme Court and other-court decisions. If Supreme Court precedents are indeed more general (implying that they cover more issues), then in a given opinion there should be fewer citations to Supreme Court than other-court decisions. The results for the court of appeals sample presented in Table 7 are consistent with this hypothesis; the average number of Supreme Court citations is about half that of other-court citations in the broad subject-matter classes. Of further interest is the dramatic reversal of these ratios in the Supreme Court sample, which supports our earlier point that decisions of other courts may have little precedential significance in the Supreme Court. There is an interesting difference between the common law area and the other subject-matter areas in the Supreme Court sample: in the common law area the ratio of Supreme Court to other-court citations is 1.04 compared to a ratio of about two in the other subject-matter areas. The explanation may lie in the Erie decision, which gives other-court (especially state-court) decisions special precedential significance in federal litigation in the common law area.⁵³

[Insert Table 7]

2. Statutory Activity. We hypothesized that the depreciation rates of legal precedents would be higher in areas of greater statutory change.

TABLE 7

Average Number of Citations Per Case, 1974-1975 Court of Appeals Sample and Supreme Court, 1974 Term

	Court of Appeals Sample		Supreme Court Samples	
	Supreme Court Citations	Other-Court Citations	Supreme Court Citations	Other-Court Citations
All Classes	4.6	9.2	15.0	7.7
Common Law	3.5	9.3	12.0	11.5
Economic Regulation	4.4	9.4	11.3	8.6
Civil Rights	4.3	9.3	21.9	8.2
Criminal	4.9	9.1	14.0	6.6
Constitutional	8.0	8.2	17.5	6.7

Notes: See Table 2.

Tables 4 and 5 provide modest support for this hypothesis. As expected, we find a lower-than-average depreciation rate in the common law area, one of limited statutory change, and a higher-than-average depreciation rate in the economic-regulation and civil-rights fields, both areas of substantial statutory activity. However, there are a number of anomalies, such as the very low depreciation rate of Supreme Court civil-rights precedents in the court of appeals sample (in contrast to a more than 30 per cent annual depreciation rate of other-court precedents), and the much higher depreciation rates of other-court precedents in antitrust (an area of relatively little statutory change over time) compared to tax (an area of great statutory change over time). The antitrust estimates, however, are probably not reliable because they are based on a small sample of cases. Thus, it is not surprising that the difference between antitrust and tax depreciation rates is reversed for Supreme Court precedents.

There are two very serious problems in measuring the effect of statutory activity on the rate at which precedents obsolesce. The first is the difficulty of measuring statutory activity; simply counting the number of statutory enactments and amendments in an area is no measure of the relevant variable. The second problem is that measuring the effect of statutory activity on the depreciation rate requires that other facts be held constant, notably the depreciation caused by changes in judicial doctrine--an important factor in the antitrust area. Much more work must be done before the statutory-activity hypothesis can be considered either rejected or confirmed.

3. Procedural Versus Substantive Precedents. The theory suggests

that the procedural precedents cited in cases within a particular subject-matter class should depreciate more slowly than the substantive precedents so cited. This is because the procedural precedent is more general or versatile--it could be used in another subject-matter area (e.g., a case deciding a point of pleading in an admiralty case could be used to decide a similar point arising in a tax case). A major problem in testing this hypothesis is our complete lack of data on investment in producing procedural precedents. We can, however, test a weaker version of this hypothesis by comparing average ages. One should observe less variation in average ages across subject-matter classes for procedural than substantive citations because the former (at least in part) come from a common pool of precedents. The results of this comparison are presented in Table 8.

[Insert Table 8]

Table 8 provides little support for the hypothesis. There is no significant difference between the standard deviations of substantive and procedural mean ages across subject-matter classes.⁵⁴ Moreover, a regression analysis indicates that the age of substantive citations is a highly significant predictor of the age of procedural citations across subject-matter classes,⁵⁵ whereas the "common pool" hypothesis would suggest that ages of substantive citations would not be a significant predictor of ages of procedural citations. There are reasons for doubting these tests, rather than the hypothesis. First, our case readers reported difficulty in classifying cases as procedural versus substantive--a difficulty any lawyer will understand. Second, our impression is that most of the procedural precedents used in a particular substantive subject-matter area are precedents involving

TABLE 8

Mean Ages of Substantive and Procedural Citations,
1974-1975 U.S. Court of Appeals Sample

	<u>Supreme Court Citations</u>		<u>Other Court Citations</u>	
	Substantive	Procedural	Substantive	Procedural
Total	18.2 [1724]	21.7 [554]	10.4 [4520]	8.0 [1265]
Common Law	31.3 [186]	38.2 [78]	16.0 [846]	9.9 [215]
Torts and Contracts	32.1 [74]	39.7 [63]	17.0 [691]	10.3 [165]
Admiralty	30.4 [61]	31.5 [15]	11.6 [155]	8.6 [50]
Economic Regulation	20.0 [461]	17.4 [127]	10.5 [1362]	9.3 [298]
Tax	26.5 [55]	24.0 [11]	15.4 [303]	11.2 [21]
Antitrust	21.1 [36]	14.1 [14]	6.1 [57]	6.9 [50]
Labor	14.3 [150]	17.5 [36]	7.9 [368]	10.5 [65]
Other federal reg. agencies	20.0 [193]	15.5 [47]	7.9 [399]	8.2 [111]
Patents	37.7 [27]	20.6 [19]	13.6 [235]	11.5 [51]
Civil Rights	8.8 [105]	12.2 [67]	3.9 [264]	4.1 [138]
Constitutional	15.0 [393]	16.6 [94]	5.6 [443]	6.9 [118]
Criminal (non- const.)	15.5 [500]	18.5 [148]	9.0 [1222]	6.8 [428]
Bankruptcy	40.4 [10]	29.8 [4]	15.3 [140]	9.4 [15]
Land Condemnation	45.2 [35]	57.2 [25]	20.2 [40]	28.2 [21]

