

ABSTRACT

Title of Dissertation: INSTITUTIONAL PERSISTENCE AND
CHANGE IN ENGLAND'S COMMON LAW:
1700-1865

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Economics

Institutions are widely regarded as important, even ultimate drivers of economic growth and performance. A recent mainstream of institutional economics has concentrated on the effect of persisting, often imprecisely measured institutions and on cataclysmic events as agents of noteworthy institutional change. As a consequence, institutional change without large-scale shocks has received little attention. In this dissertation I apply a complementary, quantitative-descriptive approach that relies on measures of actually enforced institutions to study institutional persistence and change over a long time period that is undisturbed by the typically studied cataclysmic events. By placing institutional change into the center of attention one can recognize different speeds of institutional innovation and the continuous coexistence of institutional persistence and change. Specifically, I combine text

mining procedures, network analysis techniques and statistical approaches to study persistence and change in England's common law over the Industrial Revolution (1700-1865). Based on the doctrine of precedent - a peculiarity of common law systems - I construct and analyze the apparently first citation network that reflects lawmaking in England. Most strikingly, I find large-scale change in the making of English common law around the turn of the 19th century - a period free from the typically studied cataclysmic events. Within a few decades a legal innovation process with low depreciation rates (1 to 2 percent) and strong past-persistence transitioned to a present-focused innovation process with significantly higher depreciation rates (4 to 6 percent) and weak past-persistence. Comparison with U.S. Supreme Court data reveals a similar U.S. transition towards the end of the 19th century. The English and U.S. transitions appear to have unfolded in a very specific manner: a new body of law arose during the transitions and developed in a self-referential manner while the existing body of law lost influence, but remained prominent. Additional findings suggest that Parliament doubled its influence on the making of case law within the first decades after the Glorious Revolution and that England's legal rules manifested a high degree of long-term persistence. The latter allows for the possibility that the often-noted persistence of institutional outcomes derives from the actual persistence of institutions.

INSTITUTIONAL PERSISTENCE AND CHANGE IN ENGLAND'S COMMON
LAW: 1700-1865

by

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Dedication

To my parents and Yehuda
in love

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Chapter 1: Introduction

Mankind's ability to collaborate in large groups of genetically unrelated individuals and quickly adapt its behavior to changing environments is unique in the animal kingdom. No other animal species ever colonized and transformed so many different habitats, became a lethal threat to so many other animals, or appropriated such a vast amount of the biosphere for its own purpose. Through the increasing use of knowledge, symbolic representations and material artifacts humans were able to construct ecological niches in all kinds of habitats, modify selection pressures and pave the way to their unparalleled evolutionary success (Laland and O'Brien, 2011). The biological predisposition for cumulative culture appears in the eyes of many to be the main ingredient underlying flexible large-scale collaboration among humans (Boyd et al., 2011; Tomasello, 2014; Gintis and Helbing, 2015; Harari, 2015). It not only enables the transmission of advantageous information from individual to individual and from generation to generation, but also the effective construction of new advantageous information. Socially constructed values, norms, and institutions – sometimes called imagined realities – are manifestations of cumulative culture and play an essential part in the ability of human groups to collaborate and adapt.

Over the last decades values, social norms and institutions have gained¹ prominence in the field of economics, particularly through work that studies the causes of modern economic growth². The modern, previously unknown phenomenon of intense and sustained economic growth³ – brought by the Industrial Revolution - is central to

¹ Regained is more accurate because these kinds of considerations were central to many pre-WWII economists.

economists and thought after by politicians because it results in drastic increases of material well-being and state power⁴. Last two centuries' unequal occurrence of sustained economic growth resulted in large discrepancies in the wealth of nations and state power⁵, allowed Western states to dominate the globe for two centuries, and produced historically unprecedented levels of global wealth and income inequality (Milanovic, 2012). Most individuals in today's industrialized countries, live longer, are healthier, and consume more goods and services than most individuals in humankind's history. How to ignite, maintain or accelerate economic growth is one of the main preoccupations of economists and policy makers.

² Values, social norms, and institutions also figure prominently in other subfields of economics. For example, in works that study deviations from purely self-regarding behavior (Henrich et al., 2001; Ostrom, 2005), differences in transaction costs (Williamson, 1998), questions of political economy (Tabellini, 2008a), or determinants of female behavior (Fernández, 2010).

³ As demonstrated by rough estimates of historical income (e.g. Maddison 2007), and the Kuznets argument of absurdly low incomes if one would extrapolate modern growth rates to earlier times. For a qualification of this statement see Fouquet and Broadberry (2015).

⁴ There are other benefits that are attributed to this type of growth. For example, Friedman (Friedman, 2005, p. 4) argues that "economic growth - meaning a rising standard of living for a clear majority of citizens - more often than not fosters greater opportunity, tolerance of diversity, social mobility, commitment to fairness and dedication to democracy."

⁵ Economic differences in the wealth of nations and its impact on state power became the subject of systematic reflection before the appearance of modern economic growth. The increasing prominence of manufacturing and trade in 16th century Europe affected trade balances, and spurred a discussion on the benefits of manufacturing and the most advantageous composition of a state's economic activities (in an era of frequent mercenary warfare, advantageous often meant the ability to pay for a large number of mercenaries). Serra's 1613: "A Short Treatise on the Wealth and Poverty of Nations" is one of the first treatises, while Adam Smith's 1776: "Inquiry into the Nature and Causes of the Wealth of Nations" is the most famous one.

While economists agree that intensive and sustained economic growth is the only road to general material well-being, they have debated for many decades how to achieve it. By drawing on Solow's growth model and its later variants, one can distinguish post-WWII explanations of modern economic growth according to the different aggregate production function factors they emphasize (roughly in historical order): physical capital, human capital and demographics, natural capital, and various determinants of total factor productivity: technological knowledge; values, social norms and institutions; or social capital and trust ⁶.

From a cultural perspective the apparently clear distinctions between the different production factors appear blurry. Cumulative culture permeates all of them. For example, trust and social capital - i.e. social networks resulting from repeated mutually beneficial social interactions - are indispensable for cumulative social learning. Imagined realities, knowledge, and technology derive their force from the inter-generational transmission of existing culture, the possibility to create the new from the existing and the spread of innovations within groups. Humankind's ability for cumulative culture allowed it to

⁶ Each approach tends to see the emphasized aspect as the ultimate cause of economic growth, and the emphasis of previous approaches as proximate causes. The different emphasized aspects result in different policy prescriptions. When the focus is on capital accumulation one aims at rapid accumulation of physical capital, possibly by increasing savings rates and undertaking a government-led "big push". If demography and human capital are at the center of attention, policies concentrate on fertility factors, education reform and health care programs. A preoccupation with natural capital results in policies that try to limit overuse of natural resources and establish ecological sustainability. To increase total factor productivity through knowledge, policies encourage transfer of know-how or create incentives for research & development activity. An institutional lens magnifies institutional setups, and tries to promote favorable institutional setups by improving regulations, governance mechanisms, the business environment and related institutional features. Finally, a social capital focus will try to avoid damage to existing social ties, and support beneficial social interactions (often non-market).

transform nearly the whole ecosystem of the earth into natural capital⁷. The transmission of cognitive and non-cognitive⁸ skills (particularly the latter often promoted by imagined realities) determines human capital and influences demographics. Tools, machines and vehicles are material artifacts that are useful only when embedded in knowledge structures and cooperation networks. Last, but not least, money - the grease of all commercial transactions - is an invention that draws on the symbolic skills of humans⁹.

The blurriness, of course, does not imply the futility of the distinctions between the different factors of the production function. The distinctions have guided analysis over many decades and proved to be useful. Generally speaking, distinctions allow the mind to focus on one dimension and follow it over time, to compare different dimensions at a given point of time, to study interactions between the different dimensions, or to realize the need for different distinctions. While I believe it worthwhile to point out the cultural connections between different factors of the aggregate production function, I will stick with the standard distinctions and – while maintaining a cultural perspective - concentrate on the institutional part and related research of economists.

⁷ See, for example, the proclamation of the “Anthropocene” (Zalasiewicz et al., 2008) and the subsequent debate.

⁸ Non-cognitive skills - largely due to recent work of Heckman (see e.g. Heckman, 2013) - are a recent extension of economists’ notion of human capital.

⁹ To avoid the appearance that I see culture as dominating everything, and intend to fire the conflict between idealist and materialist approaches, I would like to point out that I do not find it fruitful to accept the dichotomy between ideas and matter or between culture and nature. Culture is a biological adaptation that is common in many different species. Natural selection continues to operate on the genetic level and coevolves with culture. The ability for cumulative culture, however, seems to be a distinct feature of humans (see for example Richerson and Boyd, 2005).

The post-WWII economics literature on institutions and economic development is vast and spawns many sub-disciplines - among them economic history, comparative institutional economics, transaction cost economics, and political economy. This study is best understood as a reflection on a mainstream of the recent literature. That literature has a focus on institutional persistence. Empirically it manifests as searches for persistent institutional influences while its associated theoretical literature lays out formal models that are meant to represent mechanisms of institutional persistence. Institutional change is sidelined.

The empirical literature first demonstrated a statistical cross-country association between different measures of values, social norms, institutions and various measures of economic performance (Hall and Jones, 1999; Glaeser and Shleifer, 2002; Barro and McCleary, 2003; Rodrik et al., 2004). Subsequent studies used more sophisticated causal identification techniques to argue that these types of statistical associations reflect causal relationships (a few examples out of a long list are Acemoglu et al., 2001; Banerjee and Iyer, 2005; Nunn and Wantchekon, 2011). Partly as a consequence of these studies and their causal identification strategies, institutional persistence - i.e. the unchanging influence of specific values, norms or institutions over long time periods - became the focus of a mainstream empirical literature. As of now numerous studies proclaim some kind of institutional persistence or assume institutional persistence in their identification strategies (for a good, fairly recent overview and an extensive discussion of seminal studies in this kind of literature see Nunn, 2009; for a very recent review with a focus on the interaction between values and formal institutions see Alesina and Giuliano, 2015).

A good part of theoretical work in institutional economics aims to outline mechanisms that produce institutional persistence (see e.g. Young, 1996; Coate and Morris, 1999; Tabellini, 2008b; Guiso et al., 2008). Most researchers seem to believe that values, norms, and institutions can have an effect only if they persist over long time periods¹⁰. Consequently, In the words of Acemoglu and Robinson: “Much of the empirical work and the conceptual discussion of the impact of institutions on economic development either implicitly or explicitly assumes that institutions persist.” (2006). In the same paper they immediately admitted that “...many aspects of institutions change frequently” before redirecting their research to the persistence of institutional outcomes or as they called it: “persistence of a cluster of economic institutions”. Examples of the clusters of economic institutions they suggested were constraints on the executive or the extent of property rights enforcement.

In my view the mainstream literature has at least three problematic features. First, because the literature is undecided between measuring institutional persistence or persistence of institutional outcomes the measures as such and the underlying concepts are often vague. Because values, norms, and institutions are difficult to quantify in present times and even more so in former times, researchers very rarely try to record actually existing social rules. The most common measures rely on surveys, expert opinions, or weighted outcome measures. Consequently, claims of institutional persistence based on these measures will tend to confound constant institutional characteristics with constant subjective perceptions, constant outcome measures, or

¹⁰ Interestingly, this is in opposition to the legal professions’ mainstream view that legal development neither stalls nor leaps. In Hutchinson’s (2005, p. 10) words: “Eschewing notions of revolution or stasis, most judges and jurists insist that law evolves incrementally rather than leaps convulsively or stagnates idly.”.

present day's projections on the past (see e.g. Glaeser et al., 2004 for problems with measures of political institutions; or Voigt, 2013 for a more general discussion). Even if measures of institutional outcomes could be made unambiguous their benefits are unclear. Focusing on constant institutional outcomes in the presence of ongoing institutional change does not reveal much about the processes of institutional change. Or as Wallis (2014) puts it: "If we do not follow the time pattern of specific institutions unfolding over time we will never understand the process of institutional change. By focusing on outcomes we take our eye off the ball."

Second, emphasizing institutional persistence leaves the impression that most institutional change is superficial and that noteworthy institutional changes necessitate the occurrence of cataclysmic events, i.e. of drastic one-time events that produce large institutional changes in a short period of time. Examples of cataclysmic events are political revolutions, foreign invasions or some other massive outside interference (e.g. North and Weingast, 1989; Acemoglu et al., 2001; La Porta et al., 2008; Acemoglu et al., 2011)¹¹. Consequently, it is not surprising that quantitative empirical studies and theoretical models of institutional change are rare. While it is undeniable that cataclysmic events can result in large institutional changes, searching for large institutional changes only when such events have occurred unnecessarily restricts the study of major institutional change. It is at least conceivable that large institutional changes occur without preceding cataclysmic events.

¹¹ I am aware that the sophistication of the mentioned authors allows them to see the possibility of major institutional change without cataclysmic events. My point is that the sheer number of studies on institutional change in the aftermath of cataclysmic events obscures the possibility.

Third, an exclusive focus on institutional persistence limits the understanding of the nature of institutions. If one regards values, norms, and institutions as a form of cumulative culture it becomes clear that institutional change and institutional persistence always go together. While institutional change always occurs, a large part of values, norms, and institutions simultaneously persist for at least some time period. New values, norms, and institutions always build on existing ones. Humans cannot create new values, norms, and institutions out of thin air, and their symbolic minds depend on some degree of coherence. Sources of institutional change are various and often unexpected. For example, institutional innovation can result from individuals learning social rules in a different manner (Sperber and Claidière, 2006), from dissatisfied sub-groups using their imagination to modify institutions through recombination of the old, or from the need to adapt to changes in material artifacts, knowledge or ecology. Even sudden change during political revolutions, though very real, appears abrupt only because one sub-group of individuals was able to spread or enforce another set of slowly accumulated values, norms, and institutions.

In this study I try to address some of these shortcomings. In a nutshell, I will use quantitative measures of actually enforced social rules to study institutional persistence and change over a long time period that is free of cataclysmic events. Ideally one would be able to determine at any given point of time and for any group under consideration, which social rules exist (and are complied with), persist or change. Additionally one would be able to deconstruct the formation of new social rules. That way one could precisely answer questions regarding the length of institutional persistence, the speed of institutional change, and their coexistence. Processes that result in the formation of new

social rules could be illuminated. Moreover, one could classify social rules according to different criteria, study change and persistence of institutional categories, and possibly replace persistence of social rules with persistence of specific institutional categories. Finally, one could search for major institutional change in the absence of cataclysmic events.

Living in a non-ideal world, I will not be able to address all of the above-mentioned problematic features, and unavoidably need to embark on a more modest endeavor. Subsequently, I will restrict myself to institutional innovation in law in a specific location and time period. I will combine text mining procedures, network analysis techniques and statistical approaches to study persistence and change in England's common law over the Industrial Revolution. I am not aiming to identify drivers of England's legal change or causes of the Industrial Revolution, but hope to characterize main features of legal innovation in 18th and 19th century England. My analysis exploits a citation network that I construct based on the most comprehensive collection of English 16th to 19th century case reports.

Various reasons speak for the choice of England as location, the Industrial Revolution as time period, and law as cultural dimension. England's common law is, as of today, one of the world's most influential law systems. It features prominently in the "legal origins" literature (for an overview see La Porta et al., 2008), provided the legal basis of the British empire, and constitutes the legal basis of the world's only remaining superpower. The Industrial Revolution marks the beginning of the period of modern economic growth, the factors leading to the Industrial Revolution are still hotly debated (see e.g. Clark, 2007; Allen, 2008; Mokyr, 2009; Clark, 2012; McCloskey, 2010), and

developing countries are arguably trying to undertake a transition not too dissimilar from the one England undertook in the 18th and 19th century. Law, according to many scholars (for example, Scheiber, 1998; Lieberman, 2002), played a central role in 18th/19th century England¹². Given its cultural centrality one can expect developments in the legal domain to have counterparts in other coevolving cultural dimensions, and, thereby, hope to gain a clue about general cultural developments¹³. Last but not least, law in 18th and 19th century England, unlike social norms or other social rules, has the benefit of an unbroken written record that is accessible to quantitative techniques.

¹² Two quotes from eminent legal scholars may serve as illustration. Scheiber (1998) states: “David Hume, observing organized society's paramount task to provide for the administration of justice, conjectured that “the vast apparatus of our government [could be thought to have] ultimately no other object or purpose [but] the support of the twelve judges. Kings and parliaments, fleets and armies, officers of the court and revenue, ambassadors, ministers, and privy counselors, are all subordinate in their end to this part of administration.””. And Lieberman (2002) claims: “The eighteenth century, according to the judgment of its current historians, was England's century of law. As E. P. Thompson has put it, “The Law' [was] elevated during this century to a role more prominent than at any period’ of English history. The culture of law, it is increasingly observed, extended throughout the social fabric, conditioning popular protest as much as formal public debate. ‘From the hue-and-cry to the macabre carnival of the public hanging,’ notes Roy Porter, ‘the law and its execution were not just Government fiat or ruling-class weapons but an intimate part of community life.’ Law and legal process were equally fundamental to the political dynamic of this community. ‘Most Englishmen experienced government and understood politics through their dealings with the law,’ John Brewer has argued. In this society, ‘all parties - government, radical and spectators ... recognized the potency of [the law's] symbols and rituals, knew how significant a platform its institutions provided and what a powerful legitimizing force its endorsement could be.””.

¹³ A quote from Lord Kames (1696-1782) to substantiate this hope: “The law of a country is in perfection when it corresponds to the manners of the people, their circumstances, their government. And as these are seldom stationary, the law ought to accompany them in their changes. An institute of law accordingly, however perfect originally, cannot long continue so ... The knowledge, therefore, of the progress of law and of its innovations is essential.” (cited in Lieberman, 2002); Another quote along similar lines by Brooks (1998, p. 189) on England’s law courts: “Until it is proved otherwise it is a mistake to assume that judicial thought diverged significantly from other contemporary values.”.

The method of analyzing citation networks to advance the understanding of law is well established and has generated a large literature in American common law. Legal scholars began using the method not long after WWII. One of the first studies was carried out by Merryman (1954). He found that citation frequency of precedents decays with their age. In a landmark paper Landes and Posner (1976) advocated the use of a precedent capital model with depreciation and the systematic application of citation studies. About two decades later Posner (2000) further urged the legal community to make extensive use of citation analysis in scholarly inquiries and evaluations of the legal profession. Cross et al. (2011) gave a good overview over the literature including existing criticism. Unfortunately, there seems to exist no study that applies the approach to English law. That holds true even if one includes the burgeoning field of network science (for an excellent introduction see Newman, 2010). Though hundreds of publications investigate all kinds of citation networks (patents, scientific publications, cases), there seems to exist no publication about English law.

My citation-network-based study of persistence and change in England's legal innovation process falls into two main parts. Chapters 3 to 5 form the first part and describe the construction and validation of a citation network that embodies English law. The second part, i.e. chapters 6 to 8, contains the core of the inquiry into legal persistence and change. Here I exploit citation counts to measure characteristics of the legal innovation process, analyze the emerging patterns and compare the findings.

The study resulted in a few main findings. First, it produced a citation network of high quality that reflects English courtroom practice between 1580 and 1865. To the best of my knowledge this is the first time that a citation network on English law becomes

available. I went at great length to test the reliability of the data and the meaningfulness of its content. Second, I used information in the citation network to estimate a lower boundary for the long-term persistence of actually enforceable legal rules. Surprisingly, the degree of long-term persistence of 16th and early 18th century legal rules is very high. About 40% of preceding cases and statutes seemingly remained authoritative more than 100 years after they were decided or enacted. This opens up the possibility that persistence of institutional outcomes derives from the actual persistence of institutions. Third, I found a major change in the influence that Parliament had on the making of case law. Within the first decades after the Glorious Revolution Parliament not only convened every year and enacted a steadily increasing number of statutes, but also doubled the relative frequency with which its statutes were cited in court to about 30%. Fourth, possibly the most striking finding is a drastic change in making of common law during a period that was free from cataclysmic events. Within a few decades a legal innovation process with low depreciation rates and strong past-persistence transitioned to a present-focused innovation process with significantly higher depreciation rates and weak past-persistence. The transition accompanies the Industrial Revolution. A sharp transition in the legal innovation process is not peculiar to England: a similar, though apparently less drastic transition occurred in the United States towards the end of the 19th century. Fifth, relying on findings from a specific technique in network science it seems that the observed English and U.S. transitions unfolded in a very specific manner: apparently a new body of law arose during the transitions and developed in a self-referential manner. At the same time the existing body of law remained prominent even though the new body of law became prevalent. Sixth, while year-specific depreciation rates apparently have

not yet been systematically studied by legal scholars, they change drastically from about 1-2% before the transition to about 4-6% after the transition. This suggests an acceleration of social life that is often associated with modernity.

The following chapters are structured as follows. In chapter 2 I will present a basic outline of the history of England's common law that led to the vast collection of case reports called the English Reports. In chapter 3 I will explain how the electronic text of the English Reports was transformed into a citation network. Chapter 4 is devoted to the validation of the extracted data and the interpretation of the English Reports citation network. Chapter 5 confirms the meaningfulness of general patterns in the dataset and discusses the role of potentially confounding heterogeneities. Chapter 6 presents specific findings regarding the use of precedents in English courtrooms. Chapter 7 compares the findings of chapter 6 with analogous features of precedent use in the U.S. Supreme Court. Chapter 8 presents findings regarding the use of statutes in English courtrooms. Chapter 9 summarizes previous findings, draws conclusions, presents a few conjectures and outlines avenues of future research.

Chapter 2: The long way to the English Reports

In this chapter I give an overview of England's legal development within its political, religious, and European context. The history and context are helpful to understand the subsequent analysis and the meaning of citations in the English Reports. It should become clear that law is an important example of cumulative culture that builds the new from the past and possibly does so at different speeds. Law in England was administered in a peculiar set of courts that came to be dominated by the king's superior common law courts. The common law courts introduced peculiar doctrines of precedent as criteria for good law. These doctrines conferred a central role to written case reports and their citation during court sessions. Thereby, citations of preceding cases open a window into the workings of common law. Until 1865 private case reporters recorded case reports. Most of the pre-1865 case reports were published together in a 20th century project named The English Reports.

In the following sections I will introduce the writings of Harold Berman, which provide the framework for the chapter, and contrast them with general features of the related literature and, in particular, with the legal origins literature of institutional economists. Second, following Berman I will outline the emergence of a Western legal tradition in the aftermath of a papal revolution, before, third focusing on the emergence of English royal law, and, fourth, its embodiment in the superior common law courts. Fifth, I introduce the coexisting equity and prerogative courts and, sixth, sketch the Glorious Revolution with its ensuing predominance of common law. Seventh, I elaborate on the rise of two different doctrines of precedent and the importance of written case

reports. Eighth, I outline the history of case reports, before, ninth, concluding with the publication of the English Reports.

Literature on the history of Western European law

The overview draws to a large extent on two important books by Harold Berman (1983, 2003). I find his interpretation congenial in its breadth, emphasis on legal influences of other cultural dimensions, long time horizon and comparative pan-European perspective. Moreover, Berman's claim that the European legal development of the last 1000 years is best described as organic growth where the new consciously builds on the old exemplifies the constructivist, cultural evolution perspective used here. Although it is clear that Berman's interpretation – like any interpretation - will filter legal history in a specific way and lose sight of otherwise notable features, Berman's critics – even the fiercest ones - acknowledge the general correctness of his presented facts and figures (Landau, 1984; Peters, 1985; Ewald, 2005). Interestingly, one of Berman's main biases - his belief that legal change proceeds slowly and incrementally unless it is interrupted by drastic legal change in revolutions - is very close to the current persistence bias in institutional economics. The notion that change occurs at different speeds is interesting and central to the study of history. However, the notion and the claim that accelerated change is linked exclusively to revolutions, appear to be quantitatively not well founded and warrant further investigation¹⁴.

¹⁴ For example, Thier (2013), in a recent contribution, states: "Berman's contribution is of lasting importance for legal history research: It presents a reference model, which is perfectly suited to stimulate further research – be it as confirmation, be it as refutation of Berman's ideas. Moreover, in highlighting and elaborating the importance of revolutionary change for legal evolution, Berman points to a phenomenon which may be called »temporal structure of law and legal change«: His description of Western law »as

Legal histories as broad and comparative as Berman's are rare¹⁵. His differs from standard legal histories, which tend to focus on an isolated legal domain in a specific, modern country. Legal historians tend to focus on one country, while comparative lawyers tend to compare without much attention to history. Both breeds rarely try to integrate non-legal domains into their studies. For example, even in Zweigert and Köch (1998) - one of the best known comparative law textbooks - historical considerations serve more as highway to the present legal systems and their suggested comparative law framework than as serious inquiries into legal history. Baker (1990) is an example of a very learned legal history that is limited to one country and to interactions within the legal domain. In spite of a vast amount of detail, it is difficult to perceive an overall shape or situate England's legal history within the English and European landscape. The famous English histories of Holdsworth (1922) and Milsom (1969) belong to the same kind.

moving forward in time« with a »time dimension« as defining mark, and his attraction to the dialectics and mechanisms of revolutionary change as opposed to evolutionary legal change points to an essential topic of history in general and legal history in particular: It is the notion that legal evolution does not happen as steady process with always the same speed. Instead, there are different evolutionary layers and, presumably, patterns with different speeds of historical time. Berman might be mistaken in his belief that only revolutions represent this kind of accelerated legal change, because there might be – depending from the changing cultural, social and economic contexts of legal normativity – other phenomena of such acceleration. But his argument for a deeper research on the evolutionary mechanisms of the Western legal orders in comparison to other legal traditions is certainly right.”

¹⁵ Grossi (2010) and Lesaffer (2009), while focusing exclusively on civil law in the Continental European West, are some of the rare authors who take a broad perspective (here combining a long-term, comparative legal perspective with political and cultural context). Lesaffer makes the interesting point that European integration and legal harmonization encourage these kinds of projects.

Within institutional economics the characterization of English common law is closely associated with the so-called legal origin literature. In a series of influential studies (see e.g. Glaeser and Shleifer, 2002; and for an overview La Porta et al., 2008) on the relationship between legal origin – a grouping of different countries into a handful of legal families¹⁶ – and various economic indicators, La Porta et al. essentially plot the more market-centered common law countries against the more state-centered (French) civil law countries. La Porta et al. argue that in the 18th and 19th century European colonizers (mainly England and France) transplanted their legal systems and corresponding legal styles¹⁷ to most of today's countries and that the style of these transplants persisted. They connect the differences between the two European legal traditions with two accounts of English and French legal history: In one account the legacy of successful anti-royal resistance from landed gentry, wealthy merchants, and legal profession characterizes modern English law. The Glorious Revolution granted strong protection of property rights, robust enforcement of contracts, and judicial independence (Merryman, 1969; Zweigert and Kötz, 1998)¹⁸. In the other account the distinct character of English law was branded in medieval times and only deepened by the Glorious Revolution. The Magna Carta limited royal power (e.g. by guaranteeing a

¹⁶ Based on Zweigert and Kötz (1998).

¹⁷ To La Porta et al. legal style means a legal system's tradeoff between market failure/disorder and dictatorship/state abuse, i.e. a variation on the current market vs. government theme (e.g., stated in Djankov et al., 2003).

¹⁸ In France – according to this account - the association of judges with the Ancien Regime and the revolutionaries' attempt to rework the material basis of society ended in codification of all rules and docility of state-dependent judges.

due process of law, or the use of juries (Dawson, 1960) and laid the foundations of England's legal system¹⁹.

Both accounts including the stark dichotomy between common law and civil law do contrast with Berman's account. While Berman supports the medieval origins of differences between the legal systems and recognizes distinctive English and French features at the end of the 15th century²⁰, he emphasizes that to a non-European the differences would appear minor and that both legal systems simultaneously incorporated features of the other. In general, European lawyers enjoyed a standardized education at the medieval universities. Even the English Inns of Court - established in the 14th century as an alternative to Oxbridge university education - were profoundly influenced by legal science as it was practiced at the European universities (see e.g. Berman, 1983, p. 162). At the end of the 15th century a European legal professional did not have large difficulties to adjust to the legal order of a different European state and often enough migrated from one to another. Moreover, the two modern legal families arose from royal jurisdictions, which more or less simultaneously expanded into feudal jurisdictions, became partly professionalized, opened space for the superiority of law over rulers, and aimed at consistency across cases²¹. Berman traces the ahistorical urge to overemphasize legal differences between England and France to the need to justify England's anti-royal

¹⁹ By this account, the king in France copied the bureaucratic inquisitorial system of the church to reduce a lack of central control. This was the beginning of a century-long struggle between center and regions. Napoleon achieved victory for the center.

²⁰ E.g. oral versus written procedure, mainly lay versus professional jurors, adversarial versus inquisitorial trials, more particularistic versus more systematic, more Germanic versus more Roman, limited forms of actions versus comprehensive law (Berman, 1983, p. 477).

²¹ Berman (1983), pp. 478-480.

resistance in the 17th century and, more importantly, to the nationalism of the 19th and 20th century²². Finally, Berman depicts the different Western European legal systems as participants in an ongoing dialogue, i.e. as connected subsystems in an overarching European system²³. When major change occurred in one legal system it reached sooner or later the other legal systems. For example, the French Revolution's adoption of rationality, individualism, and utilitarianism resulted in codification and legal reform movements across all of Europe²⁴. The Russian Revolution marked a general European tendency towards legal positivism and increased government interference.

Origins of Western European law

The Western European distinction between government, law, norms, and values is a fairly recent one. According to Berman (1983) until the 11th century laws and judgments - usually not recorded in writing - came from popular assemblies and only in rare cases directly from kings. Laws and judgments back then were largely reactive, based on custom, and often drastically different from one nearby place to another. A professional body of lawyers, judges and legal scholars did not exist. The pope's 11th century attempt

²² This is the context in which the notion of “democratic, individualist, empirical, Anglo-Saxon or Germanic theory of law and government versus an autocratic, collectivist, dogmatic Romanist one” emerges (Berman, 2003, pp. 460–461).

²³ The exclusive focus on Europe, the lack of clear European borders and the neglect of Europe's interconnections with the rest of the World have become the center of an interesting debate about the limitations of European legal history (see e.g. Duve, 2013). However, because the apparent limitations are not immediately relevant to the questions I am investigating here, the usefulness of Berman's account remains untouched.

²⁴ In that context the American Revolution appears as a hybrid of the English and French systems. A written constitution, the separation of powers (driven to the extreme by an English political system inspired Montesquieu), a government accountable to the voters, and individual freedoms exhibit the influence of the French Revolution (Berman, 1983, p. 51).

to centralize authority over the whole Western church and gain independence from worldly powers resulted in a fundamental change - the Papal Revolution. The papacy set up a separate chancery, treasury, and professional judiciary to govern the reformed body. It fostered a legal system called canon law, which embodied the spirit of the supreme rule maker, symbolized the distinctiveness of the Church, and standardized interactions with secular authorities. Law was systematized with the help of a new so-called scholastic method, uniformly applied across far away places, and increasingly perceived as an autonomous, continuously evolving body. The legal corpus grew in stature, and transformed itself from a servant of rulers to an authority, in principle, entitled to rein in rulers²⁵. Berman realizes that reference to the rule of law in front of a ruler was at times a bold and dangerous.

From the late 11th century onwards, secular treasuries, chanceries, law-making bodies, dedicated courts, cohorts of legal professionals, legal writings, and a whole cultural dimension of law emerged all over Western Europe (Berman, 1983). Multiple secular jurisdictions (Berman names feudal, manorial, mercantile, urban, and royal ones)

²⁵ For example, the "Sachsenspiegel, written in the early thirteenth century about the time of Bracton, stated that "a man must resist his king and his judge if he does wrong, and must hinder him in every wrong, even if he be his relative or feudal lord. And he does not thereby break his fealty." Likewise a famous legal formula of Aragon stated that subjects will obey a king only so long as he performs his duties, "and if not, not." (Berman, 1983, p. 192). One can see here the origin of the modern idea of the Rule of Law or Rechtsstaat. Rule of Law here means "what Lord Dicey, who invented the phrase in 1885, meant by it: that statutes, regulations, rules, and other laws that are adopted by lawmaking authorities within a polity must conform to fundamental principles of justice, fundamental principles of right, fundamental principles of Law with a capital "L"—or else they have no legal validity. The rule of law, Dicey said, is the supremacy of law over the lawmaking authorities, over the state itself." (Berman, 2007). The specific rules found in the English Magna Carta of 1215, in the Hungarian Golden Bull of 1222, or in towns' charters of liberties are expressions of these principles.

began to coexist and compete with each other and the ecclesiastical jurisdiction. Strongly influenced by the pan-European ecclesiastic canon law, location-specific secular law systems began to grow out of local customs.²⁶ Among the secular law systems royal law generally increased its authority. At the same time royal governance became increasingly concentrated on a small professional body named the “king’s council”. The body included a chancery, a treasury, and the soon to be spun-off royal courts. Even though some important legislative acts were enacted, royal legislation consisted mainly in the definition of wrongs, remedies, and procedures applicable within the royal courts. Within the various European territories royal law was applied more and more uniformly, earning it the name common law (*ius commune* - a term previously associated with the universally applicable parts of canon law or the rediscovered Roman law).

Berman (e.g. 1983) attributes major shifts in Western Europe’s legal development exclusively to drastic events like the Papal Revolution or the French Revolution (his stance is similar to current inclinations in the mainstreams of institutional economics; there cataclysmic events like the Big Bang of the Glorious Revolution (North and Weingast, 1989), the arrival of Napoleon’s armies (Acemoglu et al., 2011), or the arrival of Western colonialists (Acemoglu et al., 2001; La Porta et al., 2008) fulfill the function). According to Berman these events went hand in hand with new ideas about what the purposes and sources of law should be, or more generally about what constitutes

²⁶ For example, Glanvill’s and Bracton’s writings in England, Beaumanoir’s work in France, von Reppaus’s work in Germany, or the *Liber Augustalis* in Sicily are region-specific examples (Berman, 1983).

good law²⁷. The new ideas - even though initially hostile to the traditional legal corpus – ultimately incorporated the old body of law, and simply redirected its growth. Even when drastic events and related legal ideas were region-specific, the ideas spread and their legal repercussions were felt across all of Western Europe.