Notes:

1. Mean ages are based on weighted method (see pp. _____ supra).
2. In each subject-matter class there are two numbers per column: the top one is the mean age and the bottom one is the number of citations.

that area--that most procedural precedents are in practice, though not in principle, pretty much limited in use to the substantive area in which they arose. This is partly an aspect of the first point (many apparently procedural questions are in fact influenced by the substantive context) and partly, perhaps, an aspect of lawyers' research habits (they are more apt to be familiar with the procedural decisions rendered in cases arising in the substantive areas in which they are expert). No doubt there is a class of "pure" procedural cases that are of great generality or versatility, but they may be too few to influence our statistical results measurably. That of course, is our rationale for combining substantive and procedural decisions in presenting the depreciation rates reported in Tables 4 and 5.

4. Depreciation and Investment. We hypothesized that the higher the depreciation rate of precedents, the more difficult it would be to forecast the outcomes of legal disputes, and the greater the rate of investment in precedent production. One method of testing this hypothesis is to examine the effect of differences in depreciation rates on the rate of investment across subject-matter classes. Our estimating equation is of the form

$$\ln I_t^i / L_t^i = \beta_1 + \beta_2 \delta^i + u^i \quad (18)$$

where I_t^i is the average annual investment in 1972 and 1973 in the i th subject-matter class, L_t^i is the capital stock at the end of 1971 in each class,⁵⁶ δ^i is the estimated depreciation rate from the GLS regressions on the 1974-1975 court of appeals sample in Table 4,⁵⁷ and u^i is the disturbance term. Since there are ten subject-matter classes in the courts of appeals and 11 in the Supreme Court (the "constitutional" class forming an additional class) there is a maximum of 21 observations in the regression analysis.

The results presented in Table 9 are consistent with the hypothesis that an increase in depreciation leads to a positive adjustment in the rate of precedent production. The regression coefficients on the depreciation rates, which are positive and highly significant, indicate that a ten per cent increase in depreciation is associated with approximately a seven per cent increase in the rate of precedent production.⁵⁸ The elasticity estimate for the Supreme Court is unaffected by an expansion of the number of periods used to measure the capital stock (compare the first and third equations), and there is no significant difference between the Supreme Court and courts of appeals in either the responsiveness of investment to a change in depreciation (i.e., the difference between the regression coefficients on δ_{CA} and δ_{SC} in the first equation is not significant) or the investment-capital ratio itself (i.e., the coefficient on the dummy court variable is not significant).

[Insert Table 9]

There are, however, several potential problems with the analysis. First, there could be spurious positive correlation between I_t/L_t and δ . Since the depreciation rate is used to compute the capital stock, an increase in depreciation would lower the capital stock, giving rise to a positive regression coefficient in equation (18). As it turns out, spurious correlation is not a serious problem since the correlation between the depreciation rate and the capital stock for the 21 subject-matter classes is positive (.06) and not significant.⁵⁹ Other possible difficulties arise from the limited number of observations in the regression analysis and our failure to include other variables that may affect the demand and supply of precedent production (a failure due in part to the difficulty of

TABLE 9

Weighted Investment Regressions

Court	Dependent Variable	n	Regression Coefficients (t-statistics)					R ²
			α	δ	δ_{CA}	δ_{SC}	D	
CA & SC	$\ln I_t/L_t$	21	-1.314 (1.062)		.745 (4.290)	.670 (11.444)	.127 (.229)	.92
CA & SC	$\ln I_t/L_t$	21	-1.125 (1.011)	.680 (13.130)			-.818 (.553)	.92
SC	$\ln I_t/L_{t_1}$	11	-1.870 (.895)			.755 (8.278)		.88

Symbols:

CA = Court of Appeals

SC = Supreme Court

 I_t = average annual number of written opinions in 1972 and 1973 L_t = capital stock at the end of 1971 computed from annual investment from 1952-1971 discounted by appropriate depreciation rate L_{t_1} = capital stock computed from annual investment from 1929-1971

D = dummy variable that takes the value 1 for a court of appeals observation and 0 for a Supreme Court observation

identifying variables that are specific to subject-matter classes).⁶⁰ Thus, our results should be viewed as preliminary evidence in support of the hypothesis that greater uncertainty about the outcome of legal disputes generates an increase in the rate of litigation and the production of precedents.

5. Judicial Activism and the Warren Court. Table 10 presents OLS and GLS depreciation rate estimates for the 1960 court of appeals sample.⁶¹ To facilitate comparison with the 1974-1975 court of appeals sample, we have reproduced the relevant depreciation rates from that sample in columns (3) and (4) of Table 10. Although the sampling rates in the two court of appeals samples were both 10 per cent, the 1960 sample is considerably smaller (223 decisions compared to 653 in the 1974-1975 sample) because of the growth in annual precedent production between 1960 and 1975, and the fact that the 1974-1975 sample is based on approximately 1.5 years of opinions. As a result, fewer subject-matter areas are included in Table 10 because in many areas the 1960 sample lacked a sufficient number of cases to permit reliable estimates of depreciation. Another difference between the two samples is the virtual absence in 1960 of civil rights and constitutional (both criminal and noncriminal) decisions and the corresponding (relative) reduction in the number of common law and economic regulation cases between 1960 and 1974-1975.

[Insert Table 10]

Before assessing the "judicial activism" hypothesis, two further points about the 1960 sample are worth mentioning. The first is that in each of the subject-matter classes in the 1960 sample Supreme Court precedents depreciate at a lower rate than other-court precedents. This finding is consistent with our detailed analysis of the 1974-1975 sample and our basic hypothesis that general rules

TABLE 10

Depreciation Rates, U.S. Court of Appeals, 1960 and 1974-1975 Samples

		1960 Depreciation Rate Estimate			1974-1975 Depreciation Rate Estimate			
	S	n	OLS (1)	GLS (2)	OLS (3)	GLS (4)	d ₁ (3)-(1)	d ₂ (4)-(2)
<u>Citations to Other Courts</u>								
All Classes	208	24	.049***	.042***	.052***	.042***	.003	.000
Common Law	52	24	.037***	.038***	.043***	.042***	.006	.004
Economic Regulation	88	24	.057***	.053***	.067***	.062***	.010	.009
Tax	32	24	.077***	.076***	.054***	.052***	-.023	-.024
Labor	25	24	.137***	.115***	.118***	.118***	-.019	.003
Criminal	46	24	.061***	.060***	.050***	.043***	-.011	-.017
<u>Citations to Supreme Court</u>								
All Classes	136	26	.036***	.035***	.042***	.038***	.006	.003
Common Law	26	26	.003	.018	.026***	.025***	.023	.007
Economic Regulation	61	26	.049***	.047***	.055***	.055***	.006	.008
Tax	25	26	.063***	.063***	.059***	.059***	-.004	-.004
Labor	19	26	.029	.028*	.053***	.053***	.024	.025
Criminal	36	26	.012	.010	.026***	.024***	.014	.014

Notes:

1. Complete regressions are presented in Appendix B.
2. *** - significant at .01 level in two-tail test
 ** - significant at .05 level in two-tail test
 * - significant at .10 level in two-tail test
3. S = number of sample cases in 1960 sample.
4. n = number of observations in regression analysis.
5. Complete regression equations are presented in Appendix A.

will depreciate at a slower rate than more specific ones. The second point is the increase from 1960 to 1975 in the proportion of sample cases that cite Supreme Court decisions (see Table 11). For example, in the "all" class there is a statistically significant increase in the proportion of opinions citing Supreme Court (.610 in 1960 compared to .748 in 1974-1975) while the proportion citing other courts remained approximately unchanged (.933 in 1960 and .956 in 1974-1975). The three broad subject-matter classes--common law, economic regulation, and criminal--reveal a similar increase over time in the proportion of decisions citing the Supreme Court.⁶² These figures are superficially surprising. Assuming that the relative availability of Supreme Court to other-court precedents, which is determined in part by the relative number of decisions in these courts, influences citation behavior, then with the more rapid growth of precedent production in other courts relative to the Supreme Court since 1960 one might expect to observe a decline over time in the proportion of cases citing Supreme Court relative to those citing other-court precedents. The fact that the opposite effect is observed may reflect a growing authority or generality of Supreme Court precedents since 1960, which would increase the likelihood of their being cited.⁶³ This interpretation is consistent with our earlier point that the more limited capacity of the Supreme Court compared to the courts of appeals should lead the Supreme Court to become relatively more selective over time in its choice of cases to decide and thus to be choosing cases of greater generality today.

[Insert Table 11]

TABLE 11

Proportion of Decisions Citing Supreme Court and Other Court Precedents,
1960 and 1974-1975 U.S. Court of Appeals Sample

	1960		1974-1975			
	Supreme Court (1)	Other Court (2)	Supreme Court (3)	Other Court (4)	d_1 (3)-(1)	d_2 (4)-(2)
All	.610	.933	.748	.956	.138	.023
Common Law	.481	.963	.530	.991	.049	.028
Economic Regulation	.629	.907	.721	.962	.092	.055
Tax	.676	.865	.722	.917	.046	.052
Labor	.731	.962	.849	.981	.118	.019
Criminal	.720	.920	.845	.950	.125	.030

Sources: See Tables 1 and 2.

One test of judicial activism is a comparison of the depreciation rates of precedents before and after the period of supposed activism. Since judicial activism in the 1960s would imply an acceleration in the rate of replacement of the precedents created prior to the 1960s, we should observe a higher depreciation rate in the 1974-1975 court of appeals sample than in the 1960 sample if the Warren Court was indeed an unusually activist one. But the results in Table 10 provide only weak support for this hypothesis. There appears to be a slight tendency for depreciation rates of Supreme Court precedents to be higher in 1974-1975 than in 1960 (except in the tax area) but the differences are not significant. With respect to other-court precedents, the differences between the 1974-1975 and 1960 depreciation rates are more mixed and even smaller.