For example, the Lutheran Reformation movement shifted the course of legal development in regions that fell under its spell. Lutherans promoted a so-called “two kingdoms” theory, which confined the Church to the heavenly kingdom while it expanded secular authority – exercised by a Christian, justice-loving prince - to the whole earthly kingdom of sin and death. Law – derived from the Bible and the prince’s ordinances - was meant to point sinners to their sinfulness and facilitate repentance, to deter sinners from actions hurtful to their community, and encourage the righteous to live just lives. Consequently, Lutherans erected state churches subordinate to the prince, based law on a new fundament, aimed at unification of all law using a new so-called topical method, and gave law professors an exalted role in the adjudication of difficult cases. These developments partly spilled over to non-Lutheran regions. For example, the powers of secular rulers increased across most of Western Europe.

Origins of English law

The development of English law reflects the pattern outlined above (Berman, 1983). During the reign of Henry II (1133-1189), and through the martyrdom of Thomas Becket, the pope was able to consolidate his influence over English churches, and achieve more freedom from royal and ducal domination than in most other parts of Europe. Multiple

²⁷ To determine what makes good law one needs to answer questions like: What is law?, What are the purposes of law? What are the sources of law (e.g. politics, morality, history/culture)? What makes people obey or disobey law? (Berman, 1998).

competing secular bodies of law arose from pre-existing customs. In response to the pope's large influence, the English king expanded his jurisdiction further than in most other European kingdoms. However, it took another five centuries until the common law jurisdiction eclipsed all other jurisdictions. To compete with the sophistication of ecclesiastical governance and canon law, Henry II instituted governmental and legal innovations similar to the ones by the church. A treasury (named Exchequer and running a court, which investigated treasury related wrongs), a chancery (overseeing all government functions), a permanent court (later known as Court of Common Pleas), and a court traveling with the king (soon to become the Court of King's Bench) arose as powerful, distinguishable and centralized arms of governance. The professionalized departments allowed the king to govern his kingdom without being continually on the move or even without being in England. All the departments belonged to the permanent council and household of the king (curia regis). Following Norman tradition a temporary, large council (magnum concilium) – the highest authority in the kingdom - was occasionally summoned to legislate, adjudicate²⁸, and authorize taxes. The large council came to be called Parliament in the 13th century and split into the House of Commons and House of Lords in the 14th century.

Henry II reformed royal law and became the father of English common law by defining a limited number of wrongs, establishing standardized procedures to judge particular wrongs, and providing specific remedies that would become available once the wrong was confirmed (Berman, 1983). The initial wrongs comprised felonies and

²⁸ The legislative and judicative functions were initially not separated. Even as late as the 17th century the legal profession did not make a clear-cut distinction between legislation and adjudication (Baker, 1990, p. 238).

landhold issues - two main sources of violent unrest in medieval England. To obtain justice for one of the available wrongs a plaintiff had to obtain a so-called writ from the chancery (a brief royal order in written form). Imitating procedures in canon law, the writ ordered plaintiff and defendant to appear in front of a jury, but made no other prescriptions. The jury gathered information before the trial, and communicated their verdict on the day of trial to one of the king's itinerant judges. The remedy was then ordered without further investigation. Like cases were decided alike (a feature that was common in the developing law systems all over Western Europe). The introduction of a standardized writ-jury procedure allowed Henry II to gain legitimacy and expand into other jurisdictions. At the same time, the procedure limited his direct interference and royal power.

The English king's jurisdiction continued to expand until the second half of the 13th century. The standardized writ-jury system remained unchanged, but the chancery created hundreds of new types of writs and addressable wrongs (important new writs covered trespass, money debts, or chattel returns). These writs and the corresponding procedures (also called forms of actions) constituted the core of the first legal treatises on English common law (e.g. Glanvill in 1189, and Bracton in the 1230's). The explosive growth of writs ended in the second half of the 13th century when it threatened to become unmanageable. The chancellor was forbidden to issue new types of writs without the approval of the king's council, and consequently the chancery writs remained essentially fixed until the 19th century. To adapt the fixed forms of action to a changing world, fictions, i.e. court-sanctioned construction of fictitious facts, were used to apply existing writs to situations that would otherwise not fit the writ (Baker, 1990).

Common law courts

Until a single High Court was formed in 1875 three courts had the role of superior common law courts (Baker, 1990): the Court of Common Pleas (initially presiding over cases in which the king had no direct interest – i.e. common pleas, and the first court to take a permanent seat in Westminster Hall), the Court of King’s Bench (initially a traveling court presiding over important cases in the presence of the king, and later - in the 14th century – joining the Court of Common Pleas in Westminster Hall without the king), and the Court of The Exchequer (initially handling cases related to the Crown’s revenue streams). In case of error the Exchequer Chamber (established in 1585), the King’s Bench, or the House of Lords could revisit a closed case.

The jurisdictions of the three common law courts overlapped and changed over time. Each court financed itself by fees, and litigants tried to exploit minor differences between the courts. Therefore, courts often tried to expand their jurisdiction, while litigants tended to prefer one court to another. Moreover, the number of litigated cases fluctuated strongly over time (Brooks, 1998, chap. 4, 5; for example, litigation dropped at the end of the 17th century before it began to rise again in the second half of the 18th century). Consequently, the temporal distribution of business between the courts was unstable and showed a complicated dynamics (Baker, 1990, chap. 3). For the purpose of this study, it suffices to say that by the end of the 17th century all 3 courts had comparable jurisdiction over common pleas. They differed in that the King’s Bench had a judicial review function in case of error and the right to hear criminal cases, the Common Pleas (also called Common Bench) had exclusive jurisdiction over a subclass of common pleas, and the Exchequer had exclusive jurisdiction over revenue cases. From the 18th century

onwards the judges of the superior common law courts had equal status, authority, and function, and were commonly referred to as the “twelve judges”²⁹. Each court consisted of 4 judges who heard cases in Westminster Hall 4 terms a year over a period of 3-4 weeks. The setup in Westminster Hall was peculiar: the courts operated in the vicinity of each other, next to shopkeepers and amid a chatting public (see Figure 1). When judges did not preside in Westminster Hall they frequently went on circuit to trials outside London or participated in other judicial functions.

Equity courts and prerogative courts

The inflexibility of the writ system created situations where the English sense of fairness/equity was violated (Baker, 1990, chap. 6). That might have been because a writ for a wrong did not exist, because a standardized writ resulted in remedies that did not remedy the wrong suffered, or because the due process guaranteed by common law was corrupted. Consequently, the king and his council (including the Parliament) received many petitions that appealed to the king’s grace and prerogative of justice. To remedy individual cases where justice was not within reach of the common law, the king’s chancellor or councilors investigated the cases and made arrangements. Over time the recurring petitions established the Court of Chancery and various conciliar courts.

Among the best-known conciliar courts were the Privy Council (the modern version of the king’s council and the mother of the modern Cabinet), the Star Chamber (consisting of privy councilors and common law judges), and the Court of Admiralty (having jurisdiction over the high seas). The chancery and conciliar courts relied heavily on canon

²⁹ See footnote 12 for an example.

law and the Roman law (rediscovered in 1070 and taught in Oxford and Cambridge) thereby fueling the suspicions of the common law courts.

The Court of Chancery stands out in that it developed a legal system clearly distinct from the common law. A peculiar blend of the Aristotelian concept of equity (necessary when strict application of universal rules fails in a specific case), Christian ideas of conscience, legal systematizing, and the chancery's freedom from the writ system generated a new body of law called equity. While complementing each other, common law courts and chancery competed for larger jurisdictions, legal superiority, and business. The number of cases that could be heard in the chancery was limited, because the Lord Chancellor's presence was mandatory during the whole process. Only in the 19th century were high-level proxies of the chancellor, i.e. the Vice-Chancellor or the Master of Rolls, allowed to hear cases autonomously.

The 16th and 17th century legal developments in England were strongly influenced by the Protestant Reformations (Berman, 2003). A pan-European movement towards absolutist reign justified by a divine right of kings exhibited itself in England as Henry VIII's (1491-1547) drive to expand royal powers over church, nobility, and urban centers. When Henry VIII's urge to secure the Tudor's reign through a male heir met the pope's refusal to divorce the king, Henry seized the opportunity provided by the Reformation, and separated the English churches from the Roman-Catholic church. He then - like the Lutheran princes - erected a state church subordinate to the king and expropriated the assets and income streams of monasteries. Similar to the Lutheran princes he reformed the king's council - renamed Privy Council – by reducing its size, by professionalizing civil service, by creating ministries detached from the royal household,

and by independently selecting the Privy Council members. Henry VIII summoned and presided over Parliaments more frequently than previous kings even though he kept proclaiming many more laws without the involvement of Parliament. He strengthened the conciliar courts, and greatly expanded the jurisdiction of the Court of Chancery. These governmental arrangements remained largely unchanged over more than 100 years until the second half of the 17th century.

The Glorious Revolution and the predominance of common law

The second half of the 16th and 17th centuries saw in Europe an often violent antagonism between Lutheran, Calvinist, and Catholic churches (e.g. in France, the Netherlands, and the German Empire). In England, Catholics loyal to the pope experienced persecutions, while Lutherans, Calvinists and Puritans were the target of mockery and repression (Berman, 2003, chap. 7). Before the background of religious tensions a European backlash against the rise of absolutist rulers occurred in the 17th century (e.g. in France, the Netherlands, and Spain). In England the House of Commons did not want to comply with the king's requests for increasingly arbitrary taxation, and the common law judges - under the leadership of Edmund Coke - attempted to curtail the jurisdiction of the conciliar and chancery courts. The king responded with imprisonments, dismissals, and charges from the conciliar courts. The religious and political confrontations expressed themselves in revolts and civil wars, before culminating in the Thirty Years' War and England's Glorious Revolution.

The Glorious Revolution represents Berman's (2003) next major legal shift in Western European legal development. The replacement of the Stuart king, the Bill of Rights, the Act of Settlement, the Hanoverian succession, and failed attempts to reverse

newly won rights over the kings or reinstitute the Catholic Stuart monarchy, cemented the constitutional monarchy and constraints on the king. As a consequence, Parliament's, i.e. landed gentry's and wealthy merchants', supremacy over the king crystallized³⁰, and non-Anglican Protestant denominations, including Calvinism, were respected. Within England's legal domain the common law courts gained weight, while courts closer to the king (i.e. the Chancery and conciliar courts) lost it. For example, the common law courts gained exclusive jurisdiction over criminal cases and thereby ended inquisitorial trials from the conciliar courts. Furthermore, Anglo-Calvinist belief - for example, the idea that England's status as God's elect nation reveals itself in history -, a Parliament with two adversarial parties, and the already existing influential legal guilds nourished an idiosyncratic legal system. Good law now unanimously meant continuity with the past and ceaseless debate about which principles to derive from previous cases. A lot of effort was spent to find continuity with laws of ancient times, precedents gained an authority they did not have before, and by interpreting precedents judges acquired new law-making powers.

Doctrines of precedent

Earlier, the effect of preceding judicial decisions was confined to the parties in trial and to the illustration of existing legal principles (Berman, 2003). Single decisions had no normative force beyond the single case and did not function as a source of law.

According to Bracton, one judged by reasons and not by examples. While judges intended to judge like case alike – a principle built into the writ system -, they withheld

³⁰ From 1689 onwards Parliament met every year and regularly enacted new statutes, whereas it was convened only sporadically before the Glorious Revolution (Hoppit, 1996).

judgments when they could not agree on how to apply general legal principles to a specific case. All this changed over the course of the 17th century when a doctrine of precedent emerged.

The doctrine of precedent turned preceding judicial decisions, i.e. the past, into an essential source of law³¹ and bound later courts in analogous cases (Berman, 2003). The doctrine relied on a distinction between necessary (“holding”) and unnecessary (“dictum”) parts of a judgment. The holding, i.e. the judges’ statements that were necessary to a decision, was (and still is) the part that later became binding on analogous cases. The dictum was (and still is) essentially a residual category and contained judges’ non-necessary deliberations. A precedent holding - if applied by different judges to different cases - could become a local principle. In the 17th and 18th century it became a sign of good law/good judging not to deviate from an established principle except for very weighty reasons³². Precedents and principles within the same court had (and have)

³¹ Because statutes came to have higher authority than precedents, and because judges were allowed - in the absence of applicable statutes - to draw on other sources of legal norms (incl. customs, common sense, etc.) the doctrine of precedent does not single out the past as the sole source of law.

³² According to the great 18th century judge Lord Mansfield :”It is the reason and spirit of cases that make law, not the letter of particular precedents.” Here, it is interesting to note a parallel in the approach to scientific knowledge that emerged around the same time in the Royal Society (formally founded in 1660 out of regular gatherings of natural philosophers, and only subsequently chartered by the king in 1662; in the context of the legal origin literature it is remarkable that the French counterpart, the Academy des Sciences, was founded by royal decree as a government organ in 1666). Gentlemen - no farmers, no workers, and no women - and thereby presumably trustworthy beings (Shapin, 1994) - met to discuss science in a latitudinarian manner (Shapiro, 1968) and carry out experiments. If small circles of gentleman agreed on an experimental finding a fact was established. A large number of related facts lead to the extraction of a credible law. The statutes of the Royal Society explicitly ruled out discussions about religious or political matters (analogously to the Academy des Sciences). This approach was one attempt to overcome ad hominem attacks as well as the political and religious divisions of

higher weight than precedents from outside the court. However, analogous precedents could lose their status as principle if judges stopped seeing similarities between later cases and the precedents that constituted the principle. Clearly, the litigants' lawyers would (and will) try to nudge the judge's interpretation in a direction favorable to their clients.

In the wake of Enlightenment rationalism and 19th century positivism, the doctrine of precedent became narrower and known as "stare decisis". Precedent came to be seen not as a binding local principle derived from several cases, but as a binding literal holding of an individual case. Judges' room for interpretation was narrowed. This was meant to avoid judicial prejudice and improve predictability of judgments analogous to the codifications of law on the European continent. However, because cases never exactly repeated themselves and judges needed to determine which precedent cases were analogous to the case they were investigating, judicial lawmaking power survived (see e.g. Baker, 1990, pp. 227–230; Berman, 1990, pp. 32–33). The 20th century European trend towards expansion of state power manifested itself in increased Parliamentary legislation, legal positivism, and further confinement of judicial law-making power.

the time. Over the validity of the approach Robert Boyle – council member of the Royal Society – entered into a fierce debate with Thomas Hobbes who advocated logical reasoning and discovery of natural law (Shapin et al., 1985). The combination of gentlemanly deliberation, fact discovery, and extraction of laws is analogous to how judges in the 17th and 18th century decided cases and generalized precedents to principles (Berman, 2003). In that context it is not surprising that the official hero of the Royal Society was Francis Bacon – alleged father of empiricism, practicing lawyer, Attorney General, and Chancellor.

However, to this day only statutes of Parliament surpass the authority of England's judicial precedents (a written, codified constitution does not exist)³³.

Case reports

The doctrine of precedent crucially depended (and depends) on reliable transmission of what was decided in court (i.e. issues at stake; facts of the case³⁴; judge's holding, dictum, and explanation; argumentative context)³⁵. Over the course of the 17th century hand-written reports by eminent legal professionals (e.g. judges, sergeants-at-law, etc.) of what had been argued in court became much thought after. These manuscripts contained the reporter's notes and reflected the reporter's understanding of the case. They could be shared and copied by others in the legal profession. Or, to reach wide circulation and ensure low errors of reproduction they could be printed, published and sold.

Initially the reporters produced manuscripts for their own use and, if requested, let others borrow them³⁶. In the 17th century various reporters took notes with the intent to publish them. Publication was not immediate, and editors often enough added numerous notes to the original manuscripts. The 17th century reporters built on a tradition of

³³ This does not hold true for areas where England has transferred authority to the European courts.

³⁴ The vast majority of reported cases does concern itself with issues of law and not issues of fact.

³⁵ The so-called plea rolls – official court records dating back to the 11th century – were insufficient. They simply recorded names, forms of action, and the final judgment.

³⁶ Similar to students' lecture notes in today's university classes where the lector does not provide notes.

previous case reports - the so-called yearbooks and nominate case reports³⁷ - that were used in legal training with a different focus (namely to record pleadings and debate in court). In the course of the 17th and 18th centuries the case reports became standardized, timely and focused on court's decisions. The 19th century case reports were similar in style and content to the official post-1865 so-called Law Reports. Until 1865 - when the Law Reports began to be published by the newly created Council for Law Reporting - official, standardized, and timely reporting of cases in the superior courts did not exist and law reporting remained in the hands of private reporters.

Many originally unpublished manuscripts appeared in print in the mid 17th century when the legal profession abandoned its preference for the secretive³⁸ and publishing restrictions were eased (thereby also lowering standards of publication quality). After the restoration of the monarchy in 1660 a large body of published case reports became available, new case reports were published in English, and the practice of citing other cases as authority in court became well established³⁹. The most respected

³⁷ The last yearbook was printed in 1535 and then non-anonymous case reports - called nominate or nominative reports - became common. However, style and content of these case reports remained the same.

³⁸ See e.g. Ross (1998) for a discussion of the debate about secrecy and publication; interestingly, an inclination towards the secretive was not exclusive to the legal profession - it existed much more broadly in all kinds of hermetic traditions and was abandoned at about the same time in natural philosophy (see e.g. (2001)).

³⁹ A quote from Coke's reports describes well the transition from law based on general principles over law based on general citing to law based on citing of particular authorities (and the problems of the transition): "The ancient order of arguments by our serjeants and apprentices of law at the bar is altogether altered. 1. They never cited any book, case, or authority in particular ..., which order yet remains in moots at the bar in the Inner Temple to this day. 2. Then was the citing general, but always true in the particular; and now the citing is particular, and the matter many times mistaken in general. 3. In those days few cases in law were cited, but very pithily ... and now ... such a farrago of authorities, it cannot be but there is much refuse." (as cited in Holdsworth, 1922, vol. v p. 372)

case reports before the mid 17th century came from Plowden – a lawyer and member of Parliament, Coke – chief justice at the King’s Bench and Common Bench courts and member of Parliament, and Bulstrode – a lawyer, member of Parliament and high government official. Bulstrode’s case report, written completely in English, marks the beginning of the 17th century transformation from Law French or Latin case reports to exclusively English case reports. In the middle of the 18th century Burrow’s case reports mark the beginning of high quality case reports published timely and regularly by authorized reporters attached to particular courts.

As a consequence of the uncoordinated private reporting, pre-1865 case reports did not cover all cases (however, there is a strong bias towards reporting the more difficult cases⁴⁰), did summarize the same case multiple times (different reporters at times even giving inconsistent summaries), did experience publication years after the case was recorded (sometimes without the involvement of the person who created the manuscript), did contain editors’ comments whose length could exceed the original case report (and the editor making his own sense of a manuscript), did use differing styles (ranging from the very abridged summary to the very extended elaboration of a side remark or a reporter’s opinion), and did show variation in reliability (the occasional reporter was said

⁴⁰ E.g. Burrow says in his 4th volume on page 2583: “I only report what I think may be of use, as a determination or illustration of some matter of law. I take no notice of the numerous questions of fact which are heard upon affidavits ; (the most tedious and irksome part of the whole business). I take no notice of a variety of contestations, which, after having been fully discussed, are decided without difficulty or doubt. I take no notice of many cases which turn upon a construction so peculiar and particular as not to be likely to form a precedent for any other case.”

to fall asleep during trials and make up the proceedings after trial)⁴¹. Unsurprisingly, the heterogeneity of case reports complicated application of the doctrine of precedent and knowledge of the trustworthiness of individual case reports was an important skill in legal practice. Nevertheless and in spite of all their shortcomings the “Reports [meaning the pre-1865 nominate reports], together with the Abridgments of and the indices to them, are in bulk, and, to a large extent, in substance, the most important part of the literature of the common law.” (Holdsworth, 1922, vol. v p. 378). Drawing on the authority of a precedent essentially meant citing one of the published case reports. If a previously reported case was cited the names of the opposing parties were usually followed by a so-called nominate citation, which identified the reported case by volume number, name of the case reporter, and page number. An example would be *Finlay versus Seaton*, 1 Taunton 210.

The English Reports

To gather in one place as many of the pre-1865 nominate reports as possible, a major publishing project called “The English Reports” (*The English Reports*, 1900) was begun in the year 1900. The project took about 30 years to complete and brought together the vast majority of all available pre-1865 nominate reports. Some reports do not appear in the publishing project, but nearly all cases ever reported are covered by at least one case report from the English Report (ER). The formatting of the different nominate reports was unified, their original page numbers and footnotes were maintained. Finally, various comments, meant to enhance the understanding of relationships between cases, were

⁴¹ Good histories of case reports and assessments of their quality exist (see e.g. Holdsworth, 1922, vol. v pp. 355-378, 1922, vol. vi pp. 551-574; Veeder, 1901a, 1901b; Wallace, 1882).

added. By 1932 the whole project - containing 265 distinct series of nominate reports with 130'000 case reports on over 250'000 pages, was completed and the last of the 179 volumes were published (the last 3 volumes contain the index and an index chart). The English Reports contain nominate case reports from the three superior common law courts, Nisi Prius trials (transport-cost-reducing, locally-held common law trials whose jury verdicts formed the basis for judgments from Westminster Hall), the Chancery courts, the House of Lords, the Privy Council, the Admiralty court, and the supreme ecclesiastical court (including the renamed Probate and Divorce court). The English Reports have been the authoritative source for pre-1865 case reports ever since their publication.

Chapter 3: Data preparation

In this chapter I describe the two-step process that turned the English Reports into a citation network. In the first step, I isolated individual case reports and recorded information about the reported case and the references - ER case citations and statute citations - contained therein. In a second step I cleaned and combined the extracted information. I undertook the first step in Python with the help of 3 modules (see appendix A). The first module (ER search.py) splits ER text files into individual case reports before using a technique called regular expression matching⁴² to extract case name, case parties, trial date, and number of words in the report. It then called two other modules to extract - again using regular expression matching - from any given case report ER case citations (search cases.py) and statute citations (search statutes.py). The extracted information was translated into a standardized format and saved to an SQL database.

The second step used Stata code (see appendix B) and the information stored in the SQL database to add missing information about ER volume attributes (1_prepare case information & volume attributes.do). It then combined information about case and statute citations with information about the individual case reports (2_merge cases data.do and 3_merge statutes data.do).

The following sections follow the two-step structure to lay out the steps in a more detailed manner. For each step they describe the specific problems encountered and the solutions I chose to address them. Because I preferred a smaller sample size to an erroneous sample I generally adhered to the principle of minimizing false positives (e.g. recording incorrect case citations) at the expense of increasing the number of false

⁴² A regular expression is essentially a sequence of characters that defines a search pattern.

negatives (e.g. omitting actually present case citations). This also implies that I corrected erroneous case information and citations only when the errors were unambiguous (e.g. missing dates or incorrect page numbers).

Data extraction

Starting from the physical existence of 176 volumes with ER reports I identified the publisher of an electronic ER database whose characteristics allowed reliable extraction of case information and citations. After having exported the database into text files, I applied the three Python modules to the individual text files and obtained a preliminary version of the citation network. I then corrected obvious errors, added information to fill in obvious omissions, and reran the Python modules until no further obvious errors or curable omissions remained.

I will illustrate the process that extracts information from the original English Reports with the help of a specific ER case report. Taunton reported the case of Finlay versus Seaton that went to trial in the Court of Common Pleas in the year 1808 on page 210 of his first reporter volume. The corresponding nominate citation is 1 Taunton 210. In the English Reports the case was republished on page 813 of volume 127 - often abbreviated as 127 ER 813. Figure 2 shows how the short report appeared in the original English Reports.

Choosing a database

I opted for an electronic ER database published by Juta Law (2010)⁴³. The reasons for the choice were a comparatively low error rate of Juta Law's open text recognition procedures, clear separation of distinct cases, consistent naming and reliable dating of cases. All other published databases had considerably higher OCR error rates or made it very difficult to separate cases and extract case and date information.

Creating text files

To transform the Juta Law database into a format that is open to automated text processing I installed the Juta Law software and exported the individual case reports into combined text files. Each of the resulting 176 text files corresponded to one of the volume of the English Reports. Figure 3 shows the text file excerpt that corresponds to the case report 1 Taunton 210 from the 813th page of the 127th ER volume. Close comparison of Figure 2 and Figure 3 reveals a number of OCR errors. A rough investigation suggests an OCR error rate of about 2 in 1000⁴⁴.

Extracting case information

To extract information from the individual case reports I used regular expression matching to split the 176 text files into strings that pertained to only one case report. Splitting the text files into individual case reports was straightforward because the text

⁴³ The Economics Department of the University of Maryland, College Park kindly supported the acquisition of the database. I gratefully acknowledge the departmental support.

⁴⁴ To derive the admittedly very rough estimate I tried to identify all character mismatches between the original print and the OCR-ed version. I counted 7 mismatches in 3045 characters.

files from the Juta Law database have a consistent structure: the first line of a case report begins with the names of the two opposing parties; the names are separated by the letter v (an abbreviation of the word versus) and immediately followed by the name of the nominate report and the corresponding ER reference. In the concrete case of Figure 2 this corresponds to *Finlay v Seaton* 1 Taunton 210, 127 ER 813. Apart from a small number of inconsistencies Juta Law consistently uses the same format to delineate case reports. In particular, the reporter names are used consistently within and across reporter volumes.

The Juta Law header that delineates case reports contains valuable information per se. It is easy to extract from it the case name (*Finlay v Seaton*), the name of the plaintiff (*Finlay*), the name of the defendant (*Seaton*), the nominate report reference (1 Taunton 210), the nominate report volume (1), the reporter name (Taunton) and the nominate page number (210), the ER reference (127 ER 813), the ER volume (127) and the ER page number (813). A second line added by Juta Law immediately follows the header and contains the report date. Reasonably, the second line always starts with the words “Report Date:” and then provides the year in which the reported case took place. For example, the case from Figure 2 goes back to the year 1808. Recording the date of the case (1808) and determining to which decade the case belongs (1800) is straightforward. A unique identifier is generated and saved together with the recorded information in a table of the SQL database as variables *uid*, *casename*, *casenamefirstparty*, *casenamessecondparty*, *nomcite*, *nomcitevol*, *nomciterep*, *nomcitepage*, *ercite*, *ercitevol*, *ercitepage*, *date*, *decade*.

Extracting case citations

Finding within an ER case report references to other ER case reports posed some difficulties. The vast majority of references to other ER case reports appear as nominate citations, i.e. as a combination of volume number, reporter name and page number (e.g. 1 Doug. 308 in Figure 3). The main difficulty is that reporter names are often abbreviated and that the abbreviations occur in many different forms. For example, in Figure 3, 1 Doug. 308 refers to 1 Douglas 308. However, other common abbreviations are 1 Doug. K.B. 308, 1 Dougl. KB 308 or 1 Dougl. KB, 308. Therefore, the reliability of the extracted ER case citations depends on the comprehensiveness of the list of ER reporter abbreviations. To compile the list I relied on the widely popular Cardiff Index to Legal Abbreviations (n.d., list compiled in 2012). The Cardiff Index brings together a large number of different high-quality sources. I augmented the index with Williams' (1941) insights into particularly idiosyncratic abbreviations and erased all abbreviations that did not uniquely identify reporter volumes (e.g. the abbreviation Black can refer to William Blackstone's King's Bench Reports or to Henry Blackstone's Common Pleas Reports). To avoid otherwise frequently occurring false positives I further erased all reporter abbreviations that consisted of less than three letters and no volume number.

To actually extract case citations from an ER report I then combined all the previously assembled abbreviations into a regular expression, i.e. a search pattern, that extracted text strings whenever they matched one of the abbreviations and were followed by a page number. With regard to search pattern interpunctuation I permitted periods, empty spaces, and combinations of periods and empty spaces. However, I ruled out all other interpunctuation marks like commas or semicolons because they significantly

increased the rate of false positives. This implies that an abbreviation like 1 Dougl. KB, 308 was not recognized by the search pattern.

When the search pattern matched a string within an ER case report, the string was extracted and translated into the naming convention used by Juta Law to identify cases in their database (for example, 1 Doug. K.B. 308 would be recorded as 1 Douglas 308). Without translation to the naming convention it would otherwise be impossible to determine that 1 Doug. K.B. 308 and 1 Dougl. KB 308 actually refer to the same case report. After the translation the standardized citation of the cited case and the string context surrounding the citation were recorded together with the unique identifier were in a table of the SQL database. The names of the recorded variables are *uid*, *casecite*, and *casecontext*.

Extracting statute citations

Finding within an ER case report references to enacted statutes posed other challenges. References to statutes appear in two different forms. The most common form consists of the regnal year of the ruler under which it was enacted and a chapter (chapter number *n* signifies that the statute was the *n*th statute enacted in a specific regnal year). For example, citation of the statute 11 G. 2, c. 19 (i.e. the 19th Act of Parliament in the 11th regnal year of George II or calendar year 1737) can also be found as 11 G. II ch. 19 or 11 Geo. 2, chap 19 or 11 Geo. II, chapter 19, and so on. Moreover, punctuation marks are used inconsistently (e.g. 11 G. 2, c. 19 can appear as 11 G 2, c 19, 11 G 2 c. 19, etc.). In the majority of cases the chapter number is provided, but often enough it is not. Then it is easy to confuse a statute citation with the designation of a court session (e.g. Easter 11 Geo. 2) or a simple non-statute related date reference (e.g. 11 Geo. 2). The second form is

specific to popular statutes. These statutes were frequently cited by name and not by regnal year (e.g. Statute of Uses instead of 27 Hen. 8, chap. 10).

To extract the first form of statute citations I proceeded analogously to the extraction of case citations. I manually constructed a list with possible regnal year abbreviations for thirty of England's rulers (beginning with Edward I) and calendar year correspondences. I then combined all the previously assembled abbreviations, augmented them with a search pattern that detected potentially existing chapter information, and created a regular expression. Interpunctuation constraints were less stringent than for case citations.

When the regular expression matched a string within an ER case report, the string was extracted, and the regnal year translated into a standardized format (generally the ruler abbreviation that is longest, e.g. 11 Geo. 2 and not 11 G. 2). If no chapter information existed in the matched string the regnal year it was accepted as statute citation only if the words Act or Statute appeared in close vicinity. After the translation the standardized regnal year of the cited statute, its chapter information and the string context surrounding the citation were recorded together with the unique identifier of the citing case.

To extract the second form of statute citations I compiled a list of statute names based on a table of popular statute names from the officially authorized Chronological Table of and Index to the Statutes (1873). As before the list was compiled into a regular expression and the matched string recorded. The name of the cited statute and the strings surrounding the citation were recorded together with the unique identifier of the citing case. Information about the two forms of cited statutes were combined and recorded in a

table of the SQL database as variables *uid*, *statciteregnalyear*, *statcitechapter*, *statcitename* and *statcitecontext*.

Correcting OCR errors (case names and case dates)

I checked case report names and report dates for inconsistencies that arose due to OCR errors in the Juta Law database. If reporter volumes changed unexpectedly, if page numbers did not increase from one case report to the subsequent one, if page numbers or report dates fell outside the reporter volume-specific range, I investigated the inconsistency. If the inconsistency arose from an OCR error, I corrected them. After applying the corrections I repeated the procedures from the previous step and kept iterating steps until no inconsistencies remained. All in all I made 644 corrections to report names and report dates.

After OCR corrections the Python algorithm separated 129,042 case reports, and extracted corresponding case report names, report dates, opposing parties names, and word counts. It further extracted 468,872 case citations and 157,021 statute citations (the latter together with the years of enactment).

Cleaning and combining data

The raw data extracted with Python required further processing to add missing information and merge case information with the extracted information about case and statute citations. This required the following tasks:

- merging case information of cases with the duplicate nominate citation
- adding trial dates to case information when they were missing in the Juta Law database, but clearly identifiable in the original ER reports

- adding missing reporter volume information to case information
- matching the nominate citation of cited cases with the available case information
- removing duplicate case and statute citations from the same citing case
- deleting case and statute citations with clearly erroneous page numbers, chapter numbers, or regnal years

Merging duplicate nominate citations

When case reports were short enough it could occur that two distinct case reports were printed on the same page of a reporter volume and, consequently, were identified by the same nominate citation. Figure 4 shows an example. The two cases Ball versus Adrian and Scholey and Another versus Mansell Powell were printed together on page 64 of reporter volume 1 Taunton. Therefore, both of them would be cited by the nominate citation 1 Taunton 64. To distinguish between them the name of plaintiff and defendant was usually added to the nominate citation. Because it is impossible to distinguish by the nominate citation only and because it proved technically too difficult to identify case by the names of the opposing parties, I decided to merge the case information of all cases with the same nominate citation. This reduced the number of distinguishable cases to 100,618. To date a merged case report I used the most frequently occurring or the first non-missing date of the merged case reports.

Adding missing dates

About 7 percent of (combined) cases in the Juta Law database lacked information regarding the trial date. Inspection of the original English Reports showed that the trial date of many of these cases could be unambiguously determined. Therefore, I manually

inspected all ER volumes where Juta Law dates were missing, and whenever possible used regularities in the dates of individual reporter volumes to generate the missing Juta Law dates (for example, in many ER volumes subsequent case reports belong to the same year and increments of the report year occur only once on specific pages). I then added the missing dates to the case information. Thereby, it was possible to fill in 4,436 of the 6,854 missing dates.

Adding reporter volume information

Some reporter volume-specific information needed to be added. In particular, I used an overview table in the English Reports to add information regarding the volume's earliest/latest date of reported cases, the volume's lowest/highest page number, and the court where cases went to trial (generally one court per volume).

Matching cited cases

Nominate citations within a case report were often insufficient to identify a specific case report. On the one hand, incorrect citations (due to OCR errors in the Juta Law database or due to mistakes in the original English Reports) obviously made it impossible to match the nominate citation with the case information of the intended reference. On the other hand, the cited page number often did point to a relevant page in a multi-page case report and not to the beginning page.

Therefore, I used three different methods to match the nominate citation of a cited case with case information from the Juta Law database (most importantly the trial date). The first method attempted direct matching of standardized reporter volume and page number (e.g. if the matching based on *Grindley v. Holloway* would have been

unsuccessful, the method would have tried to match the citation 1 Doug. 308 to the case report 1 douglas 308; however, only case report 1 douglas 307 and 1 douglas 309 exist and so the matching would have been unsuccessful). Whenever the first method failed, I applied the second method, which used the names of opposing parties that appeared close to the cited case (e.g. Grindley v. Holloway in front of 1 Doug. 308 was matched to Grindley v. Holloway 1 Douglas 307) and relied on fuzzy matching to match these to opposing parties' names within the cited reporter volume (e.g. 1 Douglas). Fuzzy matching was necessary because spelling of names is inconsistent across the various reporter volumes. If fuzzy matching failed, the third method matched the citation to the nearest (lower) page number in the cited reporter volume (e.g. 1 Doug. 308 would have been matched to 1 douglas 307). Direct citation matching was applied to 276,574 case citations, fuzzy matching was applied to 29,427 case citations and nearest (lower) page matching was applied to 85,377 case citations. 270 case citations could not be matched to any case report. To validate the reliability of the matching of case citations and case reports I picked a random sample of 100 case citations and identified mismatches. I found that the sequence of the three matching methods outlined above correctly identified 97 out of the 100 sampled citations. The 3 incorrect matches result from incorrect nominate citations within the English Reports.