These results must be viewed as inconclusive. Our subject-matter classes may be too gross to detect changes in depreciation due to the Warren Court (e.g., we were not able to make comparisons within the civil-rights area). Moreover, by 1974-1975 the reaction to the Warren Court associated with the emergence of a distinctive "Burger Court" may already have resulted in the resurrection of a number of precedents ignored by the Warren Court. In future work we hope to deal with these problems by expanding the number of cases in our samples and by including years between 1960 and 1974-1975.

V. Conclusion and Suggestions for Future Research

The concept of precedent is at the heart of the way in which lawyers think about the legal system. And the results of the present study suggest that an approach which treats legal precedents as a form of investment subject to the usual economic laws governing the formation and depreciation

of capital may improve our understanding of precedent. But the present study is only preliminary. Future studies will utilize much larger samples that will enable us both to utilize more information about each case and to study additional facets of legal capital. Eventually, we hope to compare the depreciation rates of judicial decisions with those of administrative-agency decisions, statutes, and constitutional provisions, to compare different courts, to examine citation practices in appellate briefs, and to examine the depreciation question from the "case history" as well as the "citation practice" standpoint.⁶⁴

Of particular interest, we believe, would be a study of secular changes in depreciation rates. There is a widely held belief in the academic legal community that adherence to precedent has declined over time, particularly in the U.S. Supreme Court, partly perhaps as a result (or cause?) of the "legal realist" movement. The trend in depreciation rates may cast light on this question, as may a comparison of trends in different courts.

There are many other interesting areas of research on legal precedent, a few of which we shall mention briefly in closing:

1. The services produced by precedents, primarily in creating specific rules of legal obligation and thereby reducing the demand for litigation across subject-matter categories and over time, may, as suggested earlier, be important in explaining changes over time (or across states or federal judicial districts) in the volume of litigation.⁶⁵

2. The measurement of precedential significance by counting citations may prove to hold the key to the problem of evaluating judicial output. For obvious reasons, the number of terminations, trials, or even judicial

opinions does not measure the output of a judicial system in a socially interesting sense; the number of precedents--weighted by the significance of each precedent as measured by the number of times it is cited in subsequent decisions--may. A precedent-based measure of judicial output could be compared with the input measures used by the Administrative Office of the U.S. Courts in its "weighted caseload" studies, which measure the amount of judicial time allocable to various substantive and procedural classifications of judicial activity.⁶⁶ Precedential significance as a measure of judicial output might also be used to compare the importance of different courts as sources of law, and even to evaluate individual judges.

3. The number of law clerks has risen sharply in relation to the number of judges in recent years, but we know of no systematic efforts to appraise the significance of this development. One hypothesis about law clerks which could be tested using citation data would be that since law clerks (especially in the federal courts of appeals and Supreme Court) tend to be drawn from a relatively small number of "elite" law schools, which employ highly uniform teaching methods and materials, judicial citation practices would tend to become more uniform, with respect to age and number of precedents, over time as law clerks played an increasingly large role in judicial research and opinion writing; and, further, that judicial citation practices would tend to be more uniform in the federal than in the state court system.

4. A comparison of citation practices in appellate briefs and judicial decisions may illuminate some of the fundamental characteristics of legal advocacy. Are there systematic differences between lawyer and judge citation

practices? Are there systematic differences between the citation practices of the winning and losing lawyer? The answers to these questions may suggest the contours of an economic theory of legal advocacy.

5. The analysis of precedent may prove helpful in explaining observed characteristics of the legal profession. Current research by Peter Pashigian indicates that lawyers' earnings increase with age relative to those of other professionals. The explanation for this phenomenon may lie in the relatively low depreciation rates of legal precedent (see Tables 4-5). They imply that an important component of lawyers' capital--their knowledge of the substantive rules of law--obsolesces slowly, more slowly, we assume, than the essential knowledge of physicians, engineers, and other professionals. Therefore, when the lawyer reaches the point in his life cycle where additional investments in human capital would not be economical, due to the shortness of the period in which they would yield income, nonetheless his income may persist at a high level since his existing stock of capital will decline slowly. It would be consistent with this analysis to find that older judges cite on average older cases--but that study, too, we leave to the future.

Landes-Poser--Footnotes

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An earlier draft of this paper was prepared for a conference held at the University of Chicago Law School on January 17, 1976, in honor of George Stigler's 65th birthday. A pioneering figure in the application of economics to law, Professor Stigler is also a generous colleague, to whom the authors of this paper are greatly indebted for inspiration and assistance in many ways over the years. This paper is dedicated to him with gratitude and affection.

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1. See generally Edward H. Levi, *The Nature of Legal Reasoning* 1-2 (1949); 1 Henry M. Hart & Albert M. Sacks, *The Legal Process: Basic Problems in the Making and Application of Law* 138-39 (tent. ed. 1958).
2. However, legal precedent is discussed as a form of social capital having public-good characteristics in James M. Buchanan, *The Limits of Liberty* (1974), especially in ch. 6, and some aspects of the economic theory of precedent are also discussed in Isaac Ehrlich & Richard A. Posner, *An Economic Analysis of Legal Rulemaking*, 3 *J. Leg. Studies* 257 (1974), and in Richard A. Posner, *An Economic Approach to Legal Procedure and Judicial Administration*, 2 *J. Leg. Studies* 399, 448-51 (1973). Professors Lawrence Friedman of Stanford Law School and Stanton Wheeler of Yale Law School, and their associates, are in the process of collecting a large sample of state appellate opinions which they plan to use for an empirical study of precedents, though not within an economic framework.
3. The research assistants who counted the citations in the opinions in our samples were instructed to exclude citations to lower-court decisions in the same case, "but see" and other citations indicating rejection of the cited case as a precedent, and multiple citations to the same case if cited on the same point.

4. See, e.g., Robert K. Merton, *The Sociology of Science: Theoretical and Empirical Investigations* 508-09, 514-15, 556 (1973), and references therein; Michael C. Lovell, *The Production of Economic Literature: An Interpretation*, 11 *J. Econ. Lit.* 27 (1973), and references therein; George J. Stigler & Claire Friedland, *The Citation Practices of Doctorates in Economics*, 83 *J. Pol. Econ.* 477 (1975).
5. Thus, the legal purist will be distressed at our placing admiralty cases in a category called "common law"; our purpose in doing so was to group together cases in which statutes have played a relatively small role as a source of legal rules. More refined classifications are used in our current research, not reported in this paper, which is based on a sample of about 7,000 federal court of appeals decisions.
6. A comparison of terminations involving a written judicial opinion (our samples) to commencements is at best a crude one. Unfortunately, the subject-matter breakdown for terminations, and subsets of terminations such as terminations with a judicial opinion, are not reported by or available from the Administrative Office. Observe that the frequencies in our subject-matter classes tend to exceed the frequencies in the Administrative Office data because of the larger proportion of unclassifiable cases in the Administrative Office data compared to our samples (e.g., 23.1 per cent compared to 2.9 per cent in 1974, and 14.9 per cent compared to .4 per cent in 1960).

7. In a separate (and not completed) study we have classified some 400 Supreme Court decisions rendered in the Court's 1900, 1938, and 1958 terms by subject matter, and then analyzed the survival rates of precedents by tracing the time path of the citations to each decision by the Supreme Court and by other courts.
8. Only citations appearing in majority opinions are included in Table 2; citations appearing in concurring and dissenting opinions were also counted but are not utilized in the present study. A case cited more than once in an opinion was counted separately every time it was cited on a different issue; but, as previously noted, a case cited repeatedly for the same point was counted only once.
9. However, a deficiency in our procedure (which will be remedied in subsequent studies) is the failure to distinguish within the category of other-court (i.e., other than U.S. Supreme Court) citations between citations to U.S. court of appeals decisions and to other decisions (decisions of federal district courts, state courts, the Court of Claims, English courts, etc.). Still, our category of "other court" citations is a serviceable, if crude, proxy for U.S. court of appeals citations, because most other-court citations are, in fact, to U.S. court of appeals decisions. Thus, in a random sample of 261 citations appearing in volumes of the Federal Reporter, Second, for 1974 and 1975 (the source and period from which our 1974-1975 U.S. court of appeals sample was drawn), 74.7 per cent of the citations (excluding citations to the Supreme Court) were to U.S. court of appeals decisions.

However, the mean age of the courts of appeals citations was only 5.8 years, compared to 14.5 years for the citations to other courts' decisions and 8.0 for both groups together (weighted). (This is somewhat lower than the mean age of other-court citations in our main 1974-1975 sample; see Table 2.) One reason why the mean age of the U.S. courts of appeals citations is lower than that of the other non-U.S. Supreme Court citations appears to be that the courts of appeals are of comparatively recent creation (1891). The oldest citation to a court of appeals decision in our 261-citation sample discussed in the preceding paragraph is 50 years old, compared to 194 years for the oldest citation to another court's decision. If all citations in the sample of more than 50 years are reduced to 50 years, the mean age of the non-courts of appeals citations in the sample falls from 14.5 to 10.5 years.

10. We also computed the ages of citations in a subsample limited to cases that cite both U.S. Supreme Court and other-court decisions, on the theory that cases citing only Supreme Court decisions might differ systematically from those citing only other courts' decisions and thus might distort a comparison of the mean ages of the citations in the respective types of decision. However, a comparison of the results of the subsample with Table 2 indicated that this refinement in the sampling method did not produce any marked change in results, so we did not utilize this subsample in our empirical analysis.

11. We have not systematically tested the statistical significance of the differences in average age of citations across subject-matter classes, between citations to Supreme Court and other-court cases, etc. The standard errors are quite low, however, suggesting that most differences in means that we are interested in comparing are significant.
12. See Michael C. Lovell, supra note 5, at 27.
13. See ibid.
14. Let C_i = number of citations per case, \bar{C} = average number of citations per case, \bar{A}_i = average age of citations per case, \bar{A} = unweighted average age of citations ($= \sum_{i=1}^n \bar{A}_i / n$ where n = the number of cases), and \bar{A} = weighted average age of citations ($= \sum_{i=1}^n C_i \bar{A}_i / \sum_{i=1}^n C_i$ where $\sum_{i=1}^n C_i = n \cdot \bar{C}$). A positive correlation between C_i and \bar{A}_i implies that

$$\begin{aligned} n \cdot \text{Cov}(C_i, \bar{A}_i) &= \sum_{i=1}^n (A_i - \bar{A})(C_i - \bar{C}) > 0. \\ &= \sum \bar{A}_i C_i - \frac{\sum \bar{A}_i \sum C_i}{n} > 0. \end{aligned}$$

Dividing by $\sum C_i$ yields

$$\frac{n \cdot \text{Cov}(C_i, \bar{A}_i)}{\sum C_i} = \bar{A} - \bar{A} > 0.$$

15. Observe that this implies that the first 15 citations in a case will have an average age of 25.8 years, and the next 15 an average age of 34.5 years in order to bring the average up to 30.2.