Removing duplicate case and statute citations

In several case reports the same nominate citation or the same statute citation appeared multiple times. Because the meaning of multiple citations within case reports of varying quality and length is unclear, and because the focus of this study is on the existence and not the frequency of connections between cases and statutes, I decided to remove

duplicate citations. Whenever a nominate citation occurred more than once in a combined case report I dropped the duplicate citations. Whenever, a combined case report cited a statute by the same regnal year and chapter or when it cited a statute by the same regnal year without chapter information, I removed the excess statute citations. After dropping duplicates 399,924 citations of combined case reports and 78,878 statute citations remained (60,697 with chapter information, 7,075 without chapter information, and 11,106 with explicit statute names).

Deleting erroneous case and statute citations

To minimize errors in the data I identified obviously incorrect case and statute citations and eliminated them without trying to infer the correct citation (the majority of errors are due to OCR errors in the Juta Law database). Consequently, I deleted 8,471 case citations where page numbers fell outside the page range of the cited reporter volume, 216 case citations that could not be matched to a case report, and 9,910 erroneous case citations that derived from three specific ambiguous abbreviations (most importantly, 6,718 references to Coke on Littleton - a canonical 17th century text on English property rights - that were misidentified as references to Littleton's case reports, and 2,839 references to post-1865 Queen's Bench case reports that were misidentified as early 19th century case reports). After the deletion of erroneous case citations 381,310 case citations remained.

I further erased 332 statute citations with erroneous regnal years (for example, 0 Victoria or 48 Elizabeth - Elizabeth reigned only for 44 years), 1,683 statute citations with chapter numbers superseding the total number of statutes enacted in a regnal year,

and 1,760 statute citations to years where no statutes were enacted. After the deletion of erroneous statute citations 75,103 statute citations remained⁴⁵.

Final dataset

Table 1 and Table 2 describe and summarize the final comprehensive data set, which includes 360,385 case citations and 75,103 statute citations. Information on 27,369 case reports that do not cite cases or statutes were incorporated for completeness. The dataset comprises various variables that were derived during or after data generation (for example, information on the case citation matching method, or number of case reports in the year of the citing/cited case report).

Citation network

One can regard the statutes and case reports as constituent nodes of a citation network. Citations of statutes and case reports then form the links that connect the distinct nodes. If one leaves aside editors' references to later statutes and case reports, then all citations are past-oriented and directional. Because published case reports exist indefinitely, the

⁴⁵ To facilitate understanding of the second step in the construction of the dataset (cleaning and combing data) I summarize its sub-steps' effects on number of cases, available dates, number of case citations and number statute citations. The consequences of restricting the dataset to the date range of 1580 to 1865 and strict precedents are added for later use.

	case reports	dates	case cites	statute cites
raw data	129,042	112,980	468,872	157,021
merging duplicate nominate citations	100,618	93,764	468,872	157,021
adding missing dates	100,618	98,200	468,872	157,021
dropping duplicate citations	100,618	98,200	399,924	78,878
cleaning erroneous citations	100,618	98,200	381,310	75,103
1580-1865 date range	96,896	96,896	360,385	56,685
strict precedents	68,896	68,896	252,179	51,907

resulting citation network is directed, static (new nodes and links can be added, but old ones do not disappear), and acyclic⁴⁶ (it is impossible to find a path that returns to the citing node). Figure 5 depicts the part of the citation network that is derived from the case report in 1 Taunton 210 (1 ER 813).

⁴⁶ That is strictly untrue for the derived citation network because of editors' references to later case reports

Chapter 4: Data interpretation and reliability

To gain insights into institutional persistence and change based on the constructed citation network, it is necessary to give case reports and the citations they contain a consistent meaning. To do so I begin with the general features of legal process and their concrete expression in English royal law. After pointing to the importance of publicly available precedents for the doctrine of precedent I describe the need for analogies and interpretation if one wants to apply the doctrine. I then turn to the meaning of precedent and statute citations and the possibility of measuring influence through citations. Because the meaning of ER citations is unclear I conduct a random sample study whose results suggest that about 80% of targeted citations were correctly extracted and that the majority of post-1700 ER citations recorded analogy use in the courtrooms. Based on the previous discussions and investigations I set out an interpretation of statutes and ER precedents as analogical basis for the construction of new legal rules and of ER citations as indicators of analogy use. I end with an evolutionary perspective on legal cumulative culture.

Legal process

Legal rules are particular social rules that - within a jurisdiction - are made, adjudicated, and enforced by clearly defined bodies of people. They define for specific social interactions a party's rights ("you can") and another party's corresponding obligations ("you cannot", "you must")⁴⁷. A legal case arises when one party (the plaintiff) claims that another party (the defendant) violated a legal rule and in so doing inflicted damage on the plaintiff (see e.g. Bruner, 2003, p. 37). To settle their accounts the two parties meet

⁴⁷ This is inspired by Crawford and Ostrom's (1995) analysis of social rules.

in court and are heard⁴⁸ by a presumably neutral third party (the judges and possibly a jury). The legal hearing generally proceeds in a formal manner and aims to see the hearing's specific case in general legal terms (see Berman, 1987). The judges and the parties' legal advisers are well acquainted with the jurisdiction's legal rules and regularly participate in hearings. The defendant and his legal advisors will try to argue that a legal rule was not violated, that the defendant was not the one violating the legal rule, or that harm was not done to the defendant. The plaintiff and his legal advisors will aim for the opposite. If a judge finds that the defendant has violated a legal rule and damaged the plaintiff, he will order that the defendant needs to make good the plaintiff's damage and/or be punished. If the defendant does not comply with the judge's order, the plaintiff can count on the help of law enforcers⁴⁹.

In England the royal common law jurisdiction became the most important of various initially coexisting jurisdictions (e.g. ecclesiastical, feudal, manorial). Over the course of many centuries it came to dominate all other jurisdictions. Beginning in the 14th century feudal and manorial jurisdictions declined together with the feudal system while local courts took over most of their functions. Justices of peace - appointed by the king and overseen by royal judges - presided over the local courts. The 16th century saw

⁴⁸ Having the possibility to be heard is - according to Berman - essential to all legal discourse. He writes: "The distinctive characteristics of legal discourse arise principally from the institution of the hearing, which is the basis of all legal activities, including not only adjudication but also legislation, administration, negotiation of legal transactions, and other legal activities. It is the opportunity of both sides to be heard that principally distinguishes adjudication from vengeance. Similarly, it is, above all, the opportunity to debate pending enactments that distinguishes legislation from mere commands, and it is the opportunity to petition for relief that distinguishes lawful administration from bureaucratic fiat." (Berman, 1987).

⁴⁹ By settling the accounts of plaintiff and defendant the legal process fulfills a political function in that it reduces the likelihood of violent cycles of revenge.

the subjugation of the Church under the state of Henry VIII and correspondingly a diminished role of the ecclesiastical jurisdiction. Finally, the power balance within royal law changed over the course of the 17th century. The royal common law courts successfully rolled back the influence of the king's prerogative courts (Berman, 2003).

In English common law the legal process unfolded in a specific manner. If the plaintiff wanted - for a specific rule violation by the defendant - to take recourse to royal justice at Westminster he purchased from the Chancery⁵⁰ a writ that ordered the opposing parties to appear in one of the three common law courts⁵¹. The different king's writs defined the rule violations that were heard by the common law courts. A king's writ ordered the two opposing parties to a hearing, and one or more royal judges - generally aided by a jury - adjudicated the trial. Lawyers usually assisted the parties and, if necessary, sheriffs enforced the judges' decision on the unwilling defendant. In case of error both defendant and plaintiff could appeal the judgment by turning to the King's Bench, Exchequer Chamber, the King's Privy Council, or the House of Lords.

Written precedents and statutes

Precedents that illustrated legal rules, principles and court strategies and statutes - legal rules made and explicitly laid down by a parliamentary assembly - constituted a fundamental part of the legal process and legal training. The written form of case reports, case abridgments, and statutes reflects the professionalization of law. It enabled temporal persistence, enhanced interpersonal consistency and enabled a level of reflection that is

⁵⁰ More precisely the Exchequer sold writs for his own court.

⁵¹ Purchase of the writ was not necessary if the plaintiff filed his complaint in one of the Assizes where traveling judges (including two from the common law courts) visited their commission-assigned circuits.

more abstract and more sophisticated than the one that pertains to exclusively oral cultures. In England the first written statutes go back to times before the Magna Charta and first hand-written collections of case reports, the so-called yearbooks, apparently emerged as aides in classroom settings as early as the 13th century. From the 16th century onwards the printing press overtook manuscripting and made it possible to distribute collections of case reports and up-to-date statute texts among the legal profession at high accuracy and relatively low cost⁵². The rise of the doctrine of precedent in the 17th century amplified the importance of case reports, and transformed the meaning of cited cases. Preceding cases and their reports began to serve as actual basis of new rulings and not only as casuistic illustrations of general principles.

According to Berman (e.g. 2003, pp. 273–275) the doctrine of precedent came in two different varieties and was a specific (and peculiar) English expression of the Western cumulative legal tradition that intentionally preserved the old and created the new from the old⁵³. The strict 19th century variety of the doctrine of precedent (*stare decisis*) would call for upholding any legal rule that was previously created by the

⁵² Manuscripts remained in use - their accuracy and cost were not abysmal. For an insightful and nuanced view on legal publishing in 16th century England see Ess III (1978).

⁵³ Berman (1983, p. 4) states this point succinctly: “To speak of a "tradition" of law in the West is to call attention to two major historical facts: first, that from the late eleventh and twelfth centuries on, except in certain periods of revolutionary change, legal institutions in the West developed continuously over generations and centuries, with each generation consciously building on the work of previous generations; and second, that this conscious process of continuous development is (or once was) conceived as a process not merely of change but of organic growth”.

common law courts⁵⁴, whereas the earlier 17th and 18th century variation would only call for upholding of broader legal rules that were derived from a series of court decisions in analogous cases⁵⁵ (so that a specific holding could be disregarded and overruled if it did not fit with the emerging broader legal rule; the broader rules emerged as a consequence of judges' decisions in independent cases⁵⁶).

Holdings, analogies and images of law

From the perspective of the doctrine of precedent the relevant features of a case are the legal issue, the operative facts, the holding, the ratio decidendi, and the dictum (see e.g. Berman, 1990). The *legal issue* is the point that is being disputed after contested facts have been settled, the *operative facts* are the facts that are necessary for a decision on the legal issue and that the court accepts as true. The court's *holding* is the court's decision regarding the legal issue (the decision essentially constitutes a legal rule in the form of an if-then statement: if this legal issue and these legal facts then the legal issue is decided as follows...) and the court's *ratio decidendi* consists of the deeper reasons underlying the court's decision. Everything else in the case is subsumed to a residual category named *dictum*. The distinction between holding, ratio decidendi, and dictum of a case are neither clear-cut nor static because they depend on applications in later similar, i.e. analogous

⁵⁴ Even at the height of the stare decisis not all holdings were upheld and applied (see e.g. Baker, 1990, p. 228).

⁵⁵ In Lord Mansfield's (1762) words (Fisher v. Prince, 3 Burrow 1363 or 97 Eng. Rep. 876): "the reason and spirit of cases make law; not the letter of particular precedents."

⁵⁶ Berman (2003, p. 275) draws an interesting parallel between this variety of doctrine of precedent and occurring changes in natural philosophy: "The traditional doctrine of precedent treated the judiciary's repeated application of previous holdings to analogous cases as the best evidence of their probable validity, just as the repeated confirmation of the results of scientific experiments by the community of physicists."

cases. Later courts can even revise the ratio decidendi if they believe there exist better grounds to justify the holding.

A specific holding is always very narrow and an identical case that falls under the holding is very unlikely to recur. Therefore, deciding what constitutes an analogous case and, similarly, when the provisions of a statute are applicable is of paramount importance (Berman, 1987; Amsterdam et al., 2002). In the 17th and 18th centuries analogous thinking was applied when cases were subjected to a broader legal rule or when cases were used to constitute it. In the 19th century a previous holding was directly applied to analogous cases. Judges needed to decide if subsequent cases were similar to a precedent or if they differed while lawyers of the opposing parties tried to convince judges that precedents suggesting a favorable outcome for their clients would be analogous, and a lot of debate in court revolved around the question. When no simple analogy was available analogical reasoning was used to construct a new legal rule that regulated a previously unregulated situation. Only when existing cases or statutes did not provide sufficient material for a new legal rule did common law judges draw on other sources (e.g. custom or equity). In general, analogy played (and plays) a central role in common law court hearings and legal reasoning (Berman, 1987). Apart from its dialectic role (“compare and contrast cases advanced by the opponents”) it is visible in law’s consistency (“treat alike cases alike”) and temporal stability (“treat alike precedents and current cases alike”).

However, what counts as analogous to something else is not a simple application of logical thinking (Berman, 1987, pp. 16–17). Finding an analogy is essentially an interpretative act (see e.g. Amsterdam et al., 2002) that is constrained by the methods of the legal profession (e.g. the method of precedent) and by ideas about what makes good

law⁵⁷ (from now on called images of law⁵⁸). Images of law provide and prioritize⁵⁹ legitimate sources of law (e.g. tradition⁶⁰ or history⁶¹, reason or theological thought or

⁵⁷ Hutchinson (2005, p. 274), for example, states: “It is not that judges ignore the extant rules or that they follow the rules in a mechanical manner. It is that, in applying the rules, they are engaging in a profoundly political and value-laden act because what the rules are and what it means to apply them inescapably and inevitably implicates the very ideological commitments that they are supposed to avoid.”

⁵⁸ The images of law concept is derived from Elkana’s (e.g. 1981) concept of images of knowledge .

⁵⁹ Winfield (1925, p. 40) summarizes hierarchies between and within tradition and law-making for 19th century English law: “The statute prevails over the judicial decision, the judicial decision over the textbook, the textbook over the unprofessional book. And there are variations as to value in each of these classes. No one would take an unofficial print of the statutes as authoritative in comparison with an official edition, or put Lord Raymond on a level with Barnardiston as a reporter, or accept the rubbish in the *Mirror of Justices* in preference to Britton.”. Coke, on the other hand, argued in the 17th century that statutes of Parliament that violate natural law, i.e. reason, could be voided by the common law judges. For example”: “it appears in our books that in many cases the common law will control acts of parliament and sometimes adjudge them to be utterly void; for when an act of parliament is against common right and reason, or repugnant, or impossible to be performed, the common law will control it and adjudge such act to be void” (Baker, 1990, p. 241).

⁶⁰ Hutchinson (Hutchinson, 2005, pp. 5–8) states the often neglected point that tradition as a source of law is not a self-evident, value-free choice: “This commitment to the so-called traditionality of the common law tradition is often premised on the unstated notion that there is something normatively compelling or worthy about what has come before; the past is not followed simply because it precedes but because it is superior to present understandings. Having withstood the test of time, tradition binds not simply because it has not been replaced or altered; it binds because it has its own normative force. For common lawyers, therefore, the legal past is not simply a store of information and materials but an obligatory source of value and guidance [...] There is no compelling reason why a decision to follow the past is any less political than a decision to ignore the past. Both strategies depend on a much thicker theory about the worth of the past as a substantively attractive vision of present and future arrangements for social living than the traditionalists offer.”

⁶¹ See, for example, the Katzmann’s (2014) recent book where he argues for a consideration of history when interpreting statutes.

biology⁶², centralized law-making⁶³). They establish and rank aims by which the system of existing legal rules can be evaluated (e.g. predictability, adaptability⁶⁴, social justice and equity⁶⁵, degree of codification⁶⁶, consistency⁶⁷, productive efficiency⁶⁸, overall utility⁶⁹). Images of law are usually not only time-dependent, but also domain-dependent.

For example, Berman (1987, p. 17) states that American courts today do value

⁶² An exclusive focus on reason, theology or biology tend to result in the declaration of universal legal rights, i.e. natural laws (comp. Berman, 1988). For example, Kant is the best known modern proponent of natural law theory, various books of Frans de Waal argue that moral behavior is an evolutionary given (e.g. Waal, 2009).

⁶³ If centralized law-making is seen as the only source of law than this translates into the positivist belief that any law that comes from a legitimate ruler is legitimate (well-known exponents are Hobbes in 17th century Europe or Han Fei Tzu in 3rd century BC China; for a good introduction to the latter see Waley, 1939).

⁶⁴ In this context see e.g. Lord Mansfield's famous quote "as the usages of society alter, the law must adapt itself to the various situations of mankind" in the ER case report 3 Douglas 373.

⁶⁵ John Rawls is a recent example of a scholar who puts a very strong emphasis on reason, universal legal rights, and fairness (see e.g. Rawls, 1971).

⁶⁶ See e.g. the following quote in Hutchinson (2005, p. 2) "Nineteenth-century positivists' savage assessment of the common law is as good a place as any to start. As unabashed enthusiasts for legislation and codification, they were no friends of the common law. Bentham and Austin's extended and uncompromising analysis led them to the firm conclusion that "as a system of rules, the common law is a thing merely imaginary" and that it is a "childish fiction employed by our judges that . . . common law is not made by them, but is a miraculous something made by nobody, existing . . . from eternity, and merely declared from time to time by the judges." They were particularly concerned with the fact that the rules of law were nowhere available in any accessible or agreed-on manner."

⁶⁷ For a proponent of legal consistency as the nearly exclusive aim of law see Kelsen (1945).

⁶⁸ The main worry in the law and economics movement (transferred from economics to law through Coase's (1960) famous paper).

⁶⁹ This is arguably Jeremy Bentham's universal concern.

predictability over adaptability in commercial law, but are more open to adaptation with regard to personal injury law. Within the legal profession there will always exist subgroups with differing images of law and their disagreements will manifest as professional debates (and sometimes even as violent conflict when the debates are linked to clashes outside the legal realm). The professionals' images of law will be influenced by their non-professional lives, worldviews and debates⁷⁰. Berman, for example, argues in his work for the strong influence of religious worldviews on the development of law.

⁷⁰ I believe, with Amsterdam and Bruner, that it is generally a fruitful perspective to see culture as the coexistence of competing worldviews. In the words of Amsterdam and Bruner (2002, pp. 231–232): "...cultures in their very nature are marked by contests for control over conceptions of reality. In any culture, there are both canonical versions of how things really are and should be and countervailing visions about what is alternatively possible. What is alternatively possible comprises both what seems desirable or beguiling, and what seems disastrous and horrifying. The statutes and conventions and authorities and orthodoxies of a culture are always in a dialectical relationship with contrarian myths, dissenting fictions, and (most important of all) the restless powers of the human imagination. Canonicity and the ordinary are typically in conflict with imaginable "otherwises"—some inchoate and even private, some vocal or even clamorous, some quasi-institutionalized as cults or movements of dissent. The dialectic between the canonical and the imagined is not only inherent in human culture, but gives culture its dynamism and, in some unfathomable way, its unpredictability—its freedom."

Wallis (2014) makes a related argument from the perspective of an institutional economist: "the forces that generate institutional change are not necessarily the forces involved in the winnowing process that determine which institutional changes persist. New institutions are continuously generated, the winnowing process runs constantly as well, without ever reaching a point at which everyone is satisfied with the rules as well as their realized outcomes under the rules."

Hutchinson (2005) points to the materialization and continuous resurgence of these conflicts in law's traditions: "..., the past is not the monolithic entity that defenders of a tradition-based approach to common law adjudication insist or pretend it is. It is not realistic to imagine accepting or rejecting the past holus-bolus. Like the social past on which it draws, the law's traditions are rich, multiple, and competing; they are notoriously difficult to pin down with any specificity or precision. Like anything and everything else, traditions do not speak for themselves but must be spoken for."

Meaning and influence of ER citations

Case and statute analogies that legal professionals use in common law courts manifest as specific references in legal documents. In the US legal system they appear as case and statute citations, for example, in judicial opinions, whereas in the English legal system they appear mainly in case reports⁷¹. Judicial opinions justify the court's decision and are written by judges involved in the trial. The case reports contained in the English Reports reflect the proceedings in common law courts. Legal professionals took and (take) citations very seriously and, thereby, pave the way for an approach that aims at an understanding of legal practice through quantitative citation analysis. In Posner's (2000) words "Judges, lawyers who brief and argue cases [...] could all be thought, with only slight exaggeration, to make their living in part by careful citation both of judicial decisions law-review articles and other secondary materials."

ER case report and statute citations reflect a good part of legal reasoning that occurred during the legal process over the centuries. English case reporters, from the 18th century onwards, regularly recorded case and statute citations when judges or counsel pointed to specific cases or statutes to advance their arguments. Before the 18th century case reporters rarely provided case and citations because most case reports were not yet printed and the doctrine of precedent was still emerging. Later editors frequently added

⁷¹ Posner's (2000) whole statement regarding the role of citations in the American legal system reads: "Both adjudication, central practical activity of the legal system, and legal research are citation-heavy activities. Judges, lawyers who brief and argue cases, and law professors and students engaged in traditional legal-doctrinal research could all be thought, with only slight exaggeration, to make their living in part by careful citation both of judicial decisions and of law-review articles and other secondary materials. The seriousness with which the legal profession takes citations suggests that the analysis of citations in law is likely to uncover more systematic features, a more consistent practice, of citing than would a similar analysis in fields for which citing is of less consequence."

case and statute citations to the earlier case reports they were publishing because they wanted to document the legal reasoning of a reported case. While the content and reliability of ER case reports changed from the late 17th to the 19th century and from case reporter to case reporter, the doctrine of precedent and Parliament's statutes continuously played central roles.

While scholars widely agree that citations play a central role in common law's legal reasoning, they debate the meaning of a citation. Nearly all of the academic literature appears to focus on the US legal system. Within the context of US judicial opinions, two main opposing views emerged (Walsh, 1997). The first view sees citations as a clear indication of judges' analogy-centered decision-making processes and reflection of an ongoing communication between courts. The second view sees citations as a legitimization exercise and mere ex-post rationalization of judicial decisions that occur largely without a pondering of precedents and statutes (the judicial decisions are seen as strongly influenced by judges' world views - an argument that gained prominence with Segal and Spaeth (1993)). The first view allows insight into judges' analogical reasoning processes whereas the second view allows insight into judges' ideas about legitimacy. In line with the idea of analogies as interpretive acts Walsh (1997) and later authors (see e.g. Baum, 2006; Johnson and Spriggs, 2007; D'Elia-Kueper and Segal, 2015) find that US judges exhibit both influences. For this study favoring one of the dichotomous views is not necessary because both views accept the significance of legal citations and regard citations as indications of analogies.

Posner (2000) has a different perspective on citations in judicial opinions. He differentiates among five different meanings of a citation. According to him a citation

“can signify an acknowledgement of priority or influence, a useful source of information, a focus of disagreement, an acknowledgment of controlling authority, or the prestige of the cited work or its author”. At the same time Posner points out that in citation studies all these motives may be subsumed under a broad category of influence. This should hold even more true if one studies aggregates and not individual judicial opinions.

Scholars of the US legal system also discuss the relationship between influence and citation counts of judicial opinions. Put in simple terms they wonder if judicial opinions that are cited more often are more influential in the resolution of legal disputes and the creation of new law than the less cited ones. It now seems to be widely accepted that the number of citations a judicial opinion receives⁷² is a valid measure of its influence. Cross and Spriggs (2010) provide a good summary of potential challenges that citation analysis faces. They conclude that various objections to using case citation counts as a measure of influence do not stand up to closer scrutiny. For example, the most common criticism is the idea of a superprecedent (Sinclair, 2006), i.e. a judicial decision so influential that it settles a legal issue once and for all without generating later citations. However, deliberation renders the idea theoretically unconvincing. It is implausible for a holding to resolve all legal issues in a broad area in the present or future and not be challenged or used for innovation in other areas⁷³. In other words it is improbable that a

⁷² The simple count of the citations a case receives can arguably be improved by constructing a centrality measure that incorporates second order effects by taking into account citation counts of citing and cited cases (Kleinberg, 1999; Fowler et al., 2007; Fowler and Jeon, 2008). However, the correlation between simple citations counts and centrality measures is high. Therefore, and because of the greater simplicity of citation counts I stick with simple citation counts for the subsequent analysis.

⁷³ In their early paper Posner and Landes (Landes and Posner, 1976) already wrote: “[S]uch cases are probably rare. If a case is highly specific, it will hardly qualify as a

precedent brings legal innovation in a broad area to a full stop and, if it really does so, has no analogical use in other areas. Even more importantly, to this day none of the few suggested candidates for superprecedent have withstood scrutiny (Cross and Spriggs, 2010, p. 424).

Another criticism is the reverse of the first one: precedent that generates a large number of citations because of its vagueness and obscurity, but has nothing intrinsically influential to offer. This possibility appears even less convincing. On the one hand, vague and unclear precedents are likely to be distinguished and clarified quickly and then attract no further citations. On the other hand, if they do indeed continue to generate citations because of their ambiguities, then it appears fair to count the precedent as influential. The final criticism concerns so-called negative citations - citations where the cited case is overruled or used as an instance of an incompetent court decision (Cross and Spriggs, 2010, p. 427). Negative citations would give a misleading picture of the influence of a judicial opinion if one conceives of a citation as a sign of constructive influence.

However, a series of negative citations of a case does not imply that the case is not influential. Moreover, the number of negative citations turns often out to be very rare⁷⁴.

All in all citation measures have withstood the criticisms and shown strong correlation with other influence measures like expert-compiled lists or newspaper

“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”.

⁷⁴ In practice negative citations usually mean overturning of precedents. Segal et al. (Segal et al., 2005, p. 316) report that the American Supreme Court overturns only about 2 out of 1000 judicial opinions. Random sample analysis of ER case reports suggests comparable numbers.

coverage (Fowler et al., 2007). Nevertheless one should aim to limit noise in the measure due to heterogeneities that arise from differences in the hierarchy of citing courts, citing conventions, the quality of judicial opinions, the idiosyncrasies of judges, the population size of citers, citing time periods or the number of citing judicial opinions, etc. (see e.g. Posner, 2000; Cross and Spriggs, 2010).

ER random sample: extraction reliability and citation content

The findings regarding the meaning of citations in US judicial opinions and the legal influence of frequently cited cases are not immediately transferrable to citations in the English Reports and - to the best of my knowledge - an independent literature on citation networks of English case reports does not exist. An ER case report is not an official judicial opinion, but an unofficial or at best a semi-official text that includes citations from judges, counsel of the opposing parties, reporters and later editors. Therefore, a case report and its citations reflect not only the analogical reasoning and legitimizing efforts of judges (and their pondering of the opposing parties' arguments), but very directly also the analogical reasoning and legitimizing efforts of the opposing parties themselves (and possibly distortions by the case reporter and later editors). Similarly, citations not only indicate influence on judges, but also influence on opposing parties. Arguably the English Reports reflect the dialectic court process more directly than the American judicial opinions, and the analogies that parties advance are less likely to be ex-post rationalizations of an unconscious decision-making process. Given the proximity between the English and American law systems, the previously outlined U.S. findings (and reservations) regarding citation frequency as a measure of legal influence plausibly generalize to the English legal system.

To go beyond plausibility arguments, explore the peculiarities of English case reporting, gain a better understanding of ER citation content and, at the same time, assess the reliability of the extracted data (as described in chapter 4) I drew on a random sample of ER case reports. By manually matching the information in the extracted data with the information in the original ER case reports I could determine success and error rates of the data extraction, and I could classify citations by categories (like party citing or negative-positive citation) that were not recognizable by the automated data extraction process. To construct the sample I randomly picked 25 combined case reports, compared the information with the original English Reports and manually classified the citations. The random sample contained 38 distinct case reports with 234 statute and case report citations.

Table 3 reproduces the relevant information from the random sample and displays variables that assess the correctness of the extracted data and classify the citations. It lists the nominate citation of the potentially combined case report (citing nomcite), the name of the opposing parties for each distinct case (citing casename), the English Reports citation, the trial date of the case, and the court at which the trial took place. It further indicates if the nominate citation of the citing case (citing nomcite correct), the trial date of the citing case (citing date correct), and the nominate citation of the cited case/statute were correctly extracted (cited nomcite correct). It also lists citations as they appear in the original (citation in original), citations as they were standardized during the extraction process (cited nomcite), reasons if a citation was not extracted from the original (reason if not extracted), and reasons if a citation was incorrectly extracted (reason if cited nomcite incorrect). Finally, it contains three categories that classify the citation content of a

citation: the person citing - counsel, court, editor/reporter, ER editor (person citing), the type of the citation - analogy, analogy cited in multiple case reports, later analogy, same case reported - (citation type), and the presence of a negative citation (citation negative). I used personal judgment to assign citations to the different classification categories.

Table 4 presents summary statistics on the reliability of the data extraction. The nominate citation and the date of the citing case were correctly extracted from all 38 distinct case reports. To extract nominate citations of the cited cases posed greater challenges. Altogether the citing case reports references 234 documents. Of these 48 were not part of the ER series (20.5%) and 26 referred to ER case reports in the same volume by using the words ante or post in combination with a page number (11.1%). The majority of non-ER documents refers to later cases, much earlier cases in the yearbooks, or fairly obscure case reports - many of them not from the common law courts. Data extraction did not target these citations. ER citations using ante or post often refer to a different session of the same case that is being reported. Therefore, and because the potential for erroneous extractions was large data extraction did not target these citations either. Out of the remaining targeted 160 statute and ER case citations 132 were correctly extracted, 3 were incorrectly extracted, and 25 were not extracted at all. The 3 incorrect extractions happened due to OCR errors that shortened page numbers. 25 citations were not extracted because they deviated in 9 cases from the standard that the data extraction algorithm targeted (e.g. a comma separating reporter name and page number). In 8 cases OCR errors forbade extraction, in 4 cases I had dropped reporter abbreviations because of ambiguous reporter abbreviations, in 3 cases the original abbreviation did not appear in any of the sources I used to collect reporter abbreviations, and in 1 case the original

citation had a typo that was transcribed. This means that 82.5% of the targeted citations were extracted correctly.

Table 5 summarizes the results of the citation content classifications. Because of the emergence of the doctrine of precedent and because of the greater availability of printed reporter volumes there exists a significant difference between pre-1700 and post-1700 content. Therefore, I present not only overall numbers, but also break down citation content by trial date of the citing case. Pre-1700 results show that the vast majority of citations (93.7%) were inserted by editors or case reporters as comments and not simply transcribed from courtroom proceedings. Because precedents played a different role before the emergence of the doctrine of precedent and because citations reflect less directly on courtroom proceedings, I decided to concentrate all subsequent analyses on post-1700 citations and will not discuss pre-1700 citations any further.

The vast majority of citations in the post-1700 cases directly reflect the courtroom experience in that they apparently record references that were explicitly used during the trial: 54.4% of citations can be traced to arguments from counsel and 25.3% to arguments from the judges. Only 16.5% of citations stem from comments of the reporter or later editors. Many of these simply provided a nominate citation when only the names of the opposing parties were mentioned in the original case report. About 3.8% of citations were inserted by ER editors and exclusively point to later cases (I will drop these in all later analyses).

Classification by citation type showed that nearly all of the citations point to similar cases and act as analogies. The vast majority of citations (82.7%) refer to proper precedents or preceding statutes. Because different case reporters frequently recorded the

same case, multiple case reports of the same case exist. As these might confound the interpretation of citations it is important to know if citations refer to distinct cases proper or to distinct case reports of the same cited case or to distinct case reports of the same citing case. Fortunately, it turned out that the confounding potential is limited. Only 6.2% of distinct citations in a citing case refer to the same case and only 7.4% of citations do not refer to a precedent, but point to an alternative case report of the citing case (these are easily identifiable because the trial dates of citing case and cited case are the same; I will drop these in all later analyses). 3.7% of citations pointed to later cases, i.e. they pointed to cases that used the citing case as precedent. Within the random sample all later analogies stem from ER editors (and were dropped later). Finally, I could not detect negative citations, i.e. cases that were cited as bad examples or overturned. Consequently, I estimate the presence of negative to be below 1%.

All in all analysis of the random sample suggests that more than 80% of targeted precedent and statute citations were correctly captured in the dataset. Moreover, the rate of false positives is very low (less than 2%) and the rate of false negatives is manageable (about 15%). In addition to this it seems clear that the vast majority of post-17th century case reports contains references to precedents (and preceding statutes) that can be traced directly to statements from court or counsel and reflect - in contrast to citations in US judicial opinions - the dialectic legal process in English courtrooms. Moreover, the likelihood is small that confounding occurs because of different case reporters having reported on the same case. A final finding - in line with findings from the US literature - suggests that citations with negative character are rare (0 out 234 citations in the sample),

i.e. citations that overrule cases or statutes or citations that refer to them as examples of poor legal craftsmanship are the exception.

Meaning of ER citation

Drawing on the findings from the random sample analysis and insights from the literature on the US legal system I will interpret preceding statutes and preceding case reports from England's highest royal law courts as analogical basis for the construction of new legal rules⁷⁵. They constitute the stock of legal elements - in Landes and Posner's (1976) words "the stock of legal capital" - that can be used to create the new from the old. The stock can depreciate when previous cases and statutes lose their value for the creation of new rules (for an overview of the US legal literature on depreciation see e.g. Black and Spriggs, 2013). Every newly reported case potentially increases the stock⁷⁶. Citations of

⁷⁵ (Berman, 2003) argues that even the notorious legal fictions - operative facts assumed as true though they were known to be false - were a way to construct the new in analogy with the the past. In his words (Berman, 2003, p. 280): "The utility of legal fictions introduced into the English common law in the late seventeenth and eighteenth centuries was that they applied to new rules procedural and substantive law embodied in older rules. Thus new situations were converted into familiar terms of the past. This, indeed, is the chief virtue of legal fictions generally; in the words of the great nineteenth-century German jurist Savigny, the new rule expressed in a legal fiction "is joined directly on to an old and existing institution and in this way the certainty and development of the old is procured for the new." In late-seventeenth and early-eighteenth-century England this had not only a practical but also a theoretical virtue: it reinforced the belief in the tradition of the common law. The resort to legal fictions by English judges was closely related to their resort to the doctrine of precedent. Both are ways of making new law—fictions directly and openly, precedent indirectly and more subtly. Both preserve continuity with the past—precedents directly and openly, fictions indirectly and more subtly."