16. The F-tests were 8.89 with 14 and 476 degrees of freedom for citations to the Supreme Court, and 14.98 with 14 and 613 degrees of freedom for citations to other courts. Both were significant at the .01 level.

17. To simplify exposition, we disregard the contributions to legal capital that are made by statutes, constitutional provisions, and administrative rulings and regulations.

18. This leaves open the question whether a 10 per cent depreciation rate, for example, implies that 10 per cent of last period's precedents "disappear" while 90 per cent survive in full, or whether the services yielded by each precedent decline on average by 10 per cent. This paper adopts the latter formulation because it encompasses both precedents that "disappear" (100 per cent decline) and those that decline partially in value.

19. There are exceptions--a long-dormant precedent may acquire a new value because of a sudden upsurge in demand, as in the recent controversies over impeachment and executive privilege. The counterpart in the realm of physical capital is the abandoned machine restored to service because of a sudden increase in demand for its services.

20. Conceivably, an increase in the stock beyond some level might produce conflicting precedents, or so increase the difficulty of discriminating among nonconflicting ones as to reduce the amount of information about the expected outcome of legal disputes; either result would imply a negative value of the marginal product of legal capital. But we prefer to view these situations as reductions in the set of precedents (i.e., negative investment) and hence in the capital stock, and thus rule out negative marginal products. Observe that the explicit replacement of an old by a new precedent (e.g., when old decisions are overruled) is analytically distinguishable from a conflict between precedents, because the overruling can be viewed, sequentially, as the depreciation of the old precedent followed by investment in developing a new one.

21. The public-good aspect of legal capital is implicit in the formulation of equation (4). Since one person's use of precedents does not exclude another's use, V_t will rise as the number of users increases (i.e., $\partial V_t / \partial N_t > 0$). If congestion eventually occurs as the number of

users increases, then beyond some point $\partial^2 V_t / \partial N_t^2 < 0$. In the development of our model we take as given the number of users.

22. Although legal capital yields information, its value ultimately depends on the underlying behavior it promotes. If "value" is synonymous with "efficiency," then the more effectively legal precedents promote behavior consistent with efficient resource allocation, the greater will be their value. Precedents in fact differ greatly in the degree to which they affect efficiency, and some may actually reduce efficiency and hence should be assigned a negative value if value and efficiency are to be equated. But in this paper we ignore ultimate questions of value and assume that precedents are valuable insofar as they promote compliance with whatever legal norms the precedents are intended to implement.
23. Nonnegative gross investment results from the inability of the community to sell its legal capital. Although zero gross investment in a period is possible, we assume for mathematical convenience that the optimality conditions yield positive gross investment in every period.
24. Equation (7) is derived by substituting $(1-\delta)\partial\pi/\partial I_{t+1}$ ($=0$) into (6) and assuming that $\tilde{C}_t\delta \approx 0$. A similar expression for health capital is developed by Michael Grossman in his Demand for Health (1974), and Kenneth Arrow develops the general formula using continuous time in his paper Optimal Capital Policy with Irreversible

Investment, in Value, Capital and Growth, Papers in Honour of Sir John Hicks (J.N. Wolfe ed. 19).

25. This effect would be strengthened if legal capital and legislation were substitutable, in the sense that on balance the value of the marginal product of legal capital was reduced by legislation. If they were complementary, however, legislation, though increasing the depreciation rate (and raising the cost of investment), would have an offsetting effect by increasing the demand for capital.
26. To demonstrate this, we assume a stationary capital stock (i.e., zero net investment). Since gross investment in period t equals δL_t , we have

$$\frac{\partial \ln I_t}{\partial \ln \delta} = 1 + \frac{\partial \ln L_t}{\partial \ln \delta} .$$

From equation (7) it follows that

$$\frac{\partial \ln I_t}{\partial \ln \delta} = 1 + \frac{C'_{t-1} \delta}{V''_t L_t} = 1 - e \cdot s$$

where $e = -(1/V''_t)(V_t/L_t)$ (the elasticity of the demand curve) and

$s = \delta/(r+\delta)$ (the share of depreciation in user cost). It follows that investment is more likely to increase with an increase in δ the smaller are e and s . This result would have to be modified if the capital stock were growing.

27. Gross investment may be written

$$I_t = L_t(\tilde{L}_t + \delta)$$

where the rate of growth of the capital stock is $\tilde{L}_t = (L_{t+1} - L_t)/L_t \cong (\partial L_t / \partial t) / L_t$. This approximation allows us to ignore the one-period lag between investment and additions to the capital stock. Thus

$$\frac{\partial \ln I_t}{\partial t} = \frac{\partial \ln L_t}{\partial t} + \frac{\partial \ln(\tilde{L}_t + \delta)}{\partial t}$$

and $\partial \ln(\tilde{L}_t + \delta) / \partial t$ equals zero by assumption.

28. See Gerhard Casper & Richard A. Posner, A Study of the Supreme Court's Caseload, 3 J. Leg. Studies 339, 340-41 (1974) (tab. 1 and fig. 1).
29. The capacity of the federal appellate courts has not, however, grown at the same rate as the demand. The result has been not only an

increase in court queues but also a decrease in the proportion of cases decided that are likely to produce precedents. Thus, while all cases tendered to the courts of appeals are (eventually) decided--the jurisdiction of these courts, unlike that of the Supreme Court, not being discretionary--an increasing number are being decided without creating a precedent, i.e., without a written opinion. See pp. _____, infra (App. A).

30. As urged by many of the Court's critics. See, e.g., Henry M. Hart, Jr., The Supreme Court 1958 Term: ForewOrd: The Time Chart of the Justices, 71 Harv. L. Rev. 84, 96-100 (1959).
31. The model developed in subpart B made the simplifying assumption of constant marginal costs of investment (see Figure 1). Thus, any discrepancy between the desired and actual capital stock would be eliminated in a single period (or instantaneously in a continuous-time model) by adjustments in investment. But if instead marginal cost is rising within a given period (and this is likely to be so, if only because the number of actual disputes capable of producing precedents is limited in each period), then discrepancies between actual and desired capital will tend to be eliminated gradually over several periods.
32. We showed in note 26 supra that the effect of a higher depreciation rate on gross investment was uncertain. However, since $I_t/L_t = \delta$

for a stationary capital stock, a higher depreciation rate must be associated with a higher investment-capital ratio. If the capital stock were growing, then $I_t/L_t = \tilde{L}_t + \delta$ (see supra note 27). Here a higher depreciation would also be associated with a higher investment-capital ratio, provided there was not an offsetting decline in the growth rate (\tilde{L}_t) of the capital stock.

33. See John P. Gould, *The Economics of Legal Conflicts*, 2 J. Leg. Studies 279, 285, 288-90 (1973); William M. Landes, *An Economic Analysis of the Courts*, in *Essays in the Economics of Crime and Punishment* 164, 172-73 (Gary S. Becker & William M. Landes eds. 1974); Richard A. Posner, supra note 2, at 418-20, 422-26.
34. We ignore, as irrelevant to the production of precedents, uncertainty purely over issues of fact, as distinct from legal issues, though factual uncertainty may also lead to litigation.
35. Presumably, defendants would be entitled to a share in the royalties only when the issue for which the case was cited had been raised by the defendant (rather than the plaintiff) in the original case by way of defense to the charge.
36. See William M. Landes & Richard A. Posner, *The Independent Judiciary in an Interest-Group Perspective*, 18 J. Law & Econ. 875 (1975).

37. The same implication--a zero depreciation rate--could be derived from a seemingly opposite theory of judicial behavior: that judges are so blindly wedded to precedent that they don't realize that a precedent ever depreciates. But perhaps this is the same theory, in that it implies a rejection of (rational) adherence to precedent.
38. See note 27 supra.
39. See the discussion and tables on investment in Appendix A, infra.
40. One can respond crudely to the question of a nonconstant growth rate by deriving an expression for the mean age of citations in which age is expressed as a function of a single depreciation rate but two growth rates: a growth rate from the base period to period j and a growth rate from j to the current period, t . Given data on average and on the two growth rates (e.g., the civil-rights growth rates before and after 1953), one can estimate the depreciate rate by an iterative procedure.
41. No substantive meaning can be attached to k , since it is a positive function of sample size; i.e., the more cases in the sample, the more citations there will be and hence the greater k will be.
42. However, we count only once multiple citations to an earlier decision if that decision is being cited for the same point in the same case. See note 3 supra.

43. Not only is our method preferable to one that assigns equal weight to all prior cited decision, but it greatly reduces the costs of data collection. Much more detailed information on citations must be kept in order to record citations in different sample cases to the same decision.
44. For convenience we use a continuous time specification in the empirical analysis.
45. Michael Lovell (see note 5 supra) employs a similar though less efficient regression technique to estimate the depreciation rate of economic knowledge. He estimates a regression of citations on time and then computes depreciation by subtracting an estimate of the growth rate of articles from the regression coefficient.
46. Because it would burden the test unduly to recount our efforts in trying to deal with these problems, here we merely summarize the main problems and our solution to them. See Appendix B for a more detailed discussion of these problems as well as tables on investment.

47. Our age distributions record the number of citations for each year from 1948 through 1973-1974 (a total of 25 observations); the average number of citations per year over five-year intervals from 1924-1948 (i.e., a total of five observations); and the average number per year over 10-year intervals from 1874-1923 (i.e., a total of five observations). Thus, only six of 35 observations in the regression analyses of citation data to the Supreme Court and eight of 33 observations in the other-courts regression are for years in which investment data by subject matter are not directly available. There are only 33 observations in regressions of citation data to other courts because the U.S. courts of appeals were not established until 1891.
48. Complete regression results appear in Appendix A, infra. The methods used in estimating depreciation rates in Tables 4 and 5 correspond to the unweighted method of estimating the age of citations. See pp. _____, supra. Procedural and substantive citations were merged for purposes of making these estimates.
49. In Table 4, δ is positive in 64 of 66 equations, statistically significant (.05 level) in 55, marginally significant (.10 level) in 5, and not significant in the remaining 6. In Table 5, δ is positive in all 22 equations, significant in 18, and marginally significant in 2 more. Of course, not all of these equations are

independent (e.g., the OLS and GLS equations, and the equations that aggregate several subject-matter classes into a larger class).

The difference between the OLS and GLS estimates are for the most part negligible.