⁷⁶ Similarly the full paragraph in Landes and Posner (1976) reads: "..., there appear to be regularities in the citation data (for example, 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

specific precedents and statutes indicate their involvement in the innovative process. Frequent citation of the same case or statute is an indication of their particular importance in the innovation process.

Two shortcomings of the ER case reports complicate the interpretation. First, the English Reports do not contain all of England's surviving case reports and a large number of cases in England's highest courts were never reported. Second, case reporters did not reference all the cases cited in court - about 25% of case reports do not contain any citation at all -, and judges or counsel most likely did not verbalize all the cases that crossed their minds. However, various factors mitigate the damage done by these shortcomings. The random sample analysis showed that the vast majority of citations in the ER volumes point to ER case reports. Moreover, while case reporters reported only a small number of cases, it is likely that unreported cases were forgotten quickly when memory of them faded and that important unrecorded arguments that recurred sooner or later found their way into recorded cases. With regard to the second shortcoming, it seems undeniable that the ER citations reflect only a subset of arguments advanced or pondered in court. However, it seems plausible that reporters left out references they found least conducive to the perceived overall argument. And that in the first place, references actually voiced in court were the ones thought to be central. If no case is cited in a case report it is because a case reporter felt no need to report it or because the analogical reasoning applied to the case on trial was not made explicit. Altogether then, even though not all cases are reported and not all analogies cited, it remains a valid

capital subject to depreciation and the production of precedents is treated as a form of investment.”.

perspective to see case reports as analogical basis for the construction of new legal rules and citations as indication of a constructive relationship.

A limitation of this interpretation is that it can provide only very modest and indirect insight into the use of royal law outside the innovation process. Or in other words, while citations can illuminate the stock underlying legal innovation and the flow of legal innovation, they do throw only dim light on the uses of legal innovations. Once a new legal rule is created it is unclear how it will be used in lower courts (e.g. in the magistrate courts) or daily life⁷⁷. As argued before an ER citation suggests that judges of the highest English courts or counsel in the courtroom regarded the cited case or statute as valuable, non-depreciated analogy. While it is likely that magistrate judges or the public would not have acted against a recently cited case or statute, the real use they made of them is uncertain. Finally, cases that lost value to the highest might still have been valuable in lower courts or daily life.

Legal evolution

It is possible to integrate the idea of case reports and statutes as innovation capital with ideas of combinatorial innovation and cultural cumulative evolution. One can conceptualize newly created legal rules as stemming from a combination of previously existing rules (holdings of cases and provisions of statutes that are transmitted from generation to generation through writing and legal training). Arthur (2009) proposes a mechanism for technological evolution that differs from the biological Darwinian mechanism. According to him new technologies arise as an autopoietic process from

⁷⁷ There is an analogy to technological innovation. While one can retrace the elements in an innovation, the diffusion across a population remains unclear.

ongoing recombination of existing elements before they are subjected to a Darwinian type of incremental change and selection. Many other authors have used the idea of a combinatorial process to explain technological innovation (see e.g. Schumpeter, 1934; Needham, 1954; Usher, 1954; Basalla, 1988; Weitzman, 1998)⁷⁸. However, most of these authors have applied the idea in case studies and historical analyses and not in a quantitative manner. The main difficulty of a quantitative treatment stems from the need to identify discrete units of technology. Youn et al. (2014) is one of the first attempts to overcome the difficulty.

Fortunately, the discretization difficulty does not arise in legal evolution if one sees preceding cases and statutes as discrete building blocks for new cases in an ongoing combinatorial process. Newly adjudicated cases then appear as legal innovations that arise from the recombination of preceding cases and statutes. Because adjudicated cases and enacted statutes persist through writing and legal training they create, in principle, a growing number of combinatorial elements even though a large number of these elements is not used or becomes useless in the legal innovation process. Persistence through inheritance, variation and innovation are features of cumulative cultural processes. If one adds selection to these features one arrives at cumulative cultural evolution - a path-dependent, non-random search algorithm in a vast combinatorial space.

The citation network that results from case and statute citations embodies the process of cumulative legal evolution. New network nodes (i.e. cases) are resolved by building on

⁷⁸ The combinatorial approach to technological innovation - mainly a process that combines elements - finds support on the individual level in constructivist theories of psychology (Piaget, 1954; Vygotsky, 1978; Bruner, 1996; Klein, 2013).

the preceding ones and new network links (i.e. citations) reflect the combinatorial innovation process.

Figure 6 presents a simple example in the form of a graphical representation. In the figure nodes represent case reports from time periods 1, 2 and 3. Cases 11 and 12 belong to time period 1, cases 21, 22, 23 and 24 belong to time period 2 and cases 31, 32 and 33 belong to time period 3. Case 22, for example, uses the previous cases 11 and 12 to construct a new rule, which is of no use in time period 3. Case 24 builds on case 12 from time period 1 and then provides a building block for case 33 from time period 3.

Network nodes persist through time and - if not used for the creation of new nodes - disappear from active cultural memory, i.e. they are forgotten and depreciate. Depreciation of the old to make space for the new can be seen as an essential feature of evolution in general and cumulative culture in particular. Because printed case reports were preserved for centuries it was possible, in principle, to rediscover and resurrect forgotten case reports. Consequently, a citation network then not only depicts available elements for combinatorial innovation, but also reflects a history of combinatorial innovations. Therefore, study of the ER citation network should allow insights into the legal evolution of England's royal law in the 18th and 19th century.

Chapter 5: Patterns in the citation network

With the previously developed interpretation and the reassuring findings from the ER random sample analysis in mind, I will now investigate whether the extracted citation network contains patterns that indicate meaningful content in the extracted data. I start by drawing attention to the substantial fluctuations in the yearly number of available case reports and then briefly introduce a random citing model. The model will serve as comparison in this and later chapters. In this chapter I explore five structural patterns that exist in the citation network. First, I confirm the expected separation between equity law and common law. Second, I show that the three common law courts have a significantly smaller, though noticeable bias towards their own courts. Third, I demonstrate that the 5 most cited cases in common law were truly influential in England's legal history, Fourth, I show that there exists a clear pattern regarding the age of cited cases. Fifth, I lay out that the frequency distribution of cases by the number of received citations follows a non-normal distribution with a long tail and that new citations are biased towards cases that were cited frequently. Finally, I discuss strategies to control for heterogeneities in the data and present a citation model that captures the data's statistical aggregate features. The citation model imagines a representative, infinitely lived courtroom whose members choose among aging citations with a bias towards frequently cited cases. The model makes it possible to account for case fluctuations and aids the analysis of persistent and changing features in England's legal innovation process.

Fluctuations in the number of cases and case reports

For this chapter and later investigations it is important to be aware of large fluctuations in the yearly number of ER case reports. An increasing number of newly reported cases increases the total number of citations that previous time periods will receive and changes the rate at which cases become available for later citation. Through these two effects they impact the number of citations a specific time period will receive. If one relies on citation frequency as a measure of influence it is important to take these effects into account. Out of all the other factors responsible for noise and heterogeneities (e.g. hierarchy of courts, conventions, quality of case reports, idiosyncrasies of judges, number of citers, time period; see page 62) the fluctuating annual number of case reports has arguably the largest potential for distortion.

Figure 7 displays the fluctuating number of ER case reports by the year in which the reported case was on trial⁷⁹. For reasons that will become clear in the next paragraph reports from the equity law courts, i.e. from the Chancery, the Master of Rolls, and the Vice-Chancellor, are separated from the common law courts (i.e. King's Bench, Common Pleas, Exchequer, and Nisi Prius cases). A few general features are visible. It is evident that the vast majority of equity law reports date from the time after 1660⁸⁰ while a substantial number of common law reports exist from earlier times⁸¹. The 17th century dip

⁷⁹ Only a few nominate case reports from before 1580 exist and even fewer are available in the ER reports. Therefore, the figure display begins in the year 1580.

⁸⁰ Chancery reporting become regular practice around the year 1660 (Baker, 1990, p. 127) even though some pre-1660 chancery reports exist.

⁸¹ Many of the early reporter volumes combined King's Bench, Common Pleas, Exchequer, and even Chancery reports (see. e.g. volume v of Holdsworth, 1922, pp. 359–

in the number of common law reports is related to the turmoil of England's Civil War. During these troubled times fewer case reports were produced and a good number of these the ER editors chose not to include in their series. The first half of the 18th century was characterized by a decline in the number of case reports in equity law and common law. This parallels a general decline in legal litigation: fewer cases were taken to trial and the number of lawyers decreased. Litigation, lawyers, and case reports began to increase again in the second half of the 18th century. Brooks (1989) discusses the phenomenon and provides statistics. Mokyr (2008) sets the phenomenon in the context of the prevalence of "gentlemanly" codes and private dispute resolution. Figure 8 reproduces a graph from Brooks (1998, p. 68) and reveals a fairly close association between the annual number of cases in advanced stages, i.e. cases where the defendant had appeared in court to respond to the plaintiff's pleas, and the number of annual ER case reports (disregarding the civil war years whose reports are largely missing from the ER records).

It should be evident that the number of actual trials and cases in advanced states, as well as the number of ER case reports fluctuated widely over the centuries. Even the year-to-year fluctuation of ER case reports is considerable. While only a small percentage of cases were reported there is a fairly close association between the number of ER case reports and cases in advanced stages (this can be asserted only for overall trends). Most of the post-1700 case reports originated in the King's Bench or equity courts. As mentioned before fluctuations in the annual number of ER case reports is a potent confounding factor. To take the fluctuations into account I will often rely on two different statistical models. The first model - I call it the random citing model - is introduced in the

363). Because the ER editors assigned these volumes to one court the court number of ER case reports do not exactly match the actual numbers.

next section. The second model - I call it the representative courtroom model - is introduced in the last section.

Random citing model

The arguably simplest way to model the citation process makes the assumption that each precedent has the same probability of being cited when citing occurs. Expressed in mathematical terms the probability that the citing case i at time t (measured in years) cites the case j from time t' is:

$$p_{ij}|i \text{ is citing at time } t = \begin{cases} \frac{1}{\sum_{t=t_0}^{t_i-1} n_t} & \text{if } t < t' \\ 0 & \text{if } t \geq t' \end{cases}$$

where t_0 is the first year of a citable case report and n_t is the number of cases reports in year t . The number of citable case reports and the number of citations in a given year are exogenously given and correspond to the actual citation network.

The justification for the use of such a simplistic model is twofold. On the one hand, the equal citing probabilities of case reports in the English Reports can be interpreted as case reports that are equally important in the legal innovation process. Because case reporters, in the first place, tend to report on important cases this is not an utterly absurd assumption. On the other hand, the random citing model serves as a standard comparison model in network science. It creates a context for comparison and makes sure that patterns in the network are not explained with sophistication when they could simply be the result of random effects. Because the number of citations and citable

cases is exogenously given the random citation model accounts for some of the effects of case report fluctuations on network patterns.

Equity law - common law split

Turning now to the structural investigation, I will study whether the commonly stated split between common law and equity law (see e.g. Baker, 1990, pp. 122–126) is reflected in the citation network. Historically the two royal law jurisdictions developed from different legal grounds. While the common law grew from the king’s writs, equity law essentially arose out of the need to bring justice to cases that did not fit the limited scope of the writs. In spite of their different origins the two jurisdictions competed and coevolved for centuries.

Figure 9 depicts the intra- and inter-jurisdiction citations rates for equity law and common law courts during the time period from 1700 to 1865. Case reports and citations are pooled by decade. The dashed lines represent expectations from the random citing model. The expected citation rate is independent of the citing jurisdiction. The probability that a case in the year t from jurisdiction j cites a case from jurisdiction j' is:

$$p_{jj'} | j \text{ is citing at time } t = \frac{\sum_{t=t_0}^{t_i-1} n_t^{j'}}{\sum_{t=t_0}^{t_i-1} n_t}$$

where $j, j' \in \{\text{common law, equity law}\}$

At the beginning of the 18th century it appears that equity law courts cited common law cases about as frequently as equity law cases. Because reporter volumes of

the 17th century often mixed cases while ER editors classified these volumes usually as King's Bench cases (see footnote 81), equity law, in reality, favored its own courts even more. This becomes clear in the subsequent decades. The citation rates of common law cases dropped to about 20% and intra-jurisdiction citations came to completely dominate equity law. The picture for the relative citation frequency of common law courts looks slightly different. From the 18th century onwards common law courts nearly exclusively cited common law cases. Equity law citations rarely accounted for more than 10% of a decade's citations.

To evaluate if the actually observed intra- and inter-jurisdiction citation rates might arise from a courtroom that randomly cites ER precedents, I calculated the expectation rates that would result from such a model. To do so, I counted ER equity and ER common law case reports that were available before a given citing decade and set them in proportion to all then available ER case reports. Because a randomly citing courtroom does not distinguish between jurisdictions the expected citation rates do not differ between citing courts. Because the number of reported common law cases always vastly outnumbered reported equity law cases, the expected citation rate of common law reports was always higher than the one for equity law. The rates move closer over the 18th and 19th century because equity law and common law reports began to be published in comparable numbers so that their relative proportion began to equalize.

Comparison between expected citation rates and actual rates makes it clear that equity law and common law courts cited case reports from their jurisdictions significantly more often than the pure random citing would lead one to expect. For example, the random citing model would predict that around the year 1800 equity and common law

courts would cite common law case reports about 80% of the time. However, the actual rates amounted to about 20% for equity law courts and about 93% for common law courts. This means that equity courts in that decade were about 20 times more likely to cite cases from their own courts than cases from common law courts and common law courts favored their own cases with a ratio of 3:1. The bias towards intra-jurisdiction citations around 1700 was about 6:1 for equity courts and 8:1 for common law courts. The degree of intra-jurisdiction bias varied over the 18th and 19th centuries, however it existed without interruption.

Altogether, it is evident that equity and common law courts manifested a strong tendency to cite case reports from their own courts. This tendency obviously differs from predictions of the random citing model. On the other hand the findings are consistent with the idea of largely autonomous, but coevolving jurisdictions. As one would expect for largely autonomous bodies of law the vast bulk of citations occurred within their jurisdictions. Because the two jurisdictions were never completely independent and because lawyers working mainly in one of the two jurisdictions were usually well acquainted with the other jurisdiction, it is reasonable that a non-negligible amount of inter-jurisdiction citations occurred.

Entanglement of common law courts

Contrary to the separation between equity law and common law, it is usually accepted that the three common law courts had obtained comparable jurisdictions with some specialized functions by the end of the 17th century and that the King's Bench court had supervisory function over the court of Common Pleas and the court of Exchequer (see e.g. Baker, 1990, pp. 59–61). Figure 10 shows the relative distribution of common law's

intra- and inter-court citations. Also here case reports and citations are pooled by decade and citation rates expected from the random citing model are shown as dashed lines. Expectations are calculated analogously to the previous section. The only difference is that there are now three jurisdictions and not two, and that the denominator sums over all common law cases and not all common law and equity cases:

$$p_{jj'} | j \text{ is citing at time } t = \frac{\sum_{t=t_0}^{t_i-1} n_t^{j'}}{\sum_{t=t_0}^{t_i-1} \tilde{n}_t}$$

where $j, j' \in \{\text{king's bench, common pleas, exchequer}\}$

Over the decades most common law citations referred to cases in the ER's King's Bench series. Citations to the Common Pleas and Exchequer series occurred at about the same rate and made up the remaining citations. The dominance of King's Bench citations decreased only over the 19th century when roughly equal numbers of King's Bench, Common Pleas, and Exchequer reports appeared every year.

Expected citation rates from the random citing model are again court independent. The high King's Bench rates in the 18th century reflect the 17th and 18th century prevalence of King's Bench ER reports (one should keep in mind that 17th century ER King's Bench reports often mix reports from the different benches). 19th century publication of roughly equal numbers of case reports from the King's Bench, Common Pleas, and Exchequer courts underlies the 19th century convergence of expected citation rates.

Comparison between actual and expected rates reveals a slight 18th century tendency of common law courts to cite cases from their own courts. This tendency was less visible than the analogous tendency of equity courts and the combined common law courts. In the 19th century the King's Bench seemingly cited its own cases less while the Common Pleas and Exchequer courts seemingly began to strongly favor their own cases at rates around 3:1. However, the effect is overstated because time depreciation (see section on time depreciation below) impacted mainly the previously prevalent King's Bench cases so that the number of non-depreciated 19th century cases differs less between the three common law courts.

In summary, the structure of the citation network is consistent with the entanglement that legal scholars ascribe to common law courts. Common law courts had a tendency to cite from their own courts. The tendency was always less pronounced than the analogous tendency in the relationship between equity and common law. The apparent 19th century move towards stronger separation of the three common law courts is likely an artificial effect that arises from time depreciation. Because of the entanglement of the three common law courts and the clear separation of equity law and common law I will focus subsequent analysis on only of the two. I opted for an analysis of common law because the latter is the older, better-documented and more central body of law. I leave the analysis of equity law to future research

Five most cited common law cases

Here I test if the number of citations a specific case report received is indeed an indication of the reported case's influence on legal innovation as judged by other sources.

Among legal experts the most cited cases should be known as influential in the

development of England's common law. To do so I focus on common law citations only, i.e. citations from common law courts to common law courts, count the number of citations a case report received between the years 1700 and 1865 (this means that I capture overall influence in legal innovation between 1700 and 1865), and consult the legal literature to assess the importance of a handful of the most cited ones. Table 6 lists the 20 most cited (combined) common law cases. I will discuss extensively only the top 5 cases and present the remaining cases mainly to show the prominence of Coke's Reports. 8 out of common law's 20 most cited cases can be found in Coke's Reports, often just known as The Reports. Baker (1990, p. 210) claims that they "have been perhaps the single most influential named reports", but does not substantiate the claim. A simple citation count gives credence to the actual influence of Coke's Reports.

The most cited case report in common law is *1 wms saunders 319*. It received 87 out of the about 115,000 post-1700 citations. The corresponding relative share of citations is about 1 per mill and, thereby, similar to the relative share of the most cited majority opinions in the U.S. Supreme Court⁸² (see Cross and Spriggs, 2010, p. 432). Reported are the case of *Pordage versus Cole*, which was on trial in front of the King's Bench in the year 1669, and the case of *Clerke versus Pywell*. Because, on closer inspection, nearly all citations refer to the former, I will not elaborate on the latter. In *Pordage versus Cole* the two parties had agreed that the defendant would pay a certain amount of money for the plaintiff's lands. The plaintiff sued for full payment of the money before conveying while the defendant was unwilling to pay before the conveyance was complete. The court ruled that the transaction consisted of two independent

⁸² The most cited majority opinion from the U.S. Supreme Court is *McCulloch v. Maryland* (1819). It received 355 out of about 215,000 citations.

covenants (i.e. promises made official through a seal) and that each party could seek remedy in court for fulfillment of the covenant, but that neither party could reject fulfillment of the one covenant by pointing to non-fulfillment of the other. The covenants were seen as independent and the plaintiff had the right to receive the full payment before conveying the lands. The question when covenants would be dependent or independent played an important role in the development of contract law. Therefore, and because the ruling was contentious to many⁸³ the case gained prominence around the mid of the 19th century until it was distinguished in various decisions and finally essentially overruled. The case was unusual in that it became most influential about more than 150 years after it went on trial (see Figure 11). More than two thirds of the citations occurred after 1830.

The second most cited case report is 1 coke report 93, a famous case from the King's Bench known as Wolfe versus Shelley or Shelley's case. It was cited 64 times in the post-1700 ER reports. Coke's report from the year 1581 records an ancient and by then regularly applied rule holding "that when O conveys "to A for life then to A's heirs", A gets a fee simple absolute and his would-be heirs not even a future interest. O's intent that A get only a life estate is frustrated" (as stated in Reppy Jr, 1997, p. 83). Bluntly stated it means that the will of O in conveying land to A and limiting its use to the benefit of A's heirs need not be respected by A, i.e. A can sell the land and need not pass it on to his heirs. The rule was contentious because it apparently defeated the conveyor's intentions until it was abolished by statute in 1925. In a law school review from that period ("The Rule in Shelley's Case Has Been Abolished," 1935) it is stated that "Throughout the six centuries of its life, the Rule has been provocative of conflicting

⁸³ In the words of Lord Kenyon - the Court of Chancery judge and later King's Bench lord chief justice - it "outraged common sense" (see 4 term reports 761).

criticism” and illustrated with a footnote saying that at some point in time “the entire bar of England is said to have been divided into the "Shelleyites" and the "Anti-Shelleyites." [...] A fierce controversy followed the decision of the court of Exchequer Chamber which reversed the judgment of the King's Bench. Lord Mansfield, Lord Thurlow, Fearn and Hargrave participated in the hostilities [...] So vehement were the attacks that a life-long friendship between Lord Thurlow and Hargrave terminated in a heated dispute.” The struggle over the rule continued in the United States (see e.g. Orth, 1988; Hoover, 1991; Reppy Jr, 1997). An American judge called it "a rule which has done more to produce litigation, and, when sustained, thwart the actual purposes of a testator than all the other arbitrary rules combined" (cited in Reppy Jr, 1997, p. 86). The case collected citations and remained influential from the beginning of the 18th century onwards (see Figure 11).

The third⁸⁴ most cited case report is 1 burrow 38 or Robinson versus Robinson, a 1756 case from Lord Mansfield’s King’s Bench. It received 60 citations. In the reported case Robinson, in his will, passed on his estate to a relative for the relative’s lifetime and, after the relative’s death, to the relative’s potential son for the son’s lifetime. In the absence of a son the estate would fall to Robinson’s cousin. The relative had two children, the relative’s first-born son died, the relative’s second son lived on, and Robinson’s cousin claimed the estate. After careful and diligent deliberation the court held that the general intent of Robinson’s will supersedes the particular intent and that the estate should remain with the second son. About 45 years later Lord Kenyon could state that it “has been the settled doctrine of Westminster Hall for the last forty or fifty years

⁸⁴ I left out kelyng j 1 as third most cited combined case report because the original 61 case citations it received referred to different cases in the reporter volume. They were all matched to kelyng j 1 as the different case reports were not differentiated in Juta Law’s electronic version of the English Reports.

that there may be a general and a particular intent in a will, and that the latter must give way when the former cannot otherwise be carried into effect.” Editors’ notes in 1 burrow 38 indicate that it was frequently cited. Therefore, it is not surprising that the case continuously collected citations soon after it was resolved (see Figure 11). However, in the legal literature the case apparently does not figure prominently as an influential case. Citation analysis can serve here as a guide for future investigations.

The fourth most cited case report is 6 adolphus and ellis 469 or Pickard versus Sears. In 1837 the King’s Bench under Chief Justice Denman held that a third party S who purchased unknowingly mortgaged property from a mortgagor while the mortgagee P - in spite of being actively involved in the sale - remained silent to all involved parties about his mortgage title, need not return the mortgage to the mortgagee P. The holding was based on the grounds that “where one by his words or conduct willfully causes another to believe the existence of a certain state of things, and induces him to act on that belief, so as to alter his own previous position, the former is concluded from averring against the latter a different state of things as existing at the same time.” The case counts as the first clear statement of the modern doctrine of equitable estoppel. For example, at the turn of the 19th century Ewart (1900, p. 8) states “Pickard v. Sears was [not] the first case of its kind, but it is indubitable that that decision marks an epoch in the history of the development of the law, and gave to the idea of estoppel by misrepresentation marked vitality and impetus. It formulated a principle which has spread into almost every department of the law”. Also references from the ER editors make it clear that the case served as analogy in numerous later cases. Moreover, a look on Figure 11 shows that the case collected an increasing number of citations right after it was decided.

The fifth most cited case report is 8 coke report 66, better known as Crogate's case. In this 1608 case from the King's Bench the judges held that the defendant M need not to make good for driving off C's cattle from the commons because C's technical reply of *De injuria sua propria, absque residua causa*⁸⁵ to M's statement of defense was technically incorrect. Coke's summarized the court's elaborate reasoning in four resolutions, which became fundamental element of common law's peculiar and highly technical system of special pleading. As in Crogart's case the technicalities of pleading came to be seen as counteracting justice⁸⁶, and a judicial reform, laid down in the Hillary Rules of 1834 (comp. Holdsworth, 1923), was carried out under the auspices of Baron Parke. The reform turned out to complicate pleadings even further until various Judicature Acts of Parliament brought some relief (as discussed in Marcus, 2008). According to Hayes (1854) Crogart's case was "familiar to every student of pleading". However, it is only after the judicial reform of 1834 that the case appears as particularly influential in legal innovation. Most of its citations originate in these years (see Figure 11).

⁸⁵ Duhaime's legal dictionary translates this as "The injury is a result of the defendant's actions and not the other proposed causes he sets out".

⁸⁶ The holding of Crogart's case was satirized in a dialogue between Crogart and Baron Parke aka Baron Surebutter (Hayes, 1854). Here an entertaining excerpt: "Crogart: I don't know what resolutions the judges made; but I know one that I made myself, and that was, never to go to law again. However, it was too late: my beasts were sold to pay the lawyer's bills, and I was a ruined man. More shame for my judges, say I. Sur. Bar: Mr. Crogate, I am astonished at your sentiments. The decision in your oase was a most sound one; it has been admirably reported by Sir E. Coke; it has given the rule to countless decisions since; and has, in fact, constituted one of the great landmarks of special pleading; and yet you are so unreasonable as to complain of it."

In summary, all the 5 most cited cases were influential in English legal history, their citation patterns differ drastically, and even the most cited cases do not receive many citations. Apart from the artificially inflated citation of *Kelyng j 1*, all 5 most cited cases have been clearly influential in English legal innovation after 1700. Apart from *1 burrow 38* the cases are well-known and widely regarded as landmark cases in the legal literature. The lack of recognition of the influence of *Robinson versus Robinson* might be an area of legal research. Citation patterns of the cases differ: the cases reported in *1 wms saunders and 8 coke report 88* gained their main influence in legal innovation about 200 years after they were decided (i.e. there exists the possibility of awakening dormant cases), while the influence of *Shelley's case (1 coke report 93)* appears non-ending, and the 2 remaining top 5 cases (*1 burrow 38*, *adolphus and ellis 469*) gained influence nearly immediately after their resolution. Finally, it is noteworthy that the number of total citations case reports receive over their lifetime is very limited. The most cited common law cases do not receive more than 100 citations out of about 115,000 common law citations⁸⁷, i.e. less than 1 per mill of all citations. The relative share of the most cited cases is comparable to the relative share of the most cited cases of the U.S. Supreme Court.

Time depreciation - aging

In this section I study the relationship between the age of cited precedents and the age of the citing cases. More precisely, I investigate whether the time difference between the cited case and the citing case affected the number of citations that preceding cases received and whether the relationship differs significantly from what one would expect if

⁸⁷ As a reminder, equity law cases citing common law cases are excluded in the analysis.

cases had been randomly cited. To economists the notion of preceding cases as innovation capital for the creation of new law naturally suggests that the innovation value of precedents might depreciate (see the original application in Landes and Posner, 1976). Findings from the study of US judicial opinions corroborate this. For example, Black and Spriggs write that the “law, and the legal rules that comprise it, change in part as precedents are cited in court opinions. Judges’ choices to reduce or eliminate citations to cases, which results observationally in the depreciation of precedent, can thus influence the shape the law takes” (2013, p. 355). They then find that US precedents in the Supreme Court and the various courts of appeals indeed depreciate over time and that the depreciation is largely independent of case characteristics. Figure 12 depicts common law’s distribution of the ages of cited cases in the form of a histogram, whereas the number of citations one would expect from a situation where cases are cited randomly appear as a line graph. The histogram makes it clear that common law precedents did indeed depreciate. The older the precedents become the less likely they are to be cited. About 50% of all precedents are not older than 30 years. At the same time it is noteworthy that the histogram features a very long, non-negligible tail. More than 20% of cited precedents are older than 100 years. The depreciation pattern resembles a pattern of exponential decay. To estimate the overall depreciation rate⁸⁸ I estimated a very simple linear model:

$$\ln(q_i) = a + b \cdot \Delta t_i + \varepsilon_i, \varepsilon_i \sim i. i. d.$$

⁸⁸ Estimating an overall depreciation rate for the entire time period 1700 to 1865 implicitly assumes that the depreciation rate is time independent. Later it will become evident that the depreciation rate actually shows an interesting time dependence.

Δt_i is the time difference between the citing case and the cited case, and q_i is the number of citations with time difference Δt_i . Using linear regression to fit the data to a model of exponential decay results in an excellent fit with an R^2 value of about 0.83 and a depreciation rate of about 1.4% (see column 1 of Table 7). Figure 13 displays the same data as in Figure 12, but utilizes a logarithmic scale that makes it easier to visually discern depreciation rates and provides, as red line, the predictions from the fitted model. Figure 12 clearly shows that the depreciation rate is age dependent. Indeed, restricting the data to precedents not older than 80 years would result in a depreciation rate of about 3%, while restricting the data to precedents older than 80 years and younger than 200 years would yield a depreciation rate of 0.8%.

To compare the actually observed time depreciation pattern in the histogram with predictions from the random citing model I calculated the time depreciation pattern one would expect from such a situation. Providing the random citing model with the annual number of ER case reports (common law cases between 1580 and 1865) and the annual number of new ER citations (common law citation between 1700 and 1865) allowed it to determine the expected distribution. While there is no discrimination between cases of different years in the random citing model, the fact that different years saw different numbers of cases and citations produces a time depreciation structure with non-trivial structure (see the red line in Figure 12).

It is evident that the expected number of citations differs markedly from the actually observed distribution. Under the random citing model only about 20% of citations are expected to occur within the preceding 30 years and more than 50% of

citations are expected to go back more than 100 years. This amounts essentially to the reverse of the actually observed values of 50% and 20%. Moreover, in striking contrast with the actually observed distribution, a monotonous time depreciation pattern is absent from the expected distribution. Taken together the findings in this section make it clear that time depreciation of innovation capital actually exists within the ER data.

Comparison with the random citing model should leave no doubt that the observed pattern is not the result of random citing behavior. The estimated depreciation rates of about 1.4% over the whole time period and of about 3% for the most recent decades appear reasonable.

Distribution of citation frequency

Subsequently, I study the frequency distribution of cases by the number of received ER citations and compare it with predictions from the random citing model. In network studies the distribution is named degree distribution and regarded as a key characteristic of networks and network formation processes (see e.g. Newman, 2010, chap. 4, 12–15).

To derive the expected degree distribution that would result from the random citing model, I simulated the corresponding network formation process. To do so I used the exogenously given annual number of ER case reports and new ER citations as inputs for the random citing process. Beginning in the year 1700, I randomly matched a case in the citing year with a precedent (one random number selected the citing case and another random number selected the cited case). I repeated the process until the correct number of annual citations was reached and then proceeded to the subsequent year. For example, in the year 1700 I generated 694 random matches between the 461 cases from 1700 and the 30,310 precedents. After applying the procedure for every year between 1700 and

1865 the same number of citations as in the dataset were generated. Counting cases with the same number of received citations yielded the expected degree distribution. To eliminate random noise I repeated the simulation 100 times and then averaged the degree distributions. Figure 14 displays the actually observed degree distribution together with the predicted degree distribution. The left side of the figure shows the full distribution while the right side of the figure shows a magnified subset of the distribution.

The random citing simulations gave rise to a degree distribution that follows a Poisson distribution. This is not surprising because emergence of the Poisson distribution can be theoretically proven for the case of non-staggered random citing (see e.g. Newman, 2010, p. 401) and the additivity property of independent Poisson functions generalizes to the staggered random citing case. A look on Figure 14 and comparison between the actual distribution in the histogram and the distribution one would expect from random citing behavior makes it clear that their main difference is in their tail behavior. The actual distribution has a long tail whereas the random citing distribution falls off quickly. More than 10% of the actual cases have received more than 7 citations, whereas less than 1% of the cases from the random citing model have received more than 7 citations. More than 1700 actual cases have received more than 10 citations compared to only 11 cases from the random citing model. Because the tail of the actual distribution is longer than the tail from the Bernoulli distribution and because the number of citations described by the distributions is the same, it follows that the body of the actual distribution must contain less observations. Indeed cases with 3 or less citations make up about 2/3 of the actual observations, whereas they account for about 80% of the

observations from the random citing model. It is clear that the actual observation differs from random citing behavior.

As a next step I investigated whether more cited cases attract more citations at later times. To do so I constructed a figure that shows the relationship between the average number of new citations cases received and the number of citations they had received earlier (see Figure 15). To construct the figure I matched - for any post-1700 decade - the number of citations a case had already accumulated with the number of citations it received in the given decade. For each decade I then grouped cases by the number of previously accumulated citations and averaged the number of the recently collected citations. Each decade produced a relationship like Figure 15. To condense the different decade graphs into one graph I calculated the frequency-weighted average over the different decades. The result appears in Figure 15 together with the prediction from the random citing model. While the predictions from random citing model show no tendency for new citations to prefer frequently cited cases, this is not so for the actual observations.

In the network literature it is well known that a citing bias towards cases that have already received a number of citations, a so-called preferential attachment, will result in degree distributions with fat tails (see e.g. Price, 1976; Barabási and Albert, 1999; Newman, 2010, pp. 487–534). Figure 15 shows that preferential attachment indeed existed in the actual citation process and that preferential attachment followed a linear relationship. For example, cases that were referenced 10 times in previous time periods were expected to receive one citation per decade whereas cases that were referenced 20 times could be expected to draw twice as many citations. Therefore, the observed

distribution of citation frequencies can be seen as a direct consequence of a preferential attachment process.

To summarize: the distribution of received citations possesses a long tail and thereby differs from the Bernoulli distribution of the random citing model. Moreover, the citation network data reveal a linear citing bias towards previously more cited cases. This bias is called preferential attachment in the scholarly literature on networks and is known to give rise to the type of long tails that were observed in the ER data.

Controlling heterogeneities

From the preceding sections it is obvious that the statistical aggregate patterns of the common law citation network did not arise from random citing behavior of judges, counsel or reporters. For the later purpose of using citation counts to measure influence, one needs to take case fluctuations and heterogeneities into account (see, for example, the previously mentioned lists of confounding factors as they appear in Posner (2000) and Cross and Spriggs (2010)). Confounding through heterogeneities is lessened if one analyzes statistical aggregate patterns because some individual heterogeneities will average out. To address potential confounders in later investigations I essentially use three approaches: limit myself to groups that are as homogenous as possible, disregard some heterogeneities as negligible, and try to account for case fluctuations with the help of a statistical model.

To avoid confounding from court hierarchies, I limit the analysis to case reports from the three superior, essentially exchangeable common law courts, i.e. the court of King's Bench, the court of Common Pleas, and the court of Exchequer (I also include ER's Nisi Prius series, i.e. reports from cases that were initiated in Westminster, but

proceeded to a large extent locally under the supervision of an assize judge). The three common law courts were at the top of the common law hierarchy. They supervised common law trials that were more routine and held at the assizes by itinerant judges. Because common law and equity law were complementary and not in a clearly defined hierarchy, I focus on common law and completely disregard case reports from equity law. On an empirical level this is justified based on the previous chapter's findings regarding the separation of equity law and common law citations. I further disregard a few volumes of case reports that contain cases from the House of Lords and Privy Council, which occasionally served as courts of appeal. Consequently, all case reports that underlie the analysis originated from courts with essentially the same hierarchy.

I will neglect heterogeneities that arise from idiosyncrasies of judges, counsel, and reporters. While the personalities of judges, counsel and reporters varied greatly and a large number of books on the differing personalities have been published⁸⁹, it held true through the 18th and 19th century that case reporters recorded references from different sources, i.e. from different judges and opposing counsel (and occasionally their explanations). Because of the mixing of sources and because 4 judges sat in each common law court it is improbable that - unlike in US judicial opinions - strong personal idiosyncrasies will characterize the citation network

I will further disregard variation in the quality of law reports. While it is certainly true that some law reporters were deemed utterly unreliable and use of their case reports

⁸⁹ E.g. for an extensive treatment of the reporters see Wallace (1882), for an extremely comprehensive collection of judges' biographies see Foss (1870), for a very recent biography on one of the most important judges see Poser (2013), and for an entertaining antidote see the book on bad judges by Graeme (2013).

was not welcomed in court⁹⁰, it is plausible that low quality case reports would receive few citations (recalling here that negative citations are rare in the English Reports). Moreover, misreporting of facts and arguments by poor case reporters does impact the citations less. As long as a case reporter does not invent court references it is enough that he records a reference even if he does not understand facts or arguments.

Also changing conventions regarding the law reports will affect the word content more than the citation content because independent of specific form the use of precedents played a central role in courts since the beginning of the 18th century. Examples for changing conventions were the movement from a focus on specific pleadings to a focus on overall arguments of counsel and the grounds for judgment, the movement towards a clear delineation of material facts, the appearance of a concise case summary or a simple increase in the length of case reports (all are exemplified in Burrow's mid-18th century reports). Also here it is possible though that conventions lead to underreporting of relevant references.

I will further ignore fluctuations in the number of practicing judges, counsel, and reporters. For judges this is easily achieved because the number of judges at the superior common law courts remained, with a few 17th century exceptions, constant at 12 over the centuries. On the other hand the size of England's legal profession underwent large fluctuations over the centuries (e.g. Brooks, 1998, pp. 63–148). While greater diversity of lawyers in the courtroom would have reduced idiosyncratic citation obsessions even a small body of professional lawyers should not have been large enough to grossly distort

⁹⁰ For instance, in 1704, as reported in 2 Lord Raymond 1072, Chief Justice Holt voiced the concern that some “scrambling reports [...] will make us appear to posterity for a parcel of blockheads”, or in 1779 Chief Justice Mansfield discouraged use of case reports from the famous William Blackstone and called them “not very accurate” (1 Douglas 92)

use of precedents in courtrooms. The most likely manifestation of a larger number of legal professionals is an increase in the number of cases in the superior common law courts.

Most of the above sources of heterogeneities are fairly homogenous across specific time periods. For example, fluctuations in the number of legal professionals, transformations of law reporting conventions, changes in the quality of law reports or even the extent of personal idiosyncrasies will manifest less variation within a specific time period than across time periods. Therefore, one possibility to limit bias from these sources would be to compare citations within narrow time periods and not across time periods. I will make use of this approach in later chapters when studying the use of innovation capital.

The representative courtroom⁹¹

As mentioned at the beginning of the chapter, the fluctuating number of case reports appears as the biggest obstacle for a coherent analysis of citation counts. More case reports first generate more citations to other case reports and later provide more opportunities to be cited. Ideally, the number of new case reports would be the same in each time period. To take the effect of case fluctuations into account and be able to provide a coherent analysis I here suggest an extension of the previously introduced random citing model: the representative courtroom model. The latter is designed to capture the presence of depreciation and preferential attachment effects that became evident in previous sections.

⁹¹ I cannot claim originality for the following model. Variants of it are common in network science models of citation networks.

In the representative courtroom model I imagine an infinitely lived courtroom whose composition never changes. At the beginning of each year the courtroom learns how many new case reports come into being and how many citations each new case report is supposed to generate. It then goes to work. A look out of the courtroom window opens a vista on the network of all reported precedent cases and arrows connecting them. Older cases are further away, appear smaller and keep shrinking exponentially every year. However, precedent cases can be rejuvenated and increase in size. Whenever they receive an arrow they get a permanent boost. The boosts they have received over the years add up linearly⁹². Consequently, the interplay between shrinkage and growth determines the size of a case report. While enjoying the vista, the members of the representative courtroom randomly generate for each new case the needed number of citations and record them on a list. The vista does not change from one new case report to another. The selection probability of the precedents equals the size of the precedents (this is due to the fortuitous fact that the sizes of all the precedents sum to one). When the courtroom has generated the required number of citations for each new case report, the court session ends. The new case reports and citations materialize in precedent land. The courtroom reconvenes the following year. In mathematical terms the conditional citation probability is given by the following expression:

$$p_{ij}|i \text{ is citing in time } t \propto \begin{cases} (k_{jt} + 1) \cdot e^{-\delta(t-t')} & \text{if } t' < t \\ 0 & \text{if } t' \geq t \end{cases}$$

⁹² The wise courtroom ordered in its very first gathering that every reported case shall receive one boost just by being reported so that no case report will be completely invisible to the eyes of subsequent generations.

where k_{jt} is the total number of citations that case j received during the years preceding time t . The representative courtroom model can reproduce statistical aggregate features that are present in the actual common law citation network including time depreciation patterns, preferential attachment, and a long-tailed degree distribution. Apart from a precedent's age and number of received citations, it disregards any other distinctive features of precedents (including personalities of judges, counsel and reporter; the size of the pool from which courtroom members are recruited; citation conventions; the words inside a case report and consequently style, meaning, type of reported cases, etc.).

A slightly generalized form of model is frequently used in citation network studies and takes the following form:

$$p_{ij}|i \text{ is citing in time } t \propto \begin{cases} (k_{jt} + 1)^\alpha \cdot e^{-\delta(t-t')} & \text{if } t' < t \\ 0 & \text{if } t' \geq t \end{cases}$$

The parameter α can modulate persistence effects. Higher α values imply an increase of the strength of preferential attachment whereas lower α values imply a decrease.

Obviously, if α values equals 1 the standard model results.

An aggregated version of the representative courtroom model will prove useful in later sections. Within the model, citation probabilities at any given time t are fixed and citations are declared independent. Therefore, it is possible to calculate the probability that a case in year t cites one of the cases in year t' by simply adding up citation probabilities of all the cases in year t' . For the standard model this leads to

$$p_{it'} | i \text{ is citing in time } t \propto \begin{cases} e^{-\delta(t-t')} \cdot \sum_{j \text{ in time } t'} (k_{jt} + 1) & \text{if } t' < t \\ 0 & \text{if } t' \geq t \end{cases}$$

Naming the total number of cases in year t' $n_{t'}$ and defining the total number of citations that cases in year t' had accumulated by time t as

$$K_{tt'} := \sum_{j \text{ in time } t'} k_{jt}$$

one can state - within the standard model - the probability that a case in year t cites one of the cases in year t' :

$$(equation 1) \quad p_{it'} | i \text{ is citing in time } t = \frac{e^{-\delta(t-t')} \cdot (K_{tt'} + n_{t'})}{\sum_{t'=t_0}^{t-1} e^{-\delta(t-t')} \cdot (K_{tt'} + n_{t'})} \text{ if } t' < t$$

Analogously one can aggregate over years in the generalized model looks as follows:

$$p_{it'} | i \text{ is citing in time } t \propto \begin{cases} e^{-\delta(t-t')} \cdot \sum_{j \text{ in time } t'} (k_{jt} + 1)^\alpha & \text{if } t' < t \\ 0 & \text{if } t' \geq t \end{cases}$$

Unfortunately, the aggregation is less straightforward because

$$\sum_{j \text{ in time } t'} (k_{jt} + 1)^\alpha \neq \left(\sum_{j \text{ in time } t'} k_{jt} + 1 \right)^\alpha = (K_{tt'} + n_{t'})^\alpha$$

However, if α does not stray too far away from 1 and if one is mainly interested in the use of probabilities, one can, as a rough approximation, use the latter term in spite of the former. Within the generalized model the approximate probability that a case in year t cites one of the cases in year t' $p_{it'}$ then becomes:

$$(equation 2) \quad p_{it'} | i \text{ is citing in time } t = \frac{e^{-\delta(t-t')} \cdot (K_{tt'} + n_{t'})^\alpha}{\sum_{t'=t_0}^{t-1} e^{-\delta(t-t')} \cdot (K_{tt'} + n_{t'})^\alpha} \text{ if } t' < t$$

The year aggregated versions of the standard model (equation 1) and the generalized model (equation 2) I will use for estimations in later chapters.

Meaningful network structure

Summing up: the distinction between equity law and common law is clearly visible in the citation network. Courts from both bodies of law have a strong bias towards citing their own cases and operate as coevolving, but largely autonomous jurisdictions. While such a bias is still detectable among the common law courts it is much less pronounced. The three different common law courts belong to the same body of law. The 5 most cited common law cases have been clearly influential in common law's legal history and corroborate the use of citation as measure of influence in English common law. The time difference between citing case and cited case has a clear impact on the number of citations that precedents receive. On average, the older the case the less likely it is to

receive citations. Therefore, the influence of precedents depreciates over time (and does so in an exponential manner). Finally, the citation network manifests a process of linear preferential attachment that is in line with the observed long tails of the degree distribution. Based on the findings in this chapter I conclude that the extracted citation network contains meaningful content that is not captured by a simple random citing model.

To prepare the subsequent analysis of persistent and changing features in England's legal innovation process I discussed the confounding potential of various heterogeneities and annual fluctuations in case numbers. I then proposed ways to control the heterogeneities as well as possible and introduced another statistical model - the representative courtroom model - that reproduces the observed time depreciation and preferential attachments patterns. Estimating the model in later chapters will account for annual fluctuations of ER case report numbers.

Chapter 6: Persistence and change - case precedents

In this chapter I will investigate the process by which the superior common law courts generated legal innovation. To do so I will study how they drew on reported cases, i.e. a good part of their innovation capital, to generate new rulings and how their use of innovation capital changed over time. The idea of capital immediately brings to mind notions of persistence and change: capital can be transferred from one time period to the next and thereby exhibit persistence; at the same time it can change through depreciation or additions to it.

The concepts of persistence and change or constancy and flux go back to the pre-Socratic roots of Western thought (Parmenides is often associated with the former while Heraclitus is linked to the latter (see e.g. Kirk et al., 1984; Barnes, 2002)) and have formed a theme⁹³ in Western thought ever since. The idea of persistence is related to ideas of stability, regularity and memory. At its heart lies the image of an entity - like the economists' idea of capital - that stays the same from one time period to another. Change on the other hand is the non-persistent, the unstable or irregular. The concept of time plays an essential role in the dichotomy of persistence and change. If one eliminates time there is no change and only persistence remains.

While institutional persistence has taken center stage in the mainstream of institutional economics (possibly influenced by economists' urge for causal identification and their strong bias towards equilibrium thinking), institutional change has moved to the sidelines (see the introduction for a discussion of the recent literature). The situation is

⁹³ For the notions of a theme and thematic analysis of Western thought see Holton (e.g. 1988); his quote "the main business of science is to trace in the chaos and flux of phenomena a consistent structure with order and meaning" (Holton and Brush, 2001, p. 158) extends the notion of persistence to concepts.

uncharacteristic of much of fruitful Western thought where persistence and change rarely appear isolated from each other. For example, Plato combined Heraclitus' idea of continuous flux with Parmenides idea of the unchanging, and created the dichotomy between the ever changing world of sense impressions and the stable world of ideas. The theory of the conservation of energy found constancy in ongoing flux. Darwin proposed a theory where persistent features are transmitted across generations and incremental innovation creates variation for an unchanging process of natural selection. Psychological constructivism is based on the belief that the new needs to be constructed from the persistent old.

It is my belief that a more balanced view of persistence and change can benefit institutional economics. Persistence and change are the hallmarks of cumulative culture and social rules are part of cumulative culture. A near exclusive focus on persistence disregards the nature of institutions and is likely to mislead. In the following sections I try to treat aspects of persistence and change in a more balanced way. I will conduct different kinds of analyses and approach the question of institutional persistence and change from various angles. All of them revolve around the use of case reports as innovation capital. The time period under consideration covers citing cases between the years 1700 to 1865 and cited cases between the years 1580 and 1865. The constructed dataset contains about 118,00 citations of case precedents for this time period. Case reports' temporal persistence as innovation capital is possible because the material artifact of a written case report can be transmitted largely unchanged over long time periods⁹⁴. Unless all copies of a written case report are lost, a materially persistent precedent can - in principle -

⁹⁴ Oral transmission over time is, of course, possible. However, it is less precise and far more prone to interruptions of the transmission chain.

influence later cases. In practice, the influence of precedents varies over time. While the influence of particular precedents is best studied in combination with profound legal expertise, the influence of groups of precedents can manifest emergent statistical aggregate patterns that provide insight into the legal innovation process without requiring comprehensive legal domain knowledge. Therefore, the focus of the subsequent analyses is on the comparison of groups of precedents and not on the investigation of particular precedents.

First, I investigate if case law embodied in specific case rulings persisted for long time horizons and find that a good part of it did. Second, examining the age composition of common law's most cited cases I find strong persistence in the 18th century and pronounced change in the 19th century. Third, I extend the study from the most cited cases and study the general use of innovation capital with the help of the random citing and representative courtroom models. It appears that one persistent mode of legal innovation transitions to another between the mid of the 18th and the beginning of the 19th century. Estimates from the representative courtroom model point to a quadrupling of depreciation rates and a decrease in attachment bias. Fourth, I apply a technique from network science called community detection to the full citation network and identify two very different types of communities. One community maintained close links across the centuries - partly by directly citing early precedents and partly by citing precedents from the previous generation that had built on its previous generation. The other community has contrasting features. While having maintained some ties with the past most of its links are with the 19th century. Apparently this body of law built nearly exclusively on the most recent precedents with little regard for the older past.

Long-term persistence of case rulings

In this section I will estimate the extent to which rulings of cases remained binding, i.e. persisted, over long periods of time. To do so I study case reports from different decades and analyze their appearance as case references in later years. Citing a precedent in later cases not only indicates that the cited case was used to construct new law, but also - with great likelihood - that the judges considered the precedent's ruling to be still binding in later circumstances⁹⁵. Therefore, citing a precedent is a sufficient indication of the precedent's persistent authority during the times of the citing case. At the same time, citing a precedent is not a necessary indication of persistent authority: a precedent that had not been cited for a long time only suggests that it was not useful in the construction of new law. However, it seems plausible that the majority of non-cited cases have not only lost their value in the construction of new law, but also their relevance and applicability to the life of the citing period.

To investigate the long-term persistence of case rulings, I focused on the time period from 1580 to 1700, split it into decades and determined for each case in a given decade the year of its most recent citation (beginning with citations from the year 1700). For example, when a case from the year 1586 was cited 3 times during the years 1839, 1841 and 1845, I recorded the year 1845 as the case's most recent (minimum) year of applicability. Figure 16 presents the resulting distributions for two representative decades: the decade of 1580 is the oldest decade with substantial coverage in the English Reports, the decade of 1700 is the first decade after the Glorious Revolution where potentially misleading editor comments became limited and the doctrine of precedent was

⁹⁵ I rely here on one of chapter 0's findings where cited cases in the English Reports apparently refer very rarely to overruled or outright incorrect case rulings.

firmly established. The distributions for the remaining decades do not differ much from the 2 representative examples and are shown in Figure 17 (the flat curves in the 1640's and 1650's result because very few case reports from this time period are included in the English Reports). To account for some of the impact of annual fluctuations in the number of cases I further determined the distribution one would expect from random citing model. To do so I relied on 100 realizations of a random citation network that I constructed following the procedure outlined in the previous chapter (essentially fixing the annual number of existing cases, new cases and new citations and creating citations between the new cases and existing cases in a random manner). The resulting distributions for the two representative decades appear together with the actual data in Figure 16.

The upper left distribution shows the fate of 589 out of 1149 cases from the 1580's. Because only post-1700 citations are included the years before 1700 record no citations. 560 out of the 1149 cases were never cited after 1700. However, 589 cases apparently remained binding more than 100 years after they had gone to court (this corresponds to a 100-year term persistence rate of 51.2%) and the vast majority of them remained binding for an even longer time. For instance, more than 350 cases remained binding for more than 200 years, and about 150 cases remained binding more than 250 years after the judges concluded the trials.

These findings differ from predictions derived from the random citing model. The random citing model cites all preceding cases with the same probability, lacks time depreciation and thereby overcites older cases. This manifests in two ways: first, many more 1580's cases show long term persistence than in the actual data (1147 versus 589);

second, the vast majority of the 1580's cases are cited at least once during the 19th century when the number of new citations was large. More than 85% of cases are predicted to be binding 200 years after their occurrence and about two thirds are predicted to be binding more than 250 years.

The lower left distribution depicts the afterlife of 1353 cases from the first decade of the 18th century. While 2016 cases were reported in that decade 643 cases never occurred in a case report during the subsequent 150 years and apparently ended in immediate oblivion⁹⁶. Another 132 cases were cited five years after they were reported and then never again. After 100 years about 800 cases (implying a 100-year term persistence rate of 39.8%) and after 150 years about 200 cases remained binding. Noteworthy is also the pronounced hump around 150 years that arose as a consequence of a large number of 19th century citations.

The citation behavior that is predicted by the random citing model for cases from the 1700's is very similar to the one for the 1580's scenario. 2006 out of 2016, i.e. virtually all, 1700's cases are cited at least once towards the end of the citation period. This manifests in the concentration of citation counts around 150 years after the original case. Within the model more than 85% of case rulings remained binding about 100 years later, and about 30% of cases remained binding about 150 years later.

All in all it seems clear that long-term persistence and decay of case rulings went together. A large part of the early case rulings in common law not only persisted materially as written reports, but remained authoritative for centuries. This constitutes a

⁹⁶ In principle, while unlikely it is always possible to bring information that is embodied and preserved in material artifacts back to life.

form of institutional long-term persistence that, however, coexisted with institutional change. Institutional change occurred through the continuous creation of new case rulings and decay of existing ones. While the citation network cannot provide complete certainty about the status of non-cited cases, plausibly cases that have not been cited for very long time periods have lost their practical applicability. The latter then suggests that institutional decay of case rulings figured prominently in common law. Institutional decay might have occurred for many reasons. For example, a case ruling might have become inapplicable because it was badly reported, because it was considered erroneous, because it concerned factual circumstances that were very narrow or ceased to exist (e.g. regarding problems of a feudal society), because it had been superseded by more elaborate rulings, or because it had paved the way of a legal road that was abandoned later.

Rise and fall of common law's top authorities

Here I will focus on the age composition of common law's most authoritative cases - the most used subset of the legal innovation capital - and study its persistence and change over time. To do so I use post-1700 citation counts as a measure of authority and determine each year's most cited cases. I then pick 8 different subsets of the most cited cases and characterize their year-dependent age composition by standard summary measures of centrality and spread. 4 out of the 8 different subsets comprise the 10 top cited, the 50 top cited, the 100 top cited, and the 500 top cited cases. I characterize their age compositions by mean and standard deviation. The remaining 4 subsets comprise

cited cases in the top 99th, 95th, 90th, and 80th percentile⁹⁷ and are characterized by medians and median absolute deviations. The approach follows methodological suggestions by Leicht et al. (2007).

I find that the measures of centrality and spread point to a long time period where the temporal composition of the most authoritative cases remained largely unchanged. This time period was followed by a pronounced and continuous shift that began around the turn of the 19th century. Finally, I show that the identified pattern of persistence and change remains evident if one measures authority not by cumulative post-1700 citation counts, but by non-cumulative, decade-specific citation counts. Figure 18 presents the annual means and standard deviations of four groups of top cited cases. The first group comprises the 10 top cited, the second the 50 top cited, the third the 100 top cited, and the fourth the 500 top cited cases. Interpretation of the two graphs is straightforward. While the first decade produced noisy data because of low citation counts (due to interpretational ambiguities all pre-1700 citations are disregarded in the analysis) a stable temporal composition soon emerged and stayed largely unchanged until the turn of the 18th century. This manifested across all four groups in 1:1 increases of mean ages and passed years, as well as largely unchanged standard deviations. However, starting around 1800 the steady increase of the different mean ages stalled and standard deviations began to rise quickly. Clearly, a continuously increasing number of young precedents became part of the top authorities and replaced the older authorities. The general replacement

⁹⁷ Note that groups defined by percentiles do possess an annually increasing number of group members. The benefit of this definition is that all citations with the same number of citations are either excluded or included in the top authorities group. The latter is not the case for groups with a fixed number of group members. There the sort order can determine if a case with the same number of citations is left out or included.

process continued over the course of the 19th century showing few signs of a slowdown. For example, the top 10 authorities resisted new entrants until around 1820. The displacements of the old top 10 authorities with newer ones resulted in jumps of the top 10's mean age and standard deviation: around 1820 the case 1 burrow 38 - a case from the year 1756 - and around 1860 the case 6 adolphus and ellis 469 - a case from the year 1837 - joined the exclusive group.

To substantiate the apparent pattern of change and persistence Figure 19 provides time-dependent medians and median absolute deviations of four different groups. The four groups comprise cases that have received a number of citations in the top 99th, 95th, 90th, and 80th percentile. The figure tells essentially the same story of persistence and change. Until about 1800 the median age of the top authorities rose linearly with every year and the median absolute deviations remained largely unchanged. Around 1800 young precedents had replaced a sufficient number of the oldest precedents to reduce medians and lower the median absolute deviations. Over the subsequent years they replaced more and more older precedents until around 1850 the majority of precedents were no older than 100 years. This resulted in steadily rising medians and median absolute deviations before the median ages underwent a sudden drastic drop. The shift of the center of the distribution of precedent ages then lowered the mean absolute deviations.

Figure 21 illustrates the findings from Figure 18 and Figure 19 with four histograms that depict the age composition of the 100 most cited cases at four different points of time. In 1750 nearly all top 100 authorities originated at the beginning of the 17th century or around the Glorious Revolution. Until 1790 the situation remained largely

unchanged. In 1810, a few cases from the end of the 18th century had appeared among the top 100 authorities. By 1850 precedents from the end of the 18th century already constituted about 40% of the 100 most cited precedents.

Figure 22 demonstrates that the observed pattern of persistence and change would not arise from a combination of random citing behavior and a large increase in the number of 19th century case reports. Means increase steadily without interruption and do so directly proportional to the number of years. Standard deviations also increase steadily. They neither feature a period of constancy nor a period of rapid increase. Like the means medians increase proportional to the number of years until they undergo a minor downwards correction at the middle of the 19th century. Mean absolute deviations remain constant until they begin to rise slightly towards the mid of the 19th century before dropping back after the minor median corrections. This behavior reflects the fact that - within the random citing model - cases, on average, accumulate the same number of citations per year. Consequently, cases that occurred earlier in time are likely to have accumulated more citations than later cases. That, in principle, locks in the distribution of top authorities. The reason why some change occurs in the distribution is that there is not a lot of variation in the accumulated number of citations (for example, by the end of 1865 the accumulated number of citations range from 1 to 12, the 90th percentile starts at 5). Therefore, when the number of new cases is large a small number of new cases can end up in the top percentile groups. This explains the rise of standard deviations and median absolute deviations.

Because citation counts accumulate over time a considerable degree of persistence in common law's top authorities is expected. To get a better understanding of the process

that transformed the top authorities, I analyzed the temporal distribution of the 100 most cited cases in four narrowly confined time periods. Only citations that occurred within the confined time periods were taken into account to determine the period-specific 100 most cited cases. The first time period comprises the years 1740-1770, the second one the years 1770-1800, the third one the years 1800-1830, and the fourth one the years 1830-1860. Figure 22 presents the temporal distribution of the 100 most cited precedents for the different time periods. Between 1740 and 1770 virtually all top authorities were more than 30 years old and the majority of them originated around the turn of the 17th century. During the years 1770 and 1800 the majority of the period's top authorities was of recent origin, i.e. the corresponding trials were held in the second part of the 18th century. However, about one third of top precedents had its roots in the 17th century. During the time period of 1800 to 1830 the top precedents were of even more recent origin and less than 10% of top authorities derived from before 1750. The years from 1830 to 1860 located about 60% of their top 100 precedents in the 19th century and (40% of these after 1830) and partly rekindled interest into older precedents (about 20% stemmed from before 1700).

Taken altogether the picture of persistence and change in common law's top authorities is clear. If one focuses on citing behavior between the years 1700 and 1865 one finds that the temporal composition of top authorities (as measured by the number of citation counts) remained largely unchanged for about 100 years⁹⁸. Around the turn of the

⁹⁸ Note that this does not imply that the most cited cases did not change over time. It just means that top authorities derived consistently from the same time period, i.e. if a top authority was replaced by another one the replacing authority was a case from the same era. Actually individual level persistence of top authorities is high, but not extremely high. For example, the overlap of top 500 authorities from the years 1760 and 1820 is

19th century the composition began a drastic change towards modern precedents. About 50 years later the majority of most cited precedents were of modern origin. The change appears even more sudden if one focuses on newly cited precedents and not cumulative ones. In addition to these findings it is noteworthy that nearly all top authorities dated back to 4 distinct time periods: the decades around the turn of the 17th century, the decades before and after the Glorious Revolution and the decades before the beginning of the 18th century. The fourth distinct time period emerged late and was constituted by the second quarter of the 19th century. Until the end of the 18th century nearly all authorities originated in the first two distinct time periods.

Time profiles

In this section I will study persistence and change more generally and concentrate on the time-specific usage of legal innovation capital. To do so I introduce year-dependent temporal compositions of new citations and name them time profiles. In contrast with the previous section I focus on new citations and all cited precedents - not on cumulative citations and top cited precedents. To account for effects of fluctuations in the annual number of reported cases, I will return to the representative courtroom model and estimate parameters of the legal innovation process.

First, I discuss the concept of a time profile and show how the random citing model and a specific application of the representative courtroom model are able to predict a good part of the actually observed time profile. In any given year, cases cited precedents when they created new rulings. While the meaning of citations on the

about 65%, and the overlap of top 500 authorities from the years 1800 and 1860 is about 39%..

individual case level is accessible only to the legal professional, emergent annual aggregate patterns of precedent use can reveal insights into the legal innovation process that are visible to the legally untrained and possibly hidden from the view of legal professionals. To analyze precedent use in a specific year I picked a citing year between 1700 and 1865 and retained all case citations that originated in that year. Each of these pointed from the current citing year to cases from previous years. For each cited year I then counted the number of citations pointing to it and calculated its share relative to all new citations. The citing-year-dependent relative shares of all cited years I named time profiles. They are best thought of as the year-dependent temporal compositions of new citations.

The time profiles show how the courtrooms drew on reported cases - the existing stock of innovation capital - to create new law and how their use of innovation capital changed over time. By creating new law the courtrooms added to the stock of innovation capital. Figure 23 presents an example time profile from the year 1780. The upper part shows the fraction of citations that went from cases in the year 1780 to cases in preceding years. The lower part shows the same data aggregated over semi-decades thereby simultaneously hiding some detail and reducing statistical noise. As in the section on common law's top authorities pre-19th century precedents are drawn nearly exclusively from three distinct time periods: the period around the turn of the 17th century, the period around the Glorious Revolution and the latter part of the 18th century. The time-aggregated graph shows this clearly.

Because the three distinctive time periods overlap with time periods where a large number of case reports became available it is difficult to disentangle the effect of

fluctuations in case numbers from changes in the citation behavior of the courts. As an attempt to limit confounding of these two factors I drew on the random citing model and the representative courtroom model. Figure 24 displays the actual time profile of the year 1790 and compares it with predictions from the random citing model and the year-pooled representative courtroom model. The left side shows relative frequencies of the actual data and model probability predictions on an annual basis. The right side aggregates the relative frequencies and model predictions by semi-decade.

Probability predictions from the random citing model are proportional to the annual number of reported cases and do not take into account time depreciation. Therefore, the probabilities tend to overpredict relative frequencies in earlier time periods and underpredict relative frequencies in later time periods. In Figure 24 this results in 17th century predictions that are generally too high and late 18th century predictions that are generally too low. Probability predictions from the representative courtroom model fare better than predictions from the random citing model. The representative courtroom model captures time depreciation effects and can, more generally, incorporate shifting probabilities. For example, in Figure 24 it avoids the random citing model's extreme overpredictions and underpredictions in the 18th century. In spite of a tendency to underpredict the most recent and the oldest time periods, the representative courtroom model reproduces the main features of the actual data.

To quantify the goodness of fit I calculated the correlation coefficients between actual data and model predictions. This resulted in a correlation coefficient of 0.26 for the random model and of 0.51 for the representative courtroom model. The numbers confirm the superiority of the representative courtroom model.

I will now draw on time profiles and the two statistical models to analyze common law's usage of innovation capital. First, I present graphical displays of the actually observed time profiles in an aggregated form and pool observations by decades and semi-decades. Second, I analyze a remarkable degree of long-term persistence in the annual time profiles, before, third, emphasizing a strong shift. Other depictions of the data, so-called time trajectories, support the findings. Fourth, motivated by the representative courtroom model I estimate a conditional logit model and find that the strong shift in conditional time profiles can be seen as the result of a significant increase in time depreciation rates and loss of persistence through attachment bias.

To gain an overview of the legal innovation process I now present time profiles from the actual data (see Figure 26). To limit the number of time profiles and ease detection of the overall patterns cited years are aggregated by semi-decades and citing years are aggregated by decades. Random citing model predictions appear as dashed lines and serve as an approximation of the impact of fluctuations in the number of reported cases. I will use the time profiles as motivation for more quantitative investigations of persistent and changing features in the legal innovation process.

During the first 6 citing decades (dividing up the years 1700-1759) the temporal composition of cited cases - a measure of the use of legal innovation capital - appeared stable and persistent. The vast majority of cited cases went back to the time period around the turn of the 16th century and the time period before and after the Glorious Revolution. The most recent cases, i.e. cases from the first half of the 18th century, were used rarely and less than the number of available case reports in combination with the random citing model would have predicted. Apart from overpredictions for the most recent cases,

underpredictions for cases directly after the Glorious Revolution, and the lack of time depreciation (manifest in the actual shrinking of the size of early peaks relative to older ones) the random citing model predicts the actual time profiles of the first six decades fairly accurately.

During the next 6 decades (covering the years 1760-1819) the temporal composition of cited cases underwent a major transformation. Beginning in the 1760's more cases closer to the citing decade gained greater weight in the creation of new law and this development continued over the 18th century. At the beginning of the 19th century the majority of citations referred to case reports not older than a few decades and the influence of cases from older times had significantly decreased. As the increase in weight of the recent past did initially not coincide with an increase of reported cases, the random citing model severely underpredicts the share of case reports from the recent past and, as a consequence, overpredicts the share of older times.

The last 5 decades (running from 1820 to 1865) complete the transformation that started in the second half of the 18th century. At the end of the ER reporting era the majority of cases cited in the courtrooms dated back not more than 20 years and 80% of cited cases had gone to trial in the 19th century. Even though the number of reported cases increased drastically over the first half of the 19th century (reaching levels the number of reported cases not seen since the end of the 17th century), the shift in the use of innovation capital towards the present is out of proportion. Consequently, the predictions of the random citing model fare worst for citing behavior in the 19th century. All pre-19th century predictions severely overpredict while all 19th century predictions severely underpredict.

Apart from the drastic change in the use of innovation capital in the mid of the 18th century and the evidently persistent features of the legal innovation process before and after the transition there exists another aspect of persistence in the actual data. While it is evident that the center of gravity moved from relatively ancient times to the present, the characteristic temporal composition of past citing behaviors remained recognizable through the centuries. For example, if one would magnify the 17th and 18th century tails of the time profile from the 1860s one would easily recognize the citing behavior of the previous time periods. If one plots one decade's fractions of citations from Figure 26 against the fractions of another decade one finds that the values form a tight linear relationship. A look on the correlation matrix in Table 9 confirms that the corresponding correlations are indeed very high. Apart from correlations between the 1780s and some other decades (mainly subsequent ones) all correlations are around 0.8 or higher. The only decade with moderate correlation coefficients, i.e. the 1780s', appears in Figure 26 as the most uneven step in the transformation from past-oriented to present-oriented time profiles. Given that the decade time profiles emerged independently and repeatedly over the 18th and 19th centuries, the high degree of persistence is remarkable. This phenomenon is partly explained by differences in the annual numbers of reported cases (there is persistence in time profiles within the random citing model) and partly by preferential attachment bias towards more cited cases (the latter is likely a combination case reports' intrinsic qualities of and cultural transmission of legal knowledge through teaching and courtroom practice).

A different view on the legal innovation process is possible through what I call time trajectories. A time trajectory arises if one follows the fraction of citations that cases

of a given year generate over subsequent years. Figure 27 presents pooled time trajectories for the years 1580 to 1860. Cited years are pooled by decade and subsequent years are pooled by semi-decade. Moreover, predictions from the random citing models are plotted as dashed lines in addition to the actual data. Over time, partly because more case reports became available (as visible in the predictions from random citing) and partly because the value of case reports depreciated, all time trajectories sloped downwards. At times some decades were represented more than their number of reported cases would have predicted. For questions regarding institutional persistence and change, the potentially most interesting feature is the change in time trajectories that became clearly evident in the 1760s. From then onwards peak heights increased, and citation fractions increased rapidly during the years immediately following the decade under consideration before falling off quickly again. The pattern became even more pronounced over the course of the 19th century. This feature is, of course, a different manifestation of the mid-18th century transition that previously emerged from the study of time profiles.

Even though the mid 18th century change in the legal innovation process appears evident and out of line with predictions from the random citing model the large fluctuations in the number of case reports remain a noteworthy confounding factor. They raise the question if they might have caused the observed change while the legal innovation process itself remained essentially unchanged. To answer this question I rely on the two year-aggregated versions of the representative courtroom model (see chapter 5). The model capture time depreciation, and preferential attachment results in persistent citing of previously cited cases. Moreover, while having a tendency to underfit the probabilities of the most recent case reports (due to their lack of cumulated citations) the

model fits the actually observed time profiles reasonably well and, unlike the random citing model, can adjust to changes in the legal innovation process. The two versions of the model are reproduced below:

version 1 (standard model)

$$p_{it'} | i \text{ is citing in time } t = \frac{e^{-\delta(t-t')} \cdot (K_{tt'} + n_{t'})}{\sum_{t'=t-120}^{t-2} e^{-\delta(t-t')} \cdot (K_{tt'} + n_{t'})} \quad \text{if } t' < t$$

version 2 (generalized model)

$$p_{it'} | i \text{ is citing in time } t = \frac{e^{-\delta(t-t')} \cdot (K_{tt'} + n_{t'})^\alpha}{\sum_{t'=t-120}^{t-2} e^{-\delta(t-t')} \cdot (K_{tt'} + n_{t'})^\alpha} \quad \text{if } t' < t$$

I estimated the standard model and the generalized model for different citing years using maximum likelihood estimation. To increase comparability between the models I kept the number of citable years constant across citing years. In practice that meant, I disregarded years that dated back more than 120 years before the citing year (the number 120 results because the dataset begins in the year 1580 and, therefore, it was impossible to include more than 120 preceding years for the citing year 1700). Figure 28 presents year-specific δ estimates and confidence intervals for the standard model. To aid perception of the overall pattern a lowess-smoothed curve is overlaid. A clear pattern emerges. Until the 1760's the estimated depreciation rate δ is constant and averages about 1%. Beginning around 1760 it rises rapidly below 3%, and then decreases temporarily to 2% before increasing continuously to 4% and even 5%. It is clear that a time depreciation rate of 4 to 5% differs drastically from a depreciation rate around 1%. As an illustration,

case reports over the first half of the 18th century had, on average, a half-life of about 70 years. With the beginning of the second half of the 19th century the half-life had shrunk to about 17.5 to 14 years - a rather dramatic and rapid change in the legal innovation process. The change indicates a type of transformation that will be resurfacing in various forms in later investigations. Therefore, I will reserve an extensive discussion for the last chapter.

Figure 29 displays results from the generalized model: α and δ estimates, corresponding confidence intervals and a lowess smoothed curve. While standard errors increased, the results reinforce the findings from the standard model. The δ estimates are nearly identical with the estimates from the standard model. The estimates of the α parameter, however, add more information. Within the 18th century the α estimates fluctuate only slightly around an average value of 1.1. Over the course of the 19th century α estimates rapidly decreased falling as low as 0.1 and averaging 0.3 around the mid of the 19th century. As low values of the alpha parameter diminish the influence of differences in accumulated citations, it follows that the decline of the alpha estimates is another indication of the reduced importance of past innovation capital.

To evaluate the appropriateness of the generalized model in comparison with the standard model I carried out likelihood ratio tests for the different citing years. The tested hypothesis was that the standard model is the correct model and that the generalized model is the incorrect one. Until about 1800 the p-values would suggest use of the standard model because p-values are rarely statistically significant for any of the pre-1800 years. However, there are two 19th century periods (about 1800-1820 and about 1840-1865) where use of the generalized model is strongly indicated by p-values. These

two periods correspond exactly to times where the α estimates underwent noticeable or very drastic jumps.

Taken altogether, the study of time profiles and time trajectories point to a swift transition from a period with strong persistence in the use of innovation capital to a period where innovation capital depreciated quickly and persistence declined. Modeling citation behavior with the help of the representative courtroom model and thereby controlling for fluctuations in case report numbers reinforce these findings. Model estimates show a large increase of time depreciation rates that began in the mid of the 18th century and accelerated over the course of the 19th century. They also exhibit a reduction of attachment bias and persistence that occurred over the course of the 19th century. Because the time profiles of the 19th century seem to converge to a specific pattern one could say that the data indicate a transition from a period with a stable legal innovation process to a period with another type of stable legal innovation process.

Common law communities

In this section I apply two community detection algorithms from network science to find out whether the common law citation network can be naturally split into a number of closely linked, non-overlapping⁹⁹ groups of cases (also called clusters or communities) and what the temporal composition of these communities would be. If the network can be split successfully one will find an above average number of links (i.e. case citations) within the detected communities and a below average number of links between them (see Figure 30 for an example citation network with 2 communities). The general hope in

⁹⁹ Recent techniques from network science allow it also to detect overlapping communities. I not will apply them in the basic community detection study of this section.

community detection studies is to reveal network structure that enhances understanding of the studied networks and the complex systems that networks reflect. My particular hope here is to gain a better understanding of the citation network's persistent and transient features that became evident in the previous sections.

Community detection is a burgeoning field that has already produced an enormous number of publications. An extensive and fairly recent review of the literature can be found in Fortunato (2010). Subsequently, I will apply two different, well-established community detection algorithms to the common law citation network. Both algorithms rely on optimization of an entity called modularity. Modularity is a measure that was first formulated by Newman and Girvan (2004) and quantifies for any given, non-overlapping network partitioning the degree to which the hypothesized communities possess more links within and less links between themselves than one would expect from a random citing model. While Newman and Girvan first used the measure to assess ex-post the quality of network partitionings they had detected with other means, the measure soon became the objective of optimization algorithms¹⁰⁰ (e.g. Newman, 2006) and the base of today's most popular class of community detection methods¹⁰¹. Out of the vast

¹⁰⁰ Unfortunately, because of its computational complexity the global modularity optimization problem is generally not solvable. Therefore, various heuristic optimization approaches exist.

¹⁰¹ Modularity optimization techniques have the general limitation that they cannot detect communities below a certain, network-dependent size called the resolution limit (Fortunato and Barthélemy, 2007; Lancichinetti and Fortunato, 2011). Another limitation is that the global maximum of the modularity function is beyond the reach of heuristic optimization procedures and that the number of local maxima with very different, high-scoring community partitions is usually extremely large (see e.g Good et al., 2010). The first limitation poses no problem because I am trying to extract large communities and - for the time being - am not interested in the granular structure of the common law citation network. The second limitation applies mostly to large networks with a large number of

array of available modularity optimization algorithms I chose two that were applicable to directed networks and allowed it to limit the number of targeted communities. The first is the spinglass algorithm and the second is called Louvain algorithm¹⁰².

Before I applied the community detection algorithms I removed about 19,000 isolates from the common law network with its roughly 61,000 nodes¹⁰³. Isolates are nodes or very small numbers of connected nodes that are virtually disconnected from the rest of the network. I used both algorithms on the remaining network of 42,000 nodes (case reports) and 118,000 links (case citations) and aimed for a partitioning of the network into 2,3 or 4 communities (groups of cases). Application of the spin glass algorithm was straightforward because community sizes could be specified directly. To apply the Louvain algorithm I experimented with the resolution parameter and repeated

communities. However, to avoid it as much as possible I searched for a small number of communities in the moderately sized common law citation network and compared results from two different, non-deterministic¹⁰¹ modularity optimization algorithms.

¹⁰² The spin glass algorithm (Reichardt and Bornholdt, 2006) optimizes the modularity measure with the help of an efficient, physics-inspired optimization method called simulated annealing (Kirkpatrick et al.(1983)). The Louvain algorithm (Blondel et al., 2008)) optimizes modularity through an iterative step-by-step process and is named after the university of its inventors. Both algorithms have the benefit that they are, in principle, directly applicable to directed networks and allow it to limit the number of desired communities. The spin glass algorithm allows it to directly set the maximum number of detectable communities, the Louvain algorithm allows it to indirectly modify a resolution parameter and thereby influence the number of detectable communities. I implemented community detection with the spin glass algorithm through the software package R (2014) and its igraph library (2006). Appendix C shows the R code used. Because the combination of R and igraph did neither permit modification of the Louvain resolution parameter nor application to directed graphs, I implemented the Louvain algorithm with the network software package Gephi (2009). After some experimentation with the number of communities I settled on the Louvain resolution parameters 3.75, 3.5, and 3.

¹⁰³ To accomplish this I applied the Louvain algorithm with resolution parameter 1 to the original network and removed out of the more than 10,000 detected communities the ones which contained less than 10 nodes (the next largest community contained more than 100 members)

the algorithm a few times until I obtained the desired number of communities. The modularity scores for the 6 different detected partitionings are given in Table 8. They all lie within the typical range of 0.3 - 0.7 and increase with community size. The spin glass algorithm generally found network partitionings with higher modularities than the Louvain algorithm. Because higher modularity at the same community size suggests a more accurate partitioning I will mainly analyze the spin glass communities and use the Louvain communities as a cross-check only. To understand the differences between the detected communities I focus on their temporal composition. Both community detection algorithms assigned about half of the 42,000 case reports to each community (see Table 10). Moreover, the communities they found overlap to a large extent: about 80% of case reports are assigned identically.

Figure 31 depicts the temporal compositions of the spinglass and Louvain 2-community-partitionings and contains the main finding of the section. The first spinglass community predominantly consists of 19th century case reports. At the same time about 30% of the remaining case reports belong to the 18th and 17th century. The second spinglass community displays a much more balanced temporal composition. The majority - about 60% of its case reports - belong to the 18th and 17th century. The Louvain communities show a similar though less pronounced pattern. About 30% of case reports of the first Louvain community and about 55% of the second community belong to the pre-19th century era. On the one hand the findings indicate a strong split between the 19th century and 17th and 18th century within the first community. On the other hand the second community presents a close-knit community of cases across centuries. This suggests that the citation network contains a first large group of 19th century cases that

developed modern law building primarily on a 19th basis, whereas a smaller second group of 19th century cases relied during the legal innovation process on pre-19th century precedents to a much larger extent. Both groups show a persistent influence of pre-1800 precedents, however, the degree of persistence in the second group is much higher.

Figure 32 illustrates the differences between the two communities in another way. For any given year, it shows the fraction of total case reports that each community contains. Before the mid of the 18th century the second community comprises the majority of cases (uniformly about 75% in the spinglass and Louvain communities). Around 1750 a break in the relative composition is evident. The number of cases that belong to the first community increases relative to the second community. Cases around the year 1800 are equally represented in both communities whereas 19th century cases belong increasingly to the first community. At the mid of the 19th century the first community encompasses the majority of cases.

These findings are robust to an increase in the number of communities and consistent across the two community detection algorithms. Figure 33 displays network partitionings with 2, 3 and 4 communities for each detection method. In all 6 network partitionings one can observe at least one type 1 community and one type 2 community. An increase in the number of spinglass communities to 3 results in one community dominated by 19th century cases (type 1), one community with a balanced composition (type 2) and one hybrid. 4 spinglass communities produce one type 1 community, one type 2 community, and 2 hybrids. 3 Louvain communities lead to two communities with 19th century domination and one community with balanced structure. 4 Louvain communities generate one type 1 community, one type 2 community and two hybrids.

Figure 33 summarizes the findings for all 6 communities with the help of relative temporal compositions.

As a final check of the detected community structure I compared its structure with one network realization from the random citing model. Analogous to the previous figures, Figure 34 and Figure 35 display the temporal composition of communities found in the random citing network. As expected, the community detection mechanisms assigned the post-1700 equally into two distinct groups near identical temporal composition. However, the pre-1700 nodes, which received the majority of citations and do not possess links between themselves, were assigned non-uniformly: the majority of pre-1650 nodes end up in one community and the remaining nodes in the other community. The lack of pre-1700 interlinkages and the general sparsity of links generate this artifice. Other network realizations from the random citing model result in different pre-1700 community assignments. Averaging over a large number of network realizations would eliminate the effect.

All in all it is evident that an integral part of common law's citation network encompasses two very different types of communities. The first type of community has roots in previous centuries, but is concentrated on the 19th century. Its existence suggests the development of a body of law that started from inherited law, but towards the end of the 18th century apparently began to draw on its freshly added parts as the capital for future growth. Within this community old law's use as innovation capital depreciated at a much quicker rate than it had in earlier times - in other words old law's degree of persistence decreased. The second type of community maintained close ties with cases

from the previous centuries. Its body of law remained deeply vested in the past's tradition and grew in a more organic way.

Varieties of persistence and change

In this chapter I examined different types of institutional persistence and change in the making of common law. All of them relate to how common law courts used the stock of case reports when generating new law. And all of them emerge as statistical aggregate properties of the common law citation network. First, I studied groups of reported 16th and 17th century cases and tracked their citation afterlife. It turned out that a large number of these cases were cited centuries after their trials had concluded. Taking this as indication that the cited case rulings were, in principle, applicable at the time of their later citation turns this finding into an instance of institutional persistence, long-term persistence for that matter. On the other hand the fact that a large number of the 16th and 17th century cases was not or cited at later times or cited only for a limited number of years can be seen as indication of institutional decay or depreciation, i.e. institutional change.

Second, I investigated the 18th and 19th century age composition of common law's top authorities, i.e. common law's most cited cases. I found that until the beginning of the 19th century the top authorities dated back to the same time period. This constitutes another form of institutional persistence. However, soon after the beginning of the 19th century the age composition of top authorities underwent a drastic change. It took only a few decades until the majority of top authorities were derived from the 19th century and the pre-19th century base was largely replaced. This constitutes another form of institutional change.

Third, with the help of time profiles I focused on the annual general usage of reported cases. This brought into view a stable apparently past-centered legal innovation process that underwent a rapid transition during the second half of the 18th century and converged to another stable, present-centered innovation process. The former is characterized by low depreciation rates and high attachment bias, whereas the latter is characterized by much higher depreciation rates and a much reduced attachment bias. One can recognize here a persistence-change-persistence pattern in the functioning of legal innovation. Moreover, traces of the pre-transition legal process remain observable in post-transition time profiles and display another type of persistence.

Finally, I used basic community detection techniques to split the common law citation network into naturally coherent groups. A robust feature was the presence of two types of communities with very different temporal distributions. The first type consists essentially out of 19th century cases that have few links with the past. The second consists of closely connected cases that stretch from the 16th to the 19th century. One can see the former as the agent of disruptive legal change and the latter as the preserver of past and persistence.

While these four different approaches present different aspects of institutional persistence and change, all of them show the continuous coexistence and interplay of persistent and changing institutional features. The finding is in line with what one would expect from a cumulative cultural process. Moreover, the second, third, and fourth approaches - in spite of their differing methodological characteristics - all point to a significant change in how England's common law was made. Over the second half of the 18th century the reinvigorated common law courts changed the law-making process from

being strongly rooted in the past towards a process that builds on the recent past to create the new, but is focused on the present. The change accompanies the heyday of European Enlightenment, the developments leading to the French Revolution, and the Industrial Revolution.

Before ending the chapter I want to bring back to mind two major confounding factors that have the potential to severely distort the findings. First, the large fluctuations in the numbers of reported cases (and associated with fluctuations in the numbers of court cases) and second, the considerable differences in the quality and timeliness of case reports. I believe that I have sufficiently addressed the first confounding factor by taking recourse to the random citing and representative courtroom models. However, the second confounding factor poses greater, partly insurmountable difficulties.

It is well known that the quality, public accessibility and content of case reports showed large variation between time periods, case reporters and individual cases. Only over the course of the 19th century and with the rise of a narrow doctrine of precedent known as *stare decisis* did the case reports turn into judge-approved, promptly published, comprehensive descriptions of courtroom proceedings. Before case reports were more courtroom sketches that reflected idiosyncrasies and preferences of case reporters and often circulated among the legally knowledgeable before finding their way into print. The stagnation of common law business during the first half of the 18th century went hand in hand with a deterioration in the quality and publication time of case reports. Analogously, the revival of common law during the second half of the 18th century coincided with an improvement in the quality of case reports. In the year 1865 the continued expansion of 19th century common law resulted in the professionalized, centralized and standardized

official Law Reports. The above poses the question if the findings of this chapter pertain to the legal innovation process or to the case reporting process. In other words the question is if the case reporting process influences developments in the legal process or if the legal innovation process influences developments in case reporting. Put even differently the question is if the supply of case reports drives the legal innovation process or if the supply and demands of the legal profession drive the case reporting process.

A balanced answer acknowledges both directions. It is clear that the availability of case reports is a necessary condition for their use as precedents in courtrooms. Moreover, prompter availability allows citing of more recent precedents and higher quality of case reports makes the cited precedent more convincing. Therefore, one would expect an increase of promptly published, high-quality case reports to shift courtroom precedents toward the present. On the other hand demands from the legal profession make it worthwhile to publish the notes of courtroom reporters in the first place. A large part of early case reports found their way into print because personal notes of legal professionals were requested by many of their colleagues. Even Burrow - the most famous case reporter of the 18th century - had originally produced case reports for his own use and published them only because his colleagues pestered him. Furthermore, it is doubtful if promptly published, high-quality case reports would have had much of an impact during the first part of the 18th century when England's common law courts lost business and relevance for public life¹⁰⁴. It is more likely that case reports became more

¹⁰⁴ e.g. Mokyr (2008, p. 74) writes "Whether eighteenth century Britain was really becoming a kinder and gentler place is a difficult issue, but at least within the circles of commerce, finance and manufacturing, trust relations and private settlement of disputes seem to have prevailed over third party enforcement. Most business was conducted

reliable, were written by more able case reporters and published more promptly when the cases on trial regained social significance and important issues were decided in the common law courts. While some scholars went so far to state that the fame of Lord Mansfield, the most famous 18th century judge, derives more from the quality of his law reporters than from the quality of Mansfield¹⁰⁵, it seems more appropriate to say that Lord Mansfield and Burrow gained their fame together because they were benefitting from each other and the times they were in. Without a Mansfield Burrow's case reports would have attracted less interest, and without a Burrow Mansfield's precedents would have been less influential. Had they both lived in the first half of the 18th century both able men would likely have chosen different careers or lived a life much less well known to posterity. Figure 36 uses the number of words in a case report as a very imperfect measure of case report quality to show that the expected association between higher quality of case reports and the number of citations they received apparently exists in the data. Overlaid on top of the scatter plot is a lowess smoothed regression line that clearly captures the association. More comprehensive case reports are associated, on average, with greater authority. At the same time the variation is very high.

Figure 37 depicts the imperfectly measured quality of case reports over time. The red line shows the average number of words in any given year. It is evident that the

through informal codes of conduct and relied on local reputation and religious moralizing to imbue honesty and responsibility.”.

¹⁰⁵ See, for example the quote from Lieberman (2002, p. 89): “Mansfield, as his contemporaries fully recognized, was singularly blessed in the private reporters he attracted, and it is easy to mistake the novelty and distinctiveness of his judicial leadership simply on account of the unmatched quality of the law reports covering his tenure at King's Bench.”.

number of long case reports and average length of case reports varied considerably over the centuries. The annual average ranged from about 500 to about 4000 words per case report. Until the mid of the 18th century increases, often drastic ones, in average length were transient. Around the time of Burrow's first case reports the average length increased by about 40% and remained high until a temporary return to previous levels. Over the 19th century the length rose steadily before it reached its maximum at the end of the reporting period covered by the English Reports.

With the data at hand I see no convincing way to disentangle the impact of case reports on the legal innovation process from the impact of the legal innovation process on case reports. However, the problem with marked differences of publication times and quality of case reports does not apply to statutes. Enacted statutes, at least since the Glorious Revolution, were available immediately and of comparable quality. Chapter 8 will investigate how statutes were cited in courtrooms. If one finds similarities in the citing of statutes one could be confident that changes in citing of cases reflect changes in the legal innovation process and not primarily changes in law reporting.

Chapter 7: Persistence and change - U.S. case

precedents

To establish a high-quality context for comparison of the previous' chapters findings I will briefly compare the citation behavior found in the English Reports with the citation behavior one finds in the majority opinions of the U.S. Supreme Court. Unlike the ER case reports the majority opinions do not suffer from heterogeneity issues and publication delays. Commonalities between findings from the previous chapters and patterns in the U.S. data would validate the ER data and results further; differences would make it possible to recognize the uniqueness of features in the ER data.

The comparison between judicial opinions from the U.S. Supreme Court and case reports from the English common law courts seems justified. Even though there existed no written, codified English constitution, the common law - bound together by the doctrine of precedent - constituted a central pillar of the English legal system. And the three Westminster courts represented the highest authority in common law. The court of King's Bench had appellate jurisdiction over local courts and the court of Common Pleas. Common law judges manned the Exchequer Chamber, which had appellate jurisdiction over the courts of King's Bench and Exchequer, and until the mid 19th century the House of Lords rarely became active as ultimate appeals court. As far as the English law reports are concerned, they fulfilled a function similar to the American judicial opinions in that they encapsulated past legal decisions and transported them through time for later consideration. Like the US majority opinions they exist only for a subset of important cases and not for all cases that came before the court.

Nevertheless, the comparison is not perfect. Neither is the Supreme Court a perfect match to the common law supreme courts nor is a majority opinion a perfect match to an ER case report. The U.S. Supreme Court is the highest federal U.S. court with ultimate appellate jurisdiction over all cases involving federal law and the power to interpret the US constitution whenever a case requires it. The most important cases under review end with a written judicial opinion that is issued by the court and authored by Supreme Court judges. If a majority of the involved judges can agree on the judicial opinion it is called a majority opinion and becomes a binding precedent. Most, though not all cases under written review result in a majority opinion. This contrasts with the common law courts and the English pre-1865 case reports. The common law courts were split in three, did not have ultimate appellate jurisdiction and did not interpret one clearly designated constitution. The case reports were not written by judges and generally recorded a good part of the dialectic courtroom experience and not exclusively the post-trial rationale of the court's decision.

It is fortunate that Fowler and others have compiled and made publicly available a citation network¹⁰⁶ that they derived from the U.S. Supreme Court's majority opinions (Fowler et al., 2007; Fowler and Jeon, 2008). Their citation network incorporates 30,264 majority opinions from the years 1780 to 2002 and 216,731 references to preceding majority opinions. In the next sections I will use methods from the previous two chapters to present and compare findings from U.S. law. The sections will discuss basic structural features, long-term persistence of case authorities, temporal patterns of U.S. law's top authorities, time profiles with their time depreciation estimates, and common law

¹⁰⁶ At the time of writing the dataset was available at <http://fowler.ucsd.edu/judicial.htm>

communities. The last chapter draws on these to develop conclusions that are more general than the ones presented in this chapter.

Basic structural features

In this section I present and compare basic structural features of the U.S. citation network. The features include the yearly number of publicly available case documents, overall time depreciation features, and the frequency distribution of citations that individual majority opinions received. First, I present the yearly number of majority opinions in comparison with the ER case reports (see Figure 38). The yearly number of majority opinions increased from a few dozen in the first half of the 19th century to about 200 with temporary peaks around 300 in the second half of the century. The number then remained on a high level until, beginning in the 1920's, it decreased steadily to about 100 cases at the end of the 1950's. A subsequent sudden rise followed by a sudden drop shortly before the year 2000 then concludes the available data series. What stands out next to the strong increase of majority opinions towards the end of the 19th century are the substantial and often sudden fluctuations. The degree of these fluctuations, the number of yearly majority opinions, and the existence of distinct periods with different degrees of activity are akin to the English situation¹⁰⁷.

Second, to compare depreciation effects I present Figure 39. The figure depicts on a logarithmic scale the number of citations that majority opinions and ER case reports received as a function of their age. The predictions from a simple exponential depreciation model appear as lines (see the model on 89). With an R^2 value of 0.98

¹⁰⁷ The annual average number of U.S. majority opinions is 136.3 with a standard deviation of 90.7. The annual average number of English common law case reports is 173.5 and the corresponding standard deviation is 190.3.

(English precedents: 0.83) the simple model fits the actual US data even better than the ER data. The estimated US overall depreciation rate of about 4% (English precedents: 1.4%) is about 3 times higher than the one derived from the English Reports.

Third, I discuss and compare the distribution frequency of case citations. As mentioned above about 30,000 US majority opinions cite each other about 215,000 times, i.e. about 7 times per case. In comparison about 60,000 ER case reports cite each other about 120,000 times, i.e. about 2 times per case. The lower average number of citations partly reflects the omission of difficult-to-interpret pre-1700 ER citations, partly incomplete ER extractions, and partly the fact that references to other cases appear less often in ER case reports than in US majority opinions. The comparatively low ER citation frequency is reflected in the degree distribution. While the shape of the two distributions is similar Figure 40 shows that the US distribution of citations has a longer and more populated tail than the English one.

Long-term persistence of case rulings

Like the English common law courts the US Supreme Court kept citing specific cases a long time after their occurrence. 136 out of the 262 majority opinions from the 1800's were cited at later times, 48 of these more than 100 years after the judgment.

Analogously, 291 of the 395 majority opinions from the 1840's were cited in later years and 36 of them more than 100 years later. This implies a 100-year-term persistence rate of 18.3% for the 1800's and of 9.1% for the 1840's. Rates of immediate oblivion are 48.1% and 26.3%. Because overrulings are rare in the U.S. Supreme Court¹⁰⁸ I see these numbers as evidence of long-term persistence of case authorities in American law.

¹⁰⁸ See footnote 74.

Compared to English common law courts (100-year-term persistence rates of 51.2%¹⁰⁹ for the 1580's and of 39.8% for the 1700's, plus an immediate oblivion rate of 31.9% for the 1700's) the U.S. Supreme Court's long-term persistence rates in the 19th century were considerably lower than the English 16th and 18th century rates. At the same time the three rates of immediate oblivion appear similar. Unfortunately, the current datasets do not allow to make long-term comparisons between US and English courts for the same time period.

U.S. Supreme Court's top authorities

Like in the previous chapters I use citation counts to study, for any given year after 1700, the age composition of top authorities. Analogously to common law I characterize the year-dependent age composition of the U.S. Supreme Court's most cited cases by standard measures of centrality (means and medians) and spread (standard deviations and median absolute deviations)¹¹⁰. To do so I distinguish, for each year after 1820, 8 groups of top cited statutes (top 10, top 50, top 100, top 500; top 1%, top 5%, top 10%, top 20%) and characterize their age composition by measures of centrality and spread. Figure 42 and Figure 43 depict the annual means and standard deviations, as well as annual medians and median absolute deviations for different groups of the U.S. Supreme Court's most cited cases. Because the years between 1780 and 1820 received only a small number of citations and resulted in very noisy data I have excluded these years from the data series. To ease comparison with English precedents I reproduced the analogous

¹⁰⁹ More precisely this is a 120-year-term persistence rate.

¹¹⁰ The findings in this section closely match the findings reported by Leicht et al. (2007) who use authority scores and restrict themselves to means of the top10, top 50, top 100 and top 500 cases.

measures in the same figures. The comparison reveals a few striking differences and similarities.

For instance, the English centrality measures attained much larger values than their U.S. counterparts. This is partly explained by the longer history of English case reports (covering a period of nearly 300 years). Moreover, a closer look reveals that, until the 19th century drop, English means and medians increased more rapidly than the U.S. ones. For example, the English means and medians increased between 1750 and 1800 increased every passing year by one year whereas the American means and medians between 1820 and 1870 increased only about half as quickly.

The measures of spread point to the reason for the different mean and median growth rates. While the English standard deviations and median absolute deviations remained essentially constant until the 19th century before undergoing a rapid increase (and for the medians a later rapid drop), the U.S. ones, with the exception of the 1880's to 1910's, increased steadily over the centuries at about the same rate. This means, as mentioned earlier, that the English most authoritative cases persisted for about 100 years before being superseded to a large extent in a short period of time. For the U.S. it means that recent cases constantly joined the most authoritative cases and continuously displaced some of the older ones. Because not all of the older cases were replaced the standard deviation and means steadily increased. Figure 44 illustrates the proposition. Comparison with the corresponding English figure (Figure 20 and Figure 21) underlines the strong persistence of common law cases from previous centuries. The difference in the degree to which past cases persisted is also evident if one compare Figure 22 and Figure 45, which presents four temporal distributions of the 100 most cited U.S. Supreme

Court cases between the years 1830 to 1860, 1870 to 1900, 1910 to 1940, and 1950 to 1980, respectively: at all times a good part of common law's most cited cases reached back centuries, whereas the most cited U.S. Supreme court cases were rarely older than 50 years.

Figure 42 and Figure 43 further demonstrate that sudden decreases in means and medians of the age composition of the top cited cases are not unique to common law. In the U.S. data one can identify two of these: a strong one between 1870 and 1900 and a weak one between 1970 and 1990. While the weak one mainly involved the highest ranks of the most cited cases, i.e. the top 10 or top 1% of cases, the strong one comprised all of the top cited groups. In comparison with the sudden decrease in common law the two U.S. ones appear less pronounced.

Time profiles

In this section I present U.S. time profiles that were constructed analogously to the common law time profiles from the previous chapter. The time profiles in Figure 46 provide a view on precedent use in the legal innovation process of the U.S. Supreme Court. As in the previous chapter cited years are aggregated by semi-decades and citing years are aggregated by decades. The time profiles span the decades from 1810 to 1999 and predictions based on the random citing model are given as dashed lines. The shape of the time profiles and the type of legal innovation process appear similar over all decades. A head that rises above the most recent years and a tail that covers the older years characterizes the shape, particularly after the 1860's. Routinely, up to 50% of cited cases were from the citing decade or previous decade. Time profiles of the first three decades

are very narrow because majority opinions date back only to 1780. The head of the time profiles broadened until the 1860's when it became tighter and maintained its tight shape until the end of the data series. The only noteworthy new feature after 1860 is the temporary appearance of a small second peak in the 1960's. Long-term persistence in the time profiles is low because precedents older than a few decades were generally rarely used in the legal innovation process.

The random citing model does not fit the time profiles well. Random citing model predictions, right from the beginning, underpredict the use of recent precedents and overpredict the use of past precedents. The mispredictions stand out particularly after variation in the number of majority opinions increased. The year-aggregated version of the representative courtroom model produced estimates that are shown in Figure 47¹¹¹. Until about 1860 the number of annual citations was low and estimates were imprecise. The first precisely estimated depreciation rates of the 1860's averaged about 2 percent. Later estimates point to a change in the legal innovation process between 1880 and 1910. By 1910 depreciation rates had doubled from about 2.5% to about 5%. The early depreciation rate corresponds to a precedent half-life of 28 years while the latter corresponds to a half-life of only 14 years. After 1900 the depreciation rates remained essentially unchanged.

¹¹¹ The figure shows estimates with initially incompatible time windows. For better comparability with the common law estimates I used a 120-year time window even though the window is not applicable to the U.S. Supreme Court data series before 1900. However, a comparison with 60-year window estimates produce qualitatively the same results. The transition from low to high depreciation rates starts around 1870 and continues until about 1900 without the temporary increase one can observe in Figure 47. Moreover, estimated depreciation rates after 1900 are naturally somewhat higher than the ones estimated with the 120-year window. They are estimated as about 6% to 7% compared with 120-year estimates of 5% to 6%.

Most of the English time profiles stand in sharp contrast to the U.S. ones. Arguably it is not before the 1830's or 1840's that the shape with heavy head and long flat tail - characteristic of precedent use in the U.S. Supreme Court - emerged within the English time profiles. The shape became more pronounced in the 1850's and in the 1860's closely matched the U.S. post-1860 time profiles. Until about 1770 estimated English depreciation rates of around 1% were lower than the U.S. pre-1880 depreciation rates of around 2% to 2.5%. Between 1770 and 1830 English depreciation rates averaged about 2% before rapidly approaching the 4% to 5% range and converging towards the U.S. 19th century depreciation rates.

U.S. communities

To take a fourth perspective on the U.S. citation network I the applied community detection techniques used in the last chapter. To ease comparison I used only the spinglass algorithm and restricted it to 2 communities. I removed about 5,000 isolates before applying the algorithm to the remaining network of 25,000 nodes (U.S. Supreme Court majority opinions) and 209,000 links (citation of majority opinions). The maximized modularity attained a value of 0.38 - similar in magnitude to the 0.41 value of the English network. Unlike the English network the two detected communities were of unequal size: the first community contained about 9,000 and the second about 16,000 majority opinions. Figure 48 shows that the first community consists nearly exclusively of 20th century cases (less than 20% of cases belong to the 19th century) while the larger community contains 19th and 20th century cases about equally. Figure 49 depicts the yearly fraction of total majority opinions that each community contains and illustrates the differing temporal compositions in another way. Essentially all cases from before 1870

belong to the larger community. Beginning in the year 1870 a break becomes visible. Every year the proportion of cases belonging to the first community increases steadily until, over the course of the 20th century, the number of cases in the first community outnumbers the number of cases in the second community¹¹².

Comparison with the English community structure reveals surprising similarities. The community structures of both countries point to the emergence of a first community that built on a comparatively small number of old cases (18th century ones in the England and 19th century in the U.S.) to develop a body of new law that appears to have been largely self-referential and less considerate of the past than the second detected community. The second community tightly links the oldest U.S. Supreme Court cases with cases of all the following generations. While its cases dominate the 19th century they are in the minority in the second half of the 20th century. It persists throughout the centuries and loses influence over the 20th century when the first community becomes visible and expands.

Commonalities and differences: insights from the U.S.

In this chapter I relied on methods from the previous two chapters to gain insights into persistent and changing features in the making of U.S. Supreme Court decisions and compare them with previously found features from the English common law courts. As in the previous chapter the analysis depended on the use of precedents in the legal process and corresponding statistical aggregate properties.

¹¹² Also the findings in this section closely match the findings reported by Leicht et al. (2007). Leicht et al. use an eigenvector algorithm that is different from the spinglass algorithm and they do not specifically analyze the temporal compositions of the different communities. However, the annual fractions of their communities, plus the 1870 onset and temporal unfolding of the break are very similar.

Basic structural properties of the U.S. and English network show fundamental similarities and some differences. For example, the yearly level and strong fluctuations of U.S. majority opinions were similar to ER case reports. Moreover, time depreciation occurred in the U.S. Supreme court's precedent use as well as in the common law courts. However, largely due to different break points in year-specific depreciation, the overall depreciation rate of about 4% percent was about 3 times larger than the English one¹¹³. Another difference between U.S. and English case documents is the greater relative frequency of U.S. citations. U.S. majority opinions were, on average, cited about 7 times, whereas an English ER case reports were, on average, cited about 2 times. Consequently, the English citation network is sparser than the U.S. one. At the same time the U.S. and English distributions of citation frequencies followed essentially the same long-tailed distribution.

Studying the long-term persistence of U.S. majority opinions one finds that - as in the English counterparts - noteworthy long-term persistence apparently existed. Comparing the degree of U.S. long-term persistence to the English ER case reports one finds a remarkable difference. The studied U.S. 100-year-term persistence rates of around 20% and 10% were about 3-4 times lower than the English ones clearly indicating a major difference in the legal innovation processes of the different time periods.

Investigating the age compositions of the most authoritative U.S. precedents and comparing them to the English counterparts it becomes evident that one major break and one minor break occurred in the U.S. time series as well. Though less pronounced the

¹¹³ The main reason for the difference is that the U.S. data contain about 100 years with low depreciation rates and 100 years with high depreciation rates, whereas the English data contain about 120 years with low depreciation rates and 40 years with high depreciation rates.

major break is comparable to the one observed in the corresponding English time series. A significant difference between U.S. and English precedent use also surfaced: the age composition of the most authoritative U.S. precedents changed at all times to a smaller or larger extent, whereas the age composition of English precedents remained nearly unchanged over the whole 18th century. This and the continuous English reliance on very old precedents suggests a greater degree of persistence in the English legal innovation process than in the U.S. one.

In addition to this, time profiles indicate that the U.S. legal innovation process, at least initially, functioned differently than the English one. From the beginning U.S. majority opinions cited mainly recent cases and usually did not reach back more than a few decades to create new law. The 1860's and the next decades saw a further tightening of the temporal basis for legal innovation. This picture is very different in the English time profiles. At least until the beginning of the 19th century the English legal innovation process strongly relied on cases that date back more than a few decades. Interestingly, over the course of the 19th century the English time profiles started to resemble the U.S. time profiles more and more. The initial difference between the U.S. and English legal innovation processes and their later convergence is evident also in estimated time depreciation estimates of the representative courtroom model. U.S. depreciation rates started out between 2% and 2.5% and then increased to about 5%. English depreciation rates started out around 1% and then converged towards 4% over the first half of the 19th century.

Detected communities point to another commonality between the U.S. and English citation network. In both networks there seems to exist a community that

emerges without strong links to the past and then builds on itself to create new law (the U.S. community becomes visible around 1870 and the English community become visible around 1750). A second community seems to connect cases from all time periods and dominate cases before the emergence of the first community.

Taken altogether the U.S. Supreme Court's majority opinions form a citation network that allows it to discern interesting commonalities with and differences between the English ER citation network. While the U.S. citation network is denser than the English one, basic structural features are similar. Four different views on institutional persistence and change paint a consistent comparative picture of coexisting and interplaying features. The second, third, and fourth views indicate the occurrence of a significant change in the U.S. legal innovation process. Towards the end of the 19th century the already present-focused U.S. innovation process accelerated further and disregarded past precedents quicker than before. All four views suggest that the U.S. innovation process showed lower degrees of persistence than its English counterpart at least until the latter underwent its transition from a past-rooted to a present-centered innovation process. Finally, it is noteworthy that the U.S. and English legal innovation processes appear to converge towards a process with nearly identical features. Moreover, the route by which they accomplish this - a quickly expanding community with weak links to the previous tradition - appears to be identical, too.

Chapter 8: Persistence and change - statutes

In this chapter I investigate how the English superior common law courts used statutes in their legal innovation process. The investigation is insightful for two reasons. On the one hand, it illuminates the influence that the second major source of law had on the English legal landscape. On the other hand it serves as a check on the findings of chapter 6. While the chapter's quantitative techniques painted a consistent picture of persistence and change, there remained some uncertainty about the findings due to considerable heterogeneity in the quality of case reports and publication dates. Statutes - at least since Tudor times - were written proposals drafted by Crown lawyers, and then discussed and deliberately adopted by Parliament and king (Baker, 1990, p. 237). Therefore, they were publicly available right after their enactment and their modern content and quality showed little variation. If the study of statute use reveals patterns of persistence and change that are similar to the ones that emerged from the study of precedents the findings would reinforce each other.

The analysis includes 41,850 post-1700 citations from common law cases to 17,765 pre-1865 statutes¹¹⁴. This translates, on average, to about 2.4 citations per statute. The structure of the following sections mirrors the previous chapter on U.S. precedents. The only difference is that, because statutes do not cite other statutes or cases, I will not study network communities and instead briefly investigate the year-averaged relative share of statute citations. The next sections summarize findings regarding basic structural features, long-term persistence of statutes, temporal patterns of the most cited statutes,

¹¹⁴ The number of statutes is derived from the Chronological Table of and Index to the Statutes (1873).

time profiles and time depreciation estimates, as well as the annual relative share of statute citations. I will use these findings in the last chapter to draw conclusions that go beyond the basic ones in this chapter.

Basic structural features

In this section I discuss the yearly number of enacted statutes, the overall time depreciation of statutes, and the frequency distribution of citations that individual statutes received. Lists of English statutes usually begin with the Magna Carta in 1215 and continue to this day¹¹⁵. Figure 50 displays the number of statutes that were enacted from 1215 onwards. A few features in the figure stand out. First, until the times of the Glorious Revolution there were many years where no statutes were enacted. This contrasts with the time following the revolution when statutes were enacted every year. The reason is that - as a consequence of the Glorious Revolution - Parliament was guaranteed annual sessions whereas previously it needed to be summoned by the king. Second, it is obvious that the number of enacted statutes increased steadily and drastically during the century following the Glorious Revolution before leveling off in the 19th century. Third, less striking, but still remarkable is the increased statutory activity in Tudor times (16th century) and the sudden drop in Stuart times (17th century). Tudor statutory activity is even more remarkable if one realizes that pre-16th century statutes were usually of a different kind than later ones. They usually embodied Parliament's oral response to a complaint that was only later recorded by various clerks and private hands (Baker, 1990, p. 236). An early statute was often artificially divided into different chapters whereas in later times each chapter effectively corresponded to a distinct statute.

¹¹⁵ I relied on the 1873 edition of the Chronological Table of and Index to the Statutes.

Depreciation effects are evident in Figure 51. Analogous to previous chapters the figure depicts (on a logarithmic scale) the number of citations that statutes received in dependence of their age. Interestingly, there appear to be three distinct depreciation rates. The first is about 5% and applies to statutes that are not older than 50 years. Later we will see that this depreciation rate is characteristic of the 19th century. The second applies to statutes ages of 50 years to 350 years and is essentially equal to the overall depreciation rate of about 0.7% (see Table 7). The third depreciation rate applies to very old statutes that were enacted more than 350 years before they were cited. Their depreciation rate is essentially 0%. The first two depreciation rates show some similarity to the ER precedent depreciation rates in Figure 13. There, two different depreciation rates were discernible. The first concerned precedents no older than 80 years and was estimated as about 3%. The second concerned precedents between 80 and 200 years of age and was estimated as about 1.2%. The possibility of a third depreciation rate that mimics the statute is not decidable because the age of precedents was limited by the data series. Overall depreciation rates already suggest a certain consistency across the statute and precedent series. However, further conclusions are better obtained from time-dependent depreciation rates of a subsequent section.

The in-degree distribution of statute citations, i.e. the frequency distribution of citations that individual statutes received, is shown in Figure 52¹¹⁶. The shape of the distribution resembles closely the English precedent distribution. The main difference is that the tail of the statute distribution is much longer and some statutes received a very

¹¹⁶ To calculate the distribution I only counted citations that pointed to clearly identifiable statutes, i.e. to statute citations that included a specific chapter number. That implied dropping about 3,500 of the 41,850 statute citations.

large number of citations¹¹⁷. This suggests that some statutes had much wider applicability than single holdings of common law court.

Long-term persistence

Taking for granted, based on the studies in chapter 6, that a statute citation in the English Reports indicated that the statute was deemed applicable at the time of the citation, I investigate the long-term persistence of statutes. Technically, a statute remains in force until it is officially repealed or superseded by a subsequent statute. However, it is possible that a statute - though in force and never officially repealed - simply lost its relevance. Therefore, it is of some interest to study the long-term persistence of statutes. It is clear that some statutes have persisted a long time. For example, in the English Reports the most recent citation of Magna Carta appeared 1865, i.e. about 650 years after its enactment (later years are not covered by the dataset). The same held true for the Statute of Limitations and the Statute of Uses (comp. footnote 117).

To compare statutes and ER precedents I followed the same procedure as in chapter 6. For two decades - the 1580's and the 1700's - that date back long enough to observe long-term persistence, I identified ER citations that referred to statutes that were

¹¹⁷ The five most cited statutes are:

- the Statute of Limitations (from the year 1540): 1275 cites - an act setting limitation periods on land-related claims
- the Statute of Frauds (1677): 1091 cites - an act requiring certain kinds of transactions to be recorded in writing
- the statute 6 George IV, chapter 16 (1825): 544 cites - the first act on voluntary bankruptcy
- the statute 4 William IV, chapter 42 (1833): 419 cites - an act regulating common law procedures
- the statute 43 Elizabeth, chapter 2 (1601): 405 cites - an act regulating poverty relief (previously carried out by the church)
- the famous Statute of Uses (1535) was cited 232 times and the Magna Carta (1215) 197 times.

enacted in one these two decades, and recorded the most recent citation date. The time difference between the most recent citation date and the date when the statute was enacted provided an estimate of the statute's degree-of long-term persistence.

The Chronological Table of and Index to the Statutes (1873) lists 73 statutes between 1580-1589 and 264 statutes between 1700-1709. Many of these statutes were personal or local, i.e. they applied only to a particular individual or group, and were unlikely to surface in later court proceedings. 38 statutes from the 1580's and 79 statutes from the 1700's were cited in common law courts more than 100 years after their enactment. That translates to 100-year term persistence rates of 52.1% and 29.9%, respectively. The 1700's rate of immediate oblivion was 56.4 percent (to recall for ER precedents the 100-year-term persistence rates were 51.2 percent for the 1580's and 39.8 percent for the 1700's, plus a 1700's immediate oblivion rate of 31.9 percent). The 100-year term persistence rates were very similar for ER precedents and statutes. This suggests comparable degrees of long-term persistence.

Top statute authorities

Like in the previous chapters I use citation counts to study, for any given year after 1700, the age composition of top authorities. I identify, for each year after 1700, 6¹¹⁸ groups of top cited statutes¹¹⁹ (top 10, top 50, top 100; top 1%, top 5%, top 10%) and characterize their age composition by standard measures of centrality and spread. The summary

¹¹⁸ I dropped 2 groups (top 500 and top 20%) that I included in the analysis of precedents. The reason is that the small number of statutes that was being cited at the beginning of the 18th century resulted in the inclusion of all statutes in the top500 group.

¹¹⁹ as in the previous section I counted only post-1700 citations and disregarded all statute citations that did not point to a specific statute name or statute chapter. To recall that meant dropping about 3,500 of the 41,850 statute citations.

measures indicate that statutes following the Glorious Revolution gained influence during the first decades of the 18th century. Half a century then followed where the temporal composition of statute authorities remained largely stable with only minor recent additions. Finally, around the turn of the 18th century the temporal composition of top statutes underwent a pronounced and continuous shift towards statutes from the 19th century.

Figure 54 and Figure 56 depict annual means and standard deviations, as well as annual medians and median absolute deviations for the different groups. Analogous measures for the ER precedents appear as dashed lines. One finds that means and medians, though initially very noisy, decrease over the first half of the 18th century while standard deviations and median absolute deviations decrease or remain unchanged. The increasing number of statutes that were enacted after the Glorious Revolution replaced a good part of older statutes as top authorities. This explains the decreasing centrality measures and spreads. After this period followed half a century where the temporal composition of top authorities remained essentially unchanged. As a consequence, means and medians increased each year by about 1 and spreads remained about constant. Finally, around 1800 the period of essentially unchanged top authorities came to an end when an increasing number of recently enacted statutes joined the top authorities and replaced the previous top authorities. This manifested as increasing spreads and fairly drastically decreasing centrality measures. For example, the mean of the top 10 statute authorities dropped from about 200 in the year 1830 to about 130 in the year 1840 when 2 statutes from the 17th and 18th centuries replaced statutes from the 13th and 16th centuries .

A different perspective on the persistent and changing features of common law's top statute authorities provides Figure 56. It demonstrates that the temporal composition of top statute authorities comprised statutes that went back hundreds of years. It further shows that a large portion of top authorities originated in the time period around the Glorious Revolution while very few top authorities emerged between 1740 and 1810. However, by the year 1860 about half of all top statutes had their origins in the 19th century. Figure 57 demonstrates how the drastic change came about. Until the beginning of the 19th century time period-specific top authorities had a general inclination towards the past and particularly so towards statutes around the Glorious Revolution. Over the 19th century first the inclination towards the past became attenuated and then a very strong inclination towards the present developed over the second quarter of the 19th century.

Comparison with ER precedents exposes similarities and differences. First, statutes go back to the 13th century whereas the ER case reports go back only to the end of the 16th century. Therefore, it is not surprising that means and medians of statute top authorities were initially 2-3 times larger than the precedent analogues. Second, statutes enacted during the decades after the Glorious Revolution joined the group of most cited statutes, whereas ER precedents showed greater persistence during the 19th century. On the other hand, statutes and ER precedents together manifested strong persistence of top authorities' temporal composition over the second half of the 18th century. Finally, both at about the same time underwent a 19th century transition that anchored the temporal composition of top authorities in the present. The transition appears to have been more radical for statutes than for precedents and so centralities and spreads converged in the

course of the 19th century. Possibly the fact that statutes were not bound by a doctrine of precedent is the reason that they could be replaced more radically than the more persistent precedents.

Statute time profiles

Statute time profiles, i.e. year-dependent temporal compositions of new statute citations, describe statute use in the English superior common law courts. The law courts drew regularly on statutes, i.e. social rules that originated in Parliament, to decide cases and create new law. Even though statutes differed from precedents in that they originated outside the law courts and were not constrained by doctrines of precedent they constituted another form of legal innovation capital whose use can be analyzed with time profiles. Courts had to take them into account when deciding cases, however, the meaning and applicability of specific statutes were open to interpretation.

Figure 58 presents statute time profiles from the common law innovation process. As in earlier chapters cited years are aggregated by semi-decades and citing years are aggregated by decades. The time profiles cover the decades from 1700 to 1865. To facilitate comparison with ER precedents I have restricted the cited semidecades to the time from 1580 to 1865 for which ER precedent data is available. Dashed lines in the figure represent predictions based on the random citing model. Because the random citing model predicts very poorly I will not discuss it further and simply record that a higher number of enacted statutes did not translate into a higher number of statute citations.

The statute time profiles can usefully be separated into a pre-1800 period and a post-1800 period. During the pre-1800 period recently enacted statutes did not dominate. This changed around 1800 and the most recent statutes were cited far more frequently

than in earlier times. For example, in the 1860's about 50% of cited statutes were less than 20 years old and 80% of statute citations were less than 50 years old. This compares to statute citations in 1780 when only 20% of statute citations were less than 20 years old and only 40% of statutes were less than 50 years old. This change is reflected in the shape of the corresponding time profiles. Pre-1800 time profiles are spread out over the cited semidecades and no semidecade dominates. After 1800 the shape changes into a head rising above the most recent years and a tail covering the older years.

Analogously to the ER precedents there are two aspects of persistence in the statute time profiles. The first one is that the shape of time profiles stays largely unchanged during the pre-1800 period and, after a short transition period, seems to converge quickly towards a persistent shape (the shape further resembles that one that emerged from the U.S. data). The second aspect is the continued recognizability of earlier citing behaviors in later times. Even though the center of gravity shifted from the past to the present, the past remained recognizable even in the 1860's. In other words if one would cut off the time profile's head and blow up the tail one would obtain a decent representation of time profiles from a century ago.

Estimating the standard version of the year-aggregated representative courtroom model (where t' is now the year of preceding statutes that could be brought up as part of the dialectic courtroom process):

$$p_{it'} | i \text{ is citing in time } t = \frac{e^{-\delta(t-t')} \cdot (K_{tt'} + n_{t'})}{\sum_{t'=t-120}^{t-2} e^{-\delta(t-t')} \cdot (K_{tt'} + n_{t'})} \quad \text{if } t' < t$$

leads to Figure 59. The initially imprecise estimates begin with an average depreciation rate of about 1% before decreasing over the second half of the 18th century to about 0.5%. Around 1800 the estimated depreciation rates begin to increase, initially to 1% until about 1820 and then rapidly to about 5% in the 1860's. These findings confirm the distinction between a pre-1800 and post-1800 period and the existence of two different modes of innovation.

Summarizing the above and adding a few more observations one can say that the time profiles of statutes and ER precedents display strong similarities and some noteworthy differences. Time profiles of both underwent a swift transition from an 18th century period with strong persistence to a 19th century period where persistence declined and change dominated. Estimates from the representative courtroom model confirm the transition and produce similar depreciation between 0.5% and 5%. Moreover, the shapes of past time profiles are persistent in the sense that they remain recognizable in later times. Statute and precedent profiles differ in that precedents apparently begin their transition a few decades earlier - even though drastic change sets in for both around 1810. Moreover, the change of statute depreciation rates is more pronounced - rates increase from 0.5% to 5% - relative to precedent depreciation rates that increase from 1% to 4%. One might conjecture that the doctrine of precedent diminishes depreciation of innovation capital.

Statute presence in courtrooms

In the aftermath of the Glorious Revolution and over the course of the 18th century statutory activity increased drastically (recall Figure 50). Because statutes directly influenced the making of new law in the common law courts one might wonder if the

observed changes in top authorities, time profiles and depreciation rates were brought by an increasing influence of statutes on decisions in the common law courts. As a first attempt to test the conjecture I created an approximate measure, the yearly average relative share of statute citations r_t , of the influence that statutes have on judicial decision-making:

$$r_t := \frac{1}{n_t} \sum_{i=1}^{n_t} \frac{\text{statute cites}_{it}}{\text{statute cites}_{it} + \text{case cites}_{it}}$$

To do so I determined for each case report the relative share of statute citations relative to the case report's total number of citations and averaged these proportions across case reports in a given citing year. The yearly average relative shares of statute citations are depicted in Figure 60. The figure shows that the influence of statutes doubled over the first half of the century from an average of about 0.15 to an average of about 0.3. From the mid of the 18th century onwards the value remained essentially unchanged. With due reservations regarding the preliminary nature of the measure the results suggest that the increased statutory activity indeed increased the influence of statutes on common law's innovation process. However, further increases in statutory activity had no further effect and, therefore, the observed drastic changes in the use of innovation capital are not easily explained by ongoing changes in statutory activity.

Commonalities and differences: insights from statutes

Courtrooms drew on cases and statutes to resolve cases on trial. All things considered, the findings of the previous sections partly confirm and partly extend the findings from the

chapter on ER precedents. The Glorious Revolution was followed by an increase in statutory activity and courtroom use of statutes. A few decades after the revolution about 3 out of 10 courtroom references involved statutes. Moreover, many statutes from the post-Revolution years soon constituted a long-persisting part of legal innovation capital. Decreasing statute depreciation rates in the first half of the 18th century further attest to this. The early 18th century emergence of persistent statute innovation capital had no equivalent in precedents. In the second half of the 18th century, however, existing statute and precedent authorities exhibited strong persistence. At the turn of the 18th century statute use and precedent use both underwent a quick transition to a legal innovation regime with low persistence of legal innovation capital. The transition in statute use appears more drastic than the precedent counterpart. Because statutes - at least since the 16th century - did not suffer from issues of delayed publication and heterogeneous quality the correspondence between statute and precedent patterns of persistence and change reinforces the majority of findings from chapter 6.

Chapter 9: Conclusions and future research

In this last chapter, I will briefly summarize the motivation of the previous investigations and the methods used, and thereafter review the main findings, derive more general conclusions and entertain a few conjectures, Finally, I will lay out a few avenues for further research.

Economists' recent main interest in institutions arguably derives from the central role modern economic growth plays in economic studies. Persistent institutions are seen as a main driver - by some even as the ultimate driver - of economic growth. The recent mainstream institutional economics literature has aimed to establish the causal effects of persistent institutions through empirical studies that built on an imprecisely measured or simply proclaimed persistence of institutional outcomes. These studies, while being very valuable, have implicit biases that deflect from the study of actually enforced rules, tend to disregard the possibility of major institutional change in the absence of cataclysmic events, and lose focus of the continuous coexistence of institutional persistence and institutional change. To balance some of these biases I quantitatively studied persistent and changing features of the actually occurring legal innovation process in England's common law between the years 1700 and 1865. The studied time period is free of cataclysmic events and saw the emergence and spread of the phenomenon of modern economic growth. The study does not aim to identify average causal effects, but instead does quantitatively describe long-term legal development within one important jurisdiction over an important time period (in comparison with one other important jurisdiction). The quantitative description led to unexpected patterns of persistence and change in the legal innovation process. Beyond their more general relevance these might

be a noteworthy contribution to the institution-sparse literature on the Industrial Revolution.

To execute the quantitative descriptive approach I chose a method that is well established and widely accepted in studies of U.S. law. It builds on actually enforced social rules and blends with recent developments in network science. The method consists in the construction of a citation network whose elements are cases or statutes and whose links are formed by citations. Cases and citations as they appear in the English Reports - the most comprehensive collection of pre-1865 case reports available - reflect a good part of the legal reasoning that occurred over the centuries in England's common law courts. Analyzing statistical aggregate patterns of the citation network and focusing on temporal aspects resulted in the observation of persisting and changing features of English law making. During the analysis I was careful to distinguish the institutional features under investigation, the exact way of measuring the institutional feature, and the relevant time period. A benefit of the chosen method is that, in principle, it allows to return for detailed analysis to the specific cases and statutes that underlie the emergent aggregate pattern.

Construction of citation network

I invested considerable effort to construct, to the best of my knowledge, the first citation network that embodies English law. The significant challenge of extracting case and citation information from the English Reports was successfully accomplished with a high positive extraction rate (about 80% of references to statutes and ER precedents) and small error rates (false positives rate of about 2%, false negatives rate of about 15%). The extraction process aimed to minimize false positives at the expense of an increase in false

negatives. Analysis of a random sample showed that the majority of post-1700 ER references to earlier cases and statutes occurred as part of courtroom arguments and that negative citations were very rare. Structural patterns of the resulting citation network - like degree distribution, preferential attachment or overall time depreciation - resemble other well-studied citation networks and are an indication of meaningful and informative content. A plausible list of top cited cases (and statutes - see footnote 117), and the expected manifest split between equity law and common law reinforce this conclusion. Moreover, clear time-consistent patterns in top authorities, time profiles, and detected communities speak for meaningful information content. The new citation network should facilitate quantitative and comparative studies in law and network science.

Long-term persistence

Actually measurable long-term persistence of a large part of English precedents and statutes, at some point of time, seems to have been a fact: during the 1580's and 1700's apparently between 50% and 40% of precedents and 40% and 30% of statutes remained authoritative more than 100 years after trial or enactment. The extent of the observed long-term persistence of clearly identifiable social rules is unexpectedly large.

Comparison with U.S. majority opinions from the 1800's and 1840's yields 100-year-term persistence rates of 20% and 10% that are significantly lower.

The high degree of English long-term persistence needs two reservations. On the one hand, because the ER data series ends in 1865 the measured long-term persistence pertains to legal rules from the 16th to the beginning 18th century (assuming continuity between 1580 and 1700) and not to legal rules from later times. On the other hand, the measured degree of long-term persistence is likely a lower bound because case holdings

or statute provisions could have remained authoritative, but their citations never made it into the ER case reports.

The large degree of long-term persisting rules from the 16th and 18th century England supports, in principle, the notion of a direct pathway to the long-term persistence of institutional outcomes and from there to beneficial economic outcomes. However, it should be clear that a vast number of English precedents and statutes appears to have lost authority after 100 years and a vast number of precedents and statutes were added to the long-term persisting ones. A mix of long-term persisting rules and recent rules might as well generate institutional outcomes that differ strongly from the outcomes that were in place when the long-term persisting rules came to life. Therefore, a direct persistence pathway remains a slippery slope unless one gains traction by showing that long-term persistence of social rules was concentrated on a specific legal area - for example, property rights or contract law, whose persistence resulted in institutional outcomes that are seen as economically beneficial by institutional economists. This is an avenue for future research that would improve on institutional economists' more indirect approaches and their reliance on vaguely defined institutional outcomes or clusters of institutions. Being aware of foreseeable obstacles on the route and acknowledging the possibility that long-term persistence of institutional outcomes does not need to derive from long-term persistence of individual rules, I can see the desirability of grouping precedents (and statutes) by categories. These categories should be derived directly and in a systematic manner from the actual case reports (and statute texts) and not inferred based on partly imagined institutional outcomes. Ideally they would capture features like the issue at stake (or the topic of legislation), important notions relied on court, and ideally even

images of law (see chapter 4). Modern text mining techniques have already advanced enough to perform some of these tasks. This is another avenue for future research.

Statute influence on law making

The decades after the Glorious Revolution saw a permanent change in the influence of statutory activity on common law making. Careful study of the most authoritative statutes, analysis of time profiles that record time-specific citation behavior and the examination of statutes' share in courtroom citations point to this conclusion. Following the Glorious Revolution Parliament convened yearly and the number of enacted statutes increased. As evidenced in time profiles and the most authoritative statutes this translated into post-revolutionary statutes that quickly gained influence in courtrooms and maintained it over the course of the 18th century. Evidently this also translated into a permanent change of statutory authority in courtrooms. The relative share of statute citations doubled from about 15% to about 30% over the first half of the 18th century and then remained constant and insensitive to further increases in the annual number of enacted statutes. One could see this as an early sign of the coming of Berman's purported (post-18th century) age of positivist law (expounded e.g. in Berman, 2000), i.e. the increasing influence of the legislative branch on law-making. At the same time it is important to remember that, even after statutes had gained greater influence on common law making, precedents constituted the vast majority of used innovation capital: about 70% of courtroom citations point to precedents and not statutes. Although the reach of case holdings is much narrower than the provisions of statutes, this finding suggests that common law judges enjoyed a substantial amount of judicial freedom.

Transition in legal innovation

Possibly the most striking finding of this study is a drastic change in the making of common law. Beginning with precedents not long after the mid of the 18th century, followed by statutes around the turn of the 19th century and intensifying during the first decades of the 19th century the common law innovation process underwent a radical transformation. A legal innovation process with low depreciation rates and strong past-persistence rapidly transitioned to a present-focused innovation process with significantly higher depreciation rates and weak past-persistence. The transition is visible in the most authoritative precedents and statutes, in time profiles, and in detected communities.

The strong pre-transition persistence is reflected in temporal compositions of common law's top authorities that remained essentially unchanged over the whole 18th century (precedents) and the latter half of the 18th century¹²⁰ (statutes). However, the innovation value of the previously important 18th century precedents and statutes was depressed to near-insignificance within only a few decades around 1800. Consequently, soon after 1800 the majority of cited precedents and statutes originated in the 19th century. Even though fast-paced change seems to be the only regularity in 19th century legal innovation, a closer look revealed a sizeable number of persisting top authorities from previous centuries and the trace of 18th century time profiles in the ones from the 19th century. Community detection techniques corroborate the sharp transition in the legal innovation process. They carved out two similarly sized communities: the first community appears to be the carrier of disruptive change, whereas the second community appears to provide persistence that stretches from the 16th century to the 19th century.

¹²⁰ increased statutory activity after the Glorious Revolution explains the lack of persistence in the first half of the 18th century

Application of the same quantitative techniques to majority opinions from the U.S. Supreme Court exposed a less striking, but similarly pronounced transition towards the end of the 19th century. The U.S. legal innovation process apparently was never as past-centered as the English one. However, the speed of the transition to a present-focused innovation process with significantly higher depreciation rates and weak past-persistence are very similar. The reasons for the comparably low degree of U.S. past-centeredness are unclear. It might be due to the Supreme Court not coming into existence until the U.S. constitution was ratified in 1789, the American legal system having borrowed from the English common law system that was transitioning in the 19th century, or the English common law system being unique.

The striking finding of an English legal innovation process that rapidly transitions from one steady-state like process to another is most likely not an artifact produced by case report heterogeneities (e.g. quality of case reports) or fluctuations in case numbers. Measurable changes in case report heterogeneities only partially coincided with the transition, statutes - where heterogeneity was limited - exhibited the same transition, and fluctuations in the number of case reports were accounted for by a representative courtroom model. Moreover, the similarly pronounced transition in the citation network of the U.S. Supreme Court's majority opinions - official, immediately published case documents with much lower variation in quality and content than the ER case reports - strongly suggests that sharp transitions in legal innovation processes are a historical reality. Finally, another quantitative study - one of the very few existing advanced quantitative studies on the development of English law - locates profound legal change around the turn of 19th century and thereby supports the current findings: Klingenstein et

al. (2014) show that criminal law's crucial distinction between violent and non-violent acts began to emerge around 1800, was clearly detectable one or two decades later and continued to strengthen over the century¹²¹.

What then follows from the observed rapid transitions in the legal innovation process? First, the rapid transformation of the English legal innovation process demonstrates that even in the absence of cataclysmic events important change in a legal system can happen swiftly. While Enlightenment thought, revolutionary sentiment and the Napoleonic wars stirred England, they did not turn it upside down. The English political order remained largely unchanged since the Glorious Revolution, and the frequently emphasized event of the Great Reform Act of 1832 occurred too late to have initiated the transformation (and might even be better seen as a manifestation of ongoing legal changes). A rapid transformation of a legal system in non-cataclysmic times goes against the grain of the mainstream's inclination towards institutional persistence in the absence of cataclysmic events, Berman's framework of accelerated legal change in revolutionary times, and the legal professions' standard view of legal development.

The current mainstream literature in institutional economics tends to emphasize persistent institutional outcomes and to look for changes in institutional settings that occur as a consequence of cataclysmic events. The notion that important institutional change might consist in a rapidly changing legal innovation process during non-cataclysmic times does not fit that research agenda. Berman would recognize radical

¹²¹ Related preliminary findings that further support the notion of significant legal changes around the turn of the 19th century are available as video recording (Harrison, 2013)

legal change only in revolutionary times and places¹²² while acknowledging weakened later repercussions in the rest of Europe. A radical transformation in legal innovation outside a revolutionary context appears at odds with his framework¹²³. The legal professions' mainstream view of steady, incremental, ever unperturbed legal change¹²⁴ contrasts with the other two views. Obviously it is incompatible with a drastically changed innovation process. In sum, none of the three views easily accommodate the finding of a radical transformation in legal innovation.

Second, the observed transition to increased depreciation and present-centered innovation is a feature of the process that generates new legal rules and not a feature of the legal rules as such. In economists' (and accountants') parlance the transition concerns the flow of institutions and not the stock of institutions. While it is clear that the character of the stock of institutions will begin to change when the flow of institutions undergoes a transformation, the resulting change in the stock of legal rules is likely more gradual than the transformation of the flow. This might be the reason why the drastic change in legal innovation went unnoticed. Unfortunately, the citation network does not allow quantitative assessments of the stock of institutions.

Third, the common view that nothing particularly noteworthy happened to legal institutions over the course of the Industrial Revolution (see e.g. Mokyr, 2009; McCloskey, 2010) probably needs some revision. To the best of my knowledge not one institutional economics study tried to quantitatively follow legal innovation over the

¹²² Compare footnote 14.

¹²³ Seeing the observed transformation as a weakened repercussion of the French Revolution seems a stretch.

¹²⁴ Compare footnote 10.

Industrial Revolution. I showed that, in the decades before and after the turn of the 19th century, the English legal innovation process underwent a drastic change. Past-centered innovation where precedents and enacted statutes had long-lasting value became present-centered and depreciation accelerated. The acceleration of the innovation process accompanied the Industrial Revolution. The observed changes in the innovation process might be an example of Mokyr's general notion of institutional adaptive flexibility that, in the particular case of common law, overlaps with the self-image of many in the legal profession¹²⁵. In that regard, it seems plausible that the transformation was an institutional adaptation that was necessary to the continued unfolding of the Industrial Revolution. A failed transformation might have curbed it. Needless to say that substantiation of these speculations requires further research.

Fourth, the remarkable parallels between English and U.S. data, and particularly the rapid transition, at very different points of time, from a low-depreciation period to high-depreciation period provide weak evidence for a bold conjecture: Is it possible that the development process of modern economic growth necessitates exactly one major transition in the legal innovation process? Unfortunately, the English data series does not extend beyond the major transition and, therefore, it is not possible to determine if another major transition followed the first one. On the other hand, the U.S. data - while mute about the time before the 18th century - indicate that no additional major transition

¹²⁵ Out of many well-known quotes along these lines a 20th century one from Justice McCardie might serve as an example: "The object of the common law is to solve difficulties and adjust relations in social and commercial life. It must meet, in so far as it can, sets of fact abnormal as well as usual. It must grow with the development of the nation. It must face and deal with changing or novel circumstances. Unless it can do that, it fails in its function and declines in its dignity. An expanding society demands an expanding common law." [1924] KB 570.

occurred after the one around the end of the 19th century. Extrapolating from the U.S. data series one can wonder if the observed English and American transitions are the only major ones that feature in development towards modern economic growth. While the transition occurred in England over the Industrial Revolution, it occurred in the United States in times of large structural change in the economy (see e.g. Hughes and Cain, 2011): in 1880 output shares of the industrial sector and the services sector had overtaken the agricultural output share, over the second half of 19th century the quickly expanding railway system drastically increased the scale of commercial interaction, infant mortality rates nearly halved between 1880 and 1900, and government policy became sympathetic to intervention in the private sector (e.g. by enacting antitrust legislation like the Sherman Antitrust Act in 1890). Should the conjecture hold true it would lead to another question. What institutional structures allow the transition to occur and then maintain it?

Fifth, I hope to have illustrated that looking out for actually enforced social rules and the continuous coexistence of clearly defined persistent and changing institutional features can benefit institutional analysis and lead to new and unexpected findings. These findings present a richer picture of institutional processes than dichotomous categories of long-term persistence and cataclysmic change. The non-dichotomous approach simultaneously endorses institutional persistence and change as hallmarks of cumulative culture and, thereby, reconnects with a fertile Western tradition of thought in which persistence and change coexist. In that way it can balance the current inclinations of institutional economics.

Unfolding of the transition

The remarkable similarities between the detected network communities in the English and U.S. data series suggest that the observed transitions unfolded in a specific, possibly general manner: it seems that in each country a new body of law arose around the onset of the transition (beginning in the 1760's in England and the 1870's in the U.S.) out of a relatively small number of precedents and then developed in a self-referential manner¹²⁶. Simultaneously the body of law that existed at the time of the transition continued even if its yearly share diminished. At the end of the two data series the new body of law was widespread, but the old body of law had remained substantial. One could see here an analogy to the way how disruptive technological change diffuses: disruptive change in well-functioning market economies appears not to be brought by the incumbents who rely on existing technologies, but by new entrants who use new technologies and grow their business at faster rates than the incumbents (for a recent review see Haltiwanger, 2015)¹²⁷.

¹²⁶ What that new body of law is (and if it really exists - see the reservations below) I do not know. If one would have to pick one area of law contract law with its notion of the freedom of contract (for an account see Scheiber, 1998) would be a potential candidate for the English transition because of its centrality to markets. It embodies the modern conception of the social world as consisting of atomistic individuals who voluntarily enter into mutually beneficial agreements. The conception that gave birth to the social contract theories of Hobbes, Locke or Rousseau found its way into the reform-centered thought of Enlightenment thinkers like Adam Smith or Jeremy Bentham around the time of the English transition.

¹²⁷ One could also see an analogy to the spread of disruptive scientific theories. They rarely emerge from the center of a discipline, but often from the periphery (e.g. Darwin's theory of evolution, Einstein's theory of relativity, or the quantum theories of Bohr, Heisenberg and Schrödinger; for an impressive illustration of a classical physicist's response to the new entrants see McCormach (1982)).

Identification of a general pathway of disruptive legal change is tempting and would be a step towards answering La Porta et al.'s (2008, p. 326) crucial questions regarding the evolution of legal systems¹²⁸. Nevertheless, it should be kept in mind that the findings of this study are only preliminary. To establish that the pathway really exists and one does not reify statistical artifacts, further research is needed¹²⁹. For example, manual investigation of a representative sample of precedents from the detected communities would give a first indication of the communities' character. And - even though imprecise - modern-text mining techniques like topic analysis would allow it to generalize the analysis to the whole dataset. Finally, emerging network science techniques allow it to detect and track communities at different points of time. Should one indeed be able to track a growing disruptive community from the beginning of the transition to the end of the data series and should one be able to assign specific areas of law to the community, the case for a pathway of disruptive legal change would be considerably strengthened.

¹²⁸ "From our perspective, the crucial open questions deal with the evolution of legal systems: How do they deal with crises? How do they enter new spheres of regulation? How do they approach reforms? We have offered many illustrations from the historical record, but a comprehensive account of legal and regulatory evolution under common and civil law does not exist." (ibid).

¹²⁹ At the same time the idea of a new body of law emerging in the second half of the 18th century and reaching to today is not unheard of among the legally knowledgeable. As an example the following quote from a biography of Lord Mansfield: "What is surprising about the English common law of the second half of the eighteenth century is how much of it is familiar. Many of the basic ideas and approaches that describe the Anglo-American legal landscape of the twenty-first century were forged in this earlier time." (Oldham, 2004, p. 364).

Accelerated legal innovation

Apart from the speed of the transition, its occurrence in a time free from cataclysmic events, and the appearance of a disruptive community another aspect stands out.

Depreciation rates after the transition drastically increased. Before the transition year-dependent depreciation rates were about 1% for precedents and about 0.5% to 1% for statutes. After the transition they reached about 4% for precedents and about 5% for statutes and seemed to increase further. This means that the innovation value of past precedents and statutes decayed much quicker after the transition. Or in blunt words, after the transition precedents and previously enacted statutes became quickly useless for innovative purposes. The initial average precedent half-life of about 70 years and the initial average statute half-life of about 70 to 140 years became significantly shorter. In the second half of the 19th century average precedent half-life had shortened to about 17.5 years and average statute half-life to 12 years.

Interestingly the phenomenon is not restricted to English common law, but was similarly observable in majority opinions of the U.S. Supreme Court. The first precisely estimated pre-transition depreciation rates date from around 1860. Precedent depreciation rates then were between 1% and 2% (corresponding to a precedent half-life of 70 to 35 years). After the transition they equaled between 5% and 6% (corresponding to a half-life of 14 years to 11.7 years) and remained essentially unchanged over the entire 20th century. In spite of largely non-overlapping time periods the estimated U.S. pre-transition rates were very similar to the English ones and the English post-transition rates were apparently converging towards the level of the U.S. post-transition rates.

The phenomenon of accelerating depreciation rates seems to have escaped the attention of legal scholars. Although they noticed the general phenomenon of precedent depreciation decades ago (Merryman, 1954) they are usually more interested in the reasons why individual, recent cases depreciate differently and less in the historical patterns of aggregated entities. Or they see different time periods and different depreciation rates as confounding factors that need to be controlled, but not studied. For example, Landes and Posner (1976, 1980) picked a random sample of cases from a hand full of post-WWII years and derived depreciation rates between 2 and 5 percent (not controlling for attachment bias). Others (e.g. Spriggs and Hansford, 2002) take time depreciation into account to make their case for a different argument. Black and Spriggs (2013) take a close look on various factors that influence time depreciation of cases and in doing so combine post-WWII years in their estimation.

Legal scholars seem to ascribe the depreciation of precedents (and presumably statutes) to changing circumstances. In the words of Landes and Posner (1976) 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. 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”. Black and Spriggs (2013) add “As judges analogically reason their way to conclusions, older cases are less likely to contain issues, principles, and reasoning appropriate for contemporary legal problems.” If one agrees that a higher pace of social and economics change in a society translates into higher depreciation rates, one

can also use higher depreciation rates as an indication of an accelerated pace of social and economic change.

The notion of an accelerated pace of modern life has often surfaced in comments on modernity. Marx's statement in the Communist Manifesto that "all that is solid melts into air"¹³⁰ is in that regard one of the best-known manifestations. A Goethe character would confer: "it is terrible that one can't learn anything for life anymore... Our ancestors held firm to what they had learned in their youth; but we have to learn everything over again every five years if we are not to be totally behind the times."¹³¹ These two statements encapsulate the decay part of cumulative culture and hint to the counterpart of accelerated innovation. Harold Berman illustrates the modern drive for change with the ideology underlying Enlightenment thought: "The political, economic, and social implications of the religion of Deism are apparent. Its individualism and its rationalism led inevitably to an emphasis on reform of existing conditions for the benefit of the majority of individuals living in a given society." On an individual level, Marshall Berman (1981, p. 13) sees a modern experience where people "are moved at once by a

¹³⁰ The whole middle paragraph reads "The bourgeoisie cannot exist without constantly revolutionizing the instruments of production, and thereby the relations of production, and with them the whole relations of society. Conservation of the old modes of production in unaltered form, was, on the contrary, the first condition of existence for all earlier industrial classes. Constant revolutionizing of production, uninterrupted disturbance of all social conditions, everlasting uncertainty and agitation distinguish the bourgeois epoch from all earlier ones. All fixed, fast-frozen relations, with their train of ancient and venerable prejudices and opinions, are swept away, all new-formed ones become antiquated before they can ossify. All that is solid melts into air, all that is holy is profaned, and man is at last compelled to face with sober senses his real conditions of life, and his relations with his kind." (Marx and Engels, 1848).

¹³¹ the quote is from Goethe's *Elective Affinities* and is cited in Rosa and Trejo-Mathys (2013, p. 108); that Goethe estimated the average half-life and implicit depreciation rate so admirably about 200 years before I did proves the genius of my German compatriot

will to change - to transform both themselves and their world - and by a terror of disorientation and disintegration, of life falling apart. They all know the thrill and the dread of a world in which "all that is solid melts into air"”.

If modernity consists of accelerated innovation and decay one would expect to see it reflected in its cumulative culture. As a final speculative stretch, I hypothesize that it would also manifest in its legal innovation processes and the depreciation rates of the current study. The sudden and sustained increase in depreciation rates would then confirm notions of a rapid transition to an accelerated pace of modern life. A life that set in around the turn of the 19th century in England and around the end of the 19th century in the United States. At the same time it would not support the idea of an ever-accelerating pace of life as expounded, for example, in a recent work by Rosa and Trejo-Mathys (2013).

Further research

At the end of this investigation I will concretize some of the avenues of research I already hinted at and point to a few additional ones. Obviously, it would be possible to apply the techniques of the current study, as well as the extensions discussed below, to citation networks from other common law countries. For example, occurrence of exactly one major transition in each country and similarity of pre- and post-transition rates would broaden the findings of this study. If one focuses on the English and American datasets of this study one can carry out further research by using exactly the same data and techniques, by extending the datasets and using the same techniques, and by using more advanced techniques with the same or extended datasets.

Some further questions can be addressed by using the current data. For example, to gain greater confidence in the reliability of results one can simply apply the methods of this study to ER equity cases - a very sizeable subset of the dataset - that were only briefly studied here. Other questions need to be answered by expanding the time horizon of the English and U.S. datasets by extending them. For example, adapting and applying data extraction techniques of this study to the publicly available dataset of U.S. Supreme Court majority opinions, would allow it to locate citations of ER precedents in the majority opinions. Because the American legal system is a continuation of the English legal tradition, one would be better able to judge its degree of past-centeredness. Slightly modifying data extraction techniques of this study would allow it to apply them to the official series of post-1865 law reports. One would then be able to find out if time depreciation rates converged to the American ones and remained stable after their convergence. One would also be able to determine if other major transitions occurred in the English legal innovation process.

Adding additional techniques to the analysis extends the range of questions one can ask and answer. Two promising avenues seem to be the use of more advanced text mining and network science techniques. Klingenstein et al. (2014) relied on automated coarse-graining of the complete texts of individual trials to automate the detection of meaning and classification of texts. Topic analysis (see e.g. Blei, 2012; Rule et al., 2015) is another promising technique that would allow classification of cases based on their content. Network science has recently invested in the analysis of dynamic networks (often by finding ways to reiteratively apply techniques from the analysis of static networks). One useful method consists in the tracking of communities' growth and decay,

birth and death, as well as merges and splits. These techniques, used individually or in combination, make it possible to characterize the content of groups of cases, e.g. all cases, all long-term persisting cases of a specific period, or cases of a detected communities. This would better understanding of the character of different groups and their temporal trends. Ideally, one would even be able to make progress with the extraction of images of law. Application of these techniques could be particularly helpful if one wants to understand the process of apparently disruptive legal change. Needless to say, that collaboration with legal scholars who have been trained to extract the meaning of individual cases could be very beneficial when trying to make sense of aggregate patterns - e.g. through interpretation of randomly sampled cases. Vice versa, even legal scholars might profit from locating individual cases in emerging aggregate patterns.

It is my hope that future research and the findings of this study will add to the understanding of the nature of institutions and particularly to the understanding of institutional change. Ultimately, one would wish that a better of understanding of institutions will facilitate desirable institutional change and contribute to an increase of social welfare.

Tables

Table 1: Variables names and descriptions of the citation dataset

name	varlab
citing_citation	case report not citing, citing case, or citing statute (citing)
citing_uidcombined	unique id number of combined case report (citing)
citing_uid	unique id number of single case report (citing)
citing_nomcite	nominative citation (citing)
citing_nomcitevol	nominative citation volume (citing)
citing_nomcitepage	nominative citation page (citing)
citing_nomciterep	reporter volume (citing)
citing_casename	name of combined case report (citing)
citing_casenamefirstparty	first party, i.e. plaintiff, of combined case report (citing)
citing_casenamessecondparty	second party, i.e. defendant, of combined case report (citing)
citing_ercite	ER citation of combined case report (citing)
citing_ercitevol	ER citation volume of combined case report (citing)
citing_date	date of combined case report (citing)
citing_decade	decade of combined case report (citing)
citing_court	court where reported case is presented (citing)
citing_numwords	number of words in combined case report (citing)
citing_nomcitevolyearstart	starting year of reporter volume (citing)
citing_nomcitevolyearend	ending year of reporter volume (citing)
citing_nomcitepagestart	starting page of reporter volume (citing)
citing_nomcitepageend	ending year of reporter volume (citing)
citing_nomcitelawfrench	law french used (citing)
cited_uidcombined	uid of combined case reports (cited)
cited_uid	uid of single or combined case reports (cited)
cited_nomcitematched	nominative citation by best matching method (cited)
cited_nomcitematchedvol	nominative citation volume by best matching method (cited)
cited_nomcitematchedpage	nominative citation page by best matching method (cited)
cited_nomciterep	reporter volume (cited)
cited_nomcitematching	matching method used for nominative citation (cited)
cited_casename	name of combined case report (cited)
cited_casenamefirstparty	first party, i.e. plaintiff, of combined case report (cited)
cited_casenamessecondparty	second party, i.e. defendant, of combined case report (cited)
cited_ercite	ER citation of combined case report (cited)
cited_ercitevol	ER citation volume of combined case report (cited)
cited_date	date of combined case report (cited)
cited_decade	decade of combined case report (cited)
cited_court	court where reported case is presented (cited)
cited_nomcitenum	number of case reports in combined case report (cited)

cited_numwords	number of words in combined case report (cited)
cited_nomcitevolyearstart	starting year of reporter volume (cited)
cited_nomcitevolyearend	ending year of reporter volume (cited)
cited_nomcitepagestart	starting page of reporter volume (cited)
cited_nomcitepageend	ending year of reporter volume (cited)
cited_nomcitelawfrench	law french used (cited)
cited_citecontext	context of nominative citation (cited)
cited_nomciteoriginal	nominative citation unmatched (cited)
cited_nomciteoriginalvol	nominative citation volume unmatched (cited)
cited_nomciteoriginalpage	nominative citation page unmatched (cited)
cited_statutedate	date of cited statute
cited_statuteregnyear	regnal year of cited statute (if available)
cited_statutechapter	chapter reference of cited statute (if available)
cited_statutename	name of cited statute (if available)
cited_statutecitecontext	context of statute citation
cited_statutechapterstotal	number of total enacted statutes in year of cited statute (if available)
cited_statutechapterspublic	number of public enacted statutes in year of cited statute (if available)

Table 2: Data summary of citation dataset

name	observations	mean	sd	min	max
citing_citation	462857	1.1	0.5	0	2
citing_uidcombined	462857	64233.0	36035.3	1	129042
citing_uid	435488	63960.0	35659.5	1	129042
citing_nomcitepage	462857	341.7	268.8	1	2833
citing_ercitevol	462857	89.3	43.6	1	618
citing_date	459933	1777.7	83.0	1061	1999
citing_decade	459598	1773.3	82.9	1500	1860
citing_nomcitenum	462857	1.3	0.7	1	15
citing_numcites	360385	20.0	45.4	1	607
citing_statutenumcites	75103	4.4	5.9	1	83
citing_numcasesyear	462857	655.6	418.3	1	2418
citing_numcasesdecade	462857	6017.7	3714.2	2	11051
citing_numwords	462857	4006.7	6692.5	13	198233
citing_nomcitevolyearstart	435477	1768.5	90.3	1220	1871
citing_nomcitevolyearend	435477	1784.6	78.5	1400	1893
citing_nomcitepagestart	435488	23.8	139.1	1	2586
citing_nomcitepageend	435488	671.4	264.0	14	2827
citing_nomcitelawfrench	435488	0.0	0.1	0	1
cited_uidcombined	360385	58784.6	34171.0	1	128928
cited_uid	360385	58784.6	34171.0	1	128928
cited_nomcitematchedpage	360385	331.6	303.6	1	2827
cited_nomcitematching	360385	2.1	0.5	1	3
cited_ercitevol	360385	81.7	40.8	1	176
cited_date	360385	1756.1	81.3	1580	1865
cited_decade	360385	1751.6	81.3	1580	1860
cited_nomcitenum	360385	1.3	0.7	1	15
cited_numcasesyear	360385	509.0	355.7	3	1276
cited_numcasesdecade	360385	4876.3	3446.6	351	11051
cited_numwords	360385	2898.7	4758.1	13	117913
cited_nomcitevolyearstart	360385	1745.2	86.4	1220	1865
cited_nomcitevolyearend	360385	1763.0	78.0	1581	1893
cited_nomcitepagestart	360385	43.2	213.2	1	2586
cited_nomcitepageend	360385	650.0	302.7	42	2827
cited_nomcitelawfrench	360385	0.0	0.2	0	1
cited_nomciteoriginalpage	360385	333.7	328.5	0	9713
cited_statutedate	75103	1694.8	153.7	1235	1900
cited_statutechapter	66589	38.0	38.5	0	194
cited_statutechapterstotal	75103	69.3	48.3	1	196
cited_statutechapterspublic	75103	60.9	47.5	0	194

Table 3: Random sample of 25 case reports used in the process of data validation; the data was collected by manual inspection of the original English Reports

citing nomcite	citing casename	citing ER cite	citing date	citation in original	cited nomcite	reason if not extracted	cited nomcite correct	reason if cited nomcite incorrect	person citing	citation type	citation negative
1 beavan 228	Heighington v Grant	48 ER 927	1839								
			1839	My. & Cr. 258	5 mylne and craig 25		0	OCR error	ER editor	same case (reported)	0
			1839	10 L. J. Ch. (N. S.), 12		non-ER citation			ER editor	same case (reported)	0
			1839	4 Jur. 1052		non-ER citation			ER editor	same case (reported)	0
			1839	6 Beav. 458 (Attorney-General v. Lord Carrington, 1843)	6 beavan 45		0	OCR error	ER editor	later analogy	0
			1839	23 L. T. 347 (Feltham v. Turner, 1870)		non-ER citation			ER editor	later analogy	0
			1839	L. R. 6 Ch. 869 (Begbie v. Fenwick, 1871)		non-ER citation			ER editor	later analogy	0
			1839	49 L. J. Ch. 121 (Knight v. Purssell, 1879)		non-ER citation			ER editor	later analogy	0

			1839	Jenkins v. Jackson [1891], 1 Ch. 96.]		non-ER citation		ER editor	later analogy	0
			1839	2 Smith's Pr. 640		non-ER citation		counsel	analogy	0
2 peere williams 526	Cleaver v Spurling	24 ER 846	1729	Mos. 189	mosely 189		1	editor/reporter	same case (reported)	0
			1729	2 Eq. Ca. Ab. 270	2 equity cases abridged		1	editor/reporter	same case (reported)	0
			1729	Salk. 426	2 salkeld 426		1	court	analogy	0
			1729	2 Vern. 234, 629, 754	2 vernon's chancery cases 234		1	court	analogy	0
			1729	ante, 1 vol. 644		ante/post citations		court	analogy	0
			1729	post, 3 vol. 315		ante/post citations		court	analogy	0
			1729	1 Atk. 64	1 atkyns 64		1	court	analogy	0
			1729	1 Atk. 403	1 atkyns 403		1	court	analogy	0
			1729	1 Vern. 216	1 vernon's chancery cases 216		1	court	analogy	0
			1729	2 Vern. 630	2 vernon's chancery cases 630		1	court	analogy	0
			1729	1 Atk. 406			0	OCR error	court analogy	0
			1729	3 Atk. 527	3 atkyns 527		1	court	analogy (same case cited)	0

			1729	1 Wils. 168	1 wilson king's bench 168	1	court	analogy (same case cited)	0
			1729	1 vol. 634	ante/post citations		court	analogy	0
			1729	ante, I vol. 136	ante/post citations		court	analogy	0
			1729	post, 626	ante/post citations		court	analogy	0
			1729	Reg. Lib. A. 1728, fol. 314	non-ER citation		court	analogy	0
4 east 585	Smith v Woodward	102 ER 955	1804						
1 freeman 457	Woolley v Robinson	89 ER 341	1677	1 Vent. 309	1 ventris 309	1	ER editor	same case (reported)	0
			1677	T. Jo. 78	2 levinz 199	1	ER editor	same case (reported)	0
			1677	2 Lev. 199	jones t 78	1	ER editor	same case (reported)	0
			1677	3 Keb. 747	3 keble 747	1	ER editor	same case (reported)	0
			1677	Dy. 165	2 dyer 165	1	editor/re porter	analogy	0
			1677	Post, p. 463	ante/post citations		editor/re porter	later analogy	0
			1677	T. Jo. 79	jones t 79	1	editor/re porter	later analogy	0
			1677	1 Ld. Raym. 18	1 lord raymond 18	1	editor/re porter	later analogy	0

1677	2 Show. 335	2 shower kb 335		1	editor/re porter	later analogy	0
1677	2 Hawk. P. C. c. 15		non-ER citation		editor/re porter	later analogy	0
1677	Carth. 131-2	carthew 131		1	editor/re porter	later analogy	0
1677	ante, p. 2		ante/post citations		editor/re porter	analogy	0
1677	2 Ld. Ray. 1105	2 lord raymond 1105		1	editor/re porter	analogy (same case cited)	0
1677	2 Salk. 503	2 salkeld 503		1	editor/re porter	analogy (same case cited)	0
1677	1 Wils. 299	1 wilson king's bench 299		1	editor/re porter	analogy	0
1677	3 Wils. 188	3 wilson king's bench 188		1	editor/re porter	analogy (same case cited)	0
1677	2 W. Black. 754	2 blackston e w 754		1	editor/re porter	analogy (same case cited)	0
1677	8 Term Rep. 314	8 term reports 314		1	editor/re porter	analogy	0
1677	14 East, 1			0	citation not in standard format	analogy (same case cited)	0

1677	4 Taunt. 401	4 taunton 401		1	editor/re porter	analogy (same case cited)	0
1677	5 Dow. 199	5 dow pc 199		1	editor/re porter	analogy	0
1677	2 Chit. Rep. 207		non-ER citation		editor/re porter	analogy	0
1677	2 Hawk. P. C. c. 15, § 73- 4		non-ER citation		editor/re porter	analogy	0
1677	2 Hats. Preced. Appendix		non-ER citation		editor/re porter	analogy	0
1677	6 Howell's State Tri. p. 1297		non-ER citation		editor/re porter	analogy	0
1677	1 Timberla nd's Lords' Debates, p. 196		non-ER citation		editor/re porter	analogy	0
1677	2 Salk. 417	2 salkeld 417		1	editor/re porter	later analogy	0
1677	5 Barn. & Ald. 617	5 barnewall and alderson 617		1	editor/re porter	later analogy	0
1677	1 Camph. 352		non-ER citation		editor/re porter	later analogy	0
1677	S. C. ante, p. 396, 407		ante/post citations		editor/re porter	later analogy	0

3 bosanquet and puller 444	Birch v Bishop of Litchfield	127 ER 241	1803	[1894] 3 Ch. 169	non-ER citation		ER editor	later analogy	0	
			1803	Bro. Abr. tit. Quare Impedit, pl. 118	non-ER citation		counsel	analogy	0	
			1803	Willes, 659		0	citation not in standard format	counsel	analogy	0
			1803	7 Ann. c. 18	7 anne 18	1		counsel	analogy	0
			1803	2 Str. 925	2 strange 925	1		counsel	analogy (same case cited)	0
			1803	Fitzg. 247	fitz- gibbon 247	1		counsel	analogy (same case cited)	0
			1803	2 Bl. 770		0	abbreviation ambiguous	counsel	analogy	0
			1803	3 Wils. 221	3 wilson king's bench 221	1		counsel	analogy	0
			1803	Winch. Ent. p. 825 (a)			non-ER citation	counsel	analogy	0
2 salkeld 478	Rex v Beard	91 ER 411	1697	Ante, pl. 8, 10, 18	ante/post citations		editor/re porter	analogy	0	
			1697	Post, pl. 50	ante/post citations		editor/re porter	analogy	0	
			1697	Post, pl. 34	ante/post citations		editor/re porter	analogy	0	
			1697	6 Mod. 180	6 modern 180	1		editor/re porter	later analogy	0

St Mary Le More Parish v Heavy Tree in Devonshire	1697	2 BI. Rep. 1017	2 blackstone w 1017		1	editor/reporter	analogy	0	
	1697	And. 238			0	abbreviation ambiguous	editor/reporter	analogy	0
	1697	Videpost, 523, pl. 1, and pag. 536		ante/post citations			editor/reporter	analogy	0
	1697	1 Show. 12	1 shower kb 12		1		editor/reporter	analogy	0
	1697	Comb. 284, 410	comberbach 284		1		editor/reporter	analogy	0
	1697	8 Mod. 38	8 modern 38		1		editor/reporter	later analogy	0
	1697	Bur. S. C. 465, 73, 522, 627			0	citation not in standard format	editor/reporter	later analogy	0
	1697	Cald. 103, 276, 365		non-ER citation			editor/reporter	later analogy	0
	1697	2 Const. 233		non-ER citation			editor/reporter	later analogy	0
	1697	Cald. 379		non-ER citation			editor/reporter	later analogy	0
St Giles Cripplegate Parish v Hackney Parish	1697	5 T. R. 240	5 term reports 240		1		editor/reporter	later analogy	0
	1697	ante, pl. 7		ante/post citations			editor/reporter	analogy	0
	1697	post, pl. 26		ante/post citations			editor/reporter	later analogy	0

			1697	post, pag. 491		ante/post citations		editor/re porter	later analogy	0
			1697	Comb. 413	comberba ch 413		1	editor/re porter	later analogy	0
			1697	Doug. 662	2 douglas 662		1	editor/re porter	later analogy	0
			1697	Str. 73	1 strange 73		1	editor/re porter	later analogy	0
			1697	1 Mod. 20	1 modern 20		1	editor/re porter	analogy	0
			1697	1 Vent. 210	1 ventris 210		1	editor/re porter	analogy	0
			1697	2 Keb. 23	2 keble 23		1	editor/re porter	analogy	0
	Rex v Barebaker		1697	Comb. 320, 321	comberba ch 320		1	editor/re porter	analogy	0
			1697	S. C. Ante, 121		ante/post citations		editor/re porter	analogy	0
			1697	Black. 234			0	abbreviation ambiguous	editor/re porter	analogy 0
			1697	Set. and Rem. 145		non-ER citation		editor/re porter	analogy	0
			1697	2 Str. 788	2 strange 788		1	editor/re porter	later analogy	0
tamlyn 77	Devey v Peace	48 ER 32	1829							
croke and elizabeth 106	East and Wilson	78 ER 364	1588	Dyer, 203			0	citation not in standard format	editor/re porter	later analogy 0
			1588	2 Hawk. 351		non-ER citation		editor/re porter	later analogy	0
			1588	8 Hen. 6. c. 9	8 hen. 6 ch. 9		1	court	analogy	0
			1588	Ld. Raym. 151			0	OCR error	editor/re porter	later analogy 0

			1588	1 T. Rep. 637		0	OCR error	editor/re porter	later analogy	0
			1588	S. C. 2 Leon. 165	2 leonard 165	1		editor/re porter	same case (reported)	0
			1588	10 Co. 125. a		0	OCR error	editor/re porter	later analogy	0
			1588	Plow. 345	1 plowden 345	1		editor/re porter	analogy	0
			1588	Dalis. 78	benloe & dalison 78	1		editor/re porter	analogy	0
			1588	Owen, 35		0	citation not in standard format	editor/re porter	analogy	0
			1588	10 Rep. 57	10 coke report 57	1		editor/re porter	later analogy	0
1 simons and stuart 463	Davies v Wattier	57 ER 184	1823	3d Geo. 4, c. 9		0	error in original ER	counsel	analogy	0
3 atkyns 388	Joynes v Statham	26 ER 1023	1746	1 Sch. & Lef. 38				editor/re porter	later analogy	0
			1746	statute of frauds and perjuries	statute of frauds	1		counsel	analogy	0
			1746	5 Co. 68	5 coke report 68	1		counsel	analogy	0
			1746	Cas. in Lord Talbot's time, 248		0	citation not in standard format	counsel	analogy	0
			1746	2 Tr. Atk. Case, 92, pa. 98				counsel	analogy	0

			1746	[Atk.], 2 vol. 99	ante/post citations		court	analogy	0
			1746	3 Bro. Cha. Rep. 154	3 brown's chancery cases 154	1	court	analogy	0
15 vesey junior 1	Anonymo us	33 ER 655	1808						
2 equity cases abridged 643	Roseberry v Taylor	22 ER 539	1718	16 Vin. Abr. 442, pl. 1	non-ER citation		court	analogy (same case cited)	0
			1718	S. C. 6 Bro. P. C. 43	6 brown pc	1	court	analogy (same case cited)	0
			1718	10 Mod. 402	10 modern 402	1	court	analogy	0
			1718	Ca.8 [2 Eq. Ca. Abr.], P. 641.		0	citation not in standard format	court analogy	0
			1718	1 Will. Rep. 707		0	abbreviation peculiar	court analogy	0
			1718	2 Will. Rep. 486		0	abbreviation peculiar	court analogy	0
5 taunton 170	Doe d Brandon v Calvert	128 ER 652	1813						
3 hurlstone and coltman 209	King v Walker	159 ER 509	1864	S. C. 33 L. J. Ex. 325	non-ER citation		ER editor	same case (reported)	0
			1864	11 Jur. (N. S.) 43	non-ER citation		ER editor	same case (reported)	0

1864	13W. R. 232	non-ER citation		ER editor	same case (reported)	0
1864	2 H. & C. 384	2 hurlstone and coltman 384	1	counsel	analogy	0
1864	Arnould on Insurance, § 370, p. 1027, 2nd ed	non-ER citation		counsel	analogy	0
1864	1 Bing. 445	1 bingham 445	1	counsel	analogy	0
1864	4 C. & P. 276	4 carrington and payne 276	1	counsel	analogy	0
1864	7 M. & W. 322	7 meeson and welsby 322	1	counsel	analogy	0
1864	2 B. & C. 691	2 barnewall and cresswell 691	1	counsel	analogy	0
1864	1 Bing. N. C. 526	1 bingham nc 526	1	counsel	analogy	0
1864	3 Bing. N. C. 266	3 bingham nc 266	1	counsel	analogy	0
1864	1 H. L. .Cas. 287, 304	1 house of lords cases 287	1	counsel	analogy	0
1864	9 C. B. 94	9 common bench 94	1	counsel	analogy	0
1864	1 H. L. Cas. 513, 535	1 house of lords cases 513	1	counsel	analogy	0
1864	2 H. & C. 385	2 hurlstone and coltman 385	1	counsel	analogy	0
1864	2 Burr. 904	2 burrow 904	1	counsel	analogy	0
1864	1 Doug. 315	1 douglas 315	1	counsel	analogy	0

1864	2 Wms. 'Saud. 202, n.	2 wms saunders 202	1		counsel	analogy	0
1864	1 E. & B. App. lxxix					non-ER citation	counsel analogy 0
1864	2 B. & S. 814	2 best and smith 814	1		counsel	analogy	0
1864	Park on Insurance, 400, note, 8th ed					non-ER citation	counsel analogy 0
1864	15 Q. B. 649	15 queen's bench 649	1		counsel	analogy	0
1864	5 M. & Sel. 47	5 maule and selwyn 47	1		counsel	analogy	0
1864	6 Taunt. 68	6 taunton 68	1		counsel	analogy	0
1864	14 East, 465		0	citation not in standard format	counsel	analogy	0
1864	1 T. R. 608, 613	1 term report 608	1		counsel	analogy	0
1864	2 B. & C. 691	2 barnewall and cresswell 691	1		court	analogy	0
1864	9 C. B. 94	9 common bench 94	1		court	analogy	0
1864	15 Q. B. 649, 669	15 queen's bench 649	1		court	analogy	0
1864	4 C. & P. 276	4 carrington and payne 276	1		editor/reporter	analogy	0

style 300	Whitway v Pinsent	82 ER 726	1864	7 M. & W. 322	7 meeson and welsby 322	1		editor/re porter	analogy	0	
			1651								
			1651 1651								
1 salkeld 221	Countess of Arran v Crispe	91 ER 196	1693	Ante, 198				ante/post citations	editor/re porter	analogy	0
			1693	Cases B. R. 54				non-ER citation	editor/re porter	analogy	0
			1693	Holt 549	holt k b 549	1		editor/re porter	analogy	0	
			1693	Comb. 211.	comberba ch 211	1		editor/re porter	analogy	0	
			1693	Post, 615				ante/post citations	editor/re porter	analogy	0
			1693	Yelv. 96, 97	yelverton 96	1		editor/re porter	analogy	0	
			1693	1 Ro. Ab. 879				non-ER citation	editor/re porter	analogy	0
			1693	2 Wils. 313	2 wilson king's bench 313	1		editor/re porter	analogy	0	
			1693	3 Wils. 20	3 wilson king's bench 20	1		editor/re porter	analogy	0	
			1693	1 T. R. 12	1 term report 12	1		editor/re porter	analogy	0	
			1693	11 Geo. 2, c. 19	11 geo. 2	1		editor/re porter	analogy	0	
			1693	Bull. N. P. 81				non-ER citation	editor/re porter	analogy	0
			1 vernon's chancery cases 140	Barker v Wyld	23 ER 373	1682	Eq. Ca. Ab. 35, pl. 4,		0	citation not in standard format	editor/re porter

1682	3 P. Wms. 237	3 peere williams 237		1	editor/re porter	later analogy	0	
1682	1 Ch. Ca. 21	1 chancery cases 21		1	editor/re porter	analogy	0	
1682	Prac. Reg. 375		non-ER citation		editor/re porter	later analogy	0	
1682	Mosely 296	mosely 296		1	editor/re porter	later analogy	0	
1682	Prac. Reg. 375		non-ER citation		editor/re porter	later analogy	0	
1682	post, 2 vol. 195		ante/post citations		editor/re porter	later analogy	0	
1682	2 P. Wins. 313	2 peere williams 313		1	editor/re porter	later analogy	0	
1682	2 Dick. 738	dickens 738		1	editor/re porter	later analogy	0	
1682	3 Swan. 147	3 swanston 147		1	editor/re porter	later analogy	0	
1682	6 Madd.11 3	6 maddock 113		1	editor/re porter	later analogy	0	
1682	1 S. & S. 246	1 simons and stuart 246		1	editor/re porter	later analogy	0	
1682	Pre. Ch. 83			0	abbreviation peculiar	editor/re porter	later analogy	0
1682	ibid. 592		ante/post citations		editor/re porter	later analogy	0	
1682	Hard. 333	hardres 333		1	editor/re porter	analogy	0	
1682	11 Ves. 429	11 vesey junior 429		1	editor/re porter	later analogy	0	

			1682	13 Ves. 397	13 vesey junior 397		1	editor/re porter	later analogy	0
			1682	16 Ves. 321	16 vesey junior 321		1	editor/re porter	later analogy	0
			1682	2 Swan. 277	2 swanston 277		1	editor/re porter	later analogy	0
			1682	2 S. & S. 67	2 simons