50. Although the number of observations is typically 35 in regressions to Supreme Court precedents and 33 in regressions to other-court precedents, the number of sample cases that are the basis for the data need only be equal to or greater than one, for it is possible to estimate a regression on $\ln(C_t^0/I_t)$ using the citations contained in a single sample case. We of course do not expect the citations in a single case to yield a reliable estimate of δ , and in general the more sample cases in a subject-matter class the more reliable should be our estimate. In the Supreme Court sample, the number of cases in the detailed classes was often too small for us to make reliable estimates (e.g., in citations to other-court cases there are only 2 admiralty, 6 tax, 5 antitrust, 2 patents, 5 bankruptcy and 2 land cases; see Table 2 for the number of cases in other categories). Even in the 1974-1975 court of appeals sample, the small numbers of cases in antitrust (12 citing other-court cases and 10 citing the Supreme Court), bankruptcy (17 and 8) and land (8 and 8) suggest that the estimates of δ for these classes should be viewed cautiously. Notice also that the R^2 's tend to be lower in these subject-matter classes; presumably, this is due to a greater amount of error in measuring the dependent variable.

The reason why, in Tables 4 and 5, the number of observations in the regression analysis was sometimes less than either 35 or 33 (e.g., 22 in antitrust and civil rights in Table 4) is that in some years there were neither citations nor investment. For example, in the civil-rights area, there were no citations to cases and no (measured) investment before 1952. We excluded from the analysis any year when both citations and investment were zero, but if there were positive citations but zero investment, or positive investment but zero citations, then the year was included. In the former case we arbitrarily assumed that investment equaled 1, and in the latter case that the number of citations equaled .01.

51. If high depreciation is offset by a rapid growth in investment, then the survival rate of precedents produced over a given period might be independent of the depreciation rate.
52. Higher survival rates for Supreme Court precedents occur in most subject-matter classes but not in the "all" category.
53. *Erie R.R. Co. v. Tompkins*, 304 U.S. 64 (1938), held that in cases brought in federal courts only

because of the diversity of citizenship of the parties, the courts had to apply substantive state law, including decisional law. Since most of the common law cases in our sample are diversity cases, the principally relevant precedents are state-law decisions, which are part of the "other court" category. We plan a more refined analysis of precedent in federal diversity cases in subsequent studies.

54. The standard deviations across the 12 subject-matter classes are 11.6 and 13.1 years respectively for substantive and procedural citations to Supreme Court precedents, and 5.2 and 6.1 years respectively for substantive and procedural citations to other courts.

55. The regression estimates are as follows

$$\begin{array}{l} \text{Supreme Court Precedents: } Y_i = 1.93 + .89X_i \quad R^2 = 60 \\ \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad (4.15) \\ \text{Other-Court Precedents: } Y_i = .36 + .89X_i \quad R^2 = 53 \\ \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad (3.62) \end{array}$$

where Y_i = mean age of procedural citations in i th subject-matter class, and X_i = mean age of substantive citations in i th class.

The number in parentheses is the t-statistic. There are 12 observations in each regression.

56. In order to include the court of appeals civil rights and antitrust classes in the regression analysis (investment data for these two

classes are available only since 1952) we estimated L_t^i from annual investments over the 20 year period 1952-1971. When the Supreme Court is analyzed separately, L_t^i can be computed over a 43-year period, 1929-1971, since investment data for each class are available for this longer period.

57. There are two exceptions. OLS estimates were used for the patent and bankruptcy precedents produced in the court of appeals because the GLS method generated negative depreciation rates.
58. Each observation in Table 9 was weighted by \sqrt{C} where C is the number of sample cases used to estimate δ^i in Table 4. Weighted regressions were estimated because the error in the estimated depreciation rates is likely to be a positive function of the number of sample cases. (See pp. _____, supra.) Unweighted regressions, however, were also estimated, with little change in the results.
59. For the Supreme Court, the unweighted correlations between δ and L_t are .09 and .04 (depending on whether L_t is computed from annual investment since 1952 or 1929), and for the courts of appeals the unweighted correlation is -.32. None of these correlation coefficients is significant.
60. An alternative and promising approach would be to examine investment over time within a subject-matter area. The advantage is that one can

identify variables (e.g., the volume of business transactions, population changes, key legislation, judicial turnover, subsidies to litigants) that are likely to affect the demand and supply of precedent production. This approach would require one to estimate a depreciation rate that varied over time within a given subject-matter area. (For further discussion see pp. _____, supra.)

61. In most instances GLS estimates are unnecessary because first-order serial correlation is not present. Two exceptions are the all and labor classes in the citations to other courts. In one other regression--economic regulation in the citations to other courts--the Durbin-Watson test was inconclusive.

62. The only significant increase, however, is in the criminal subject-matter class. Observe also that there were slight but statistically insignificant increases in the proportion of cases citing other court decisions. In one class (tax) there was a greater increase from 1960 to 1974-1975 in the proportion of cases citing other courts than in the proportion citing the Supreme Court.

63. This conclusion is of course a preliminary one. We have only examined two years and thus do not know whether the observed change reflects a persistent trend, as our explanation implies.
64. See pp. _____ supra.
65. Indeed, we first became interested in the possibility of studying legal precedents quantitatively as part of an ongoing study of the federal courts since 1874. That study is described briefly in Richard A. Posner, *The Economic Approach to Law*, 53 *Texas L. Rev.* 757, 769 (1975).
66. See, e.g., Federal Judicial Center, *The 1969-1970 Federal District Court Time Study* (June 1971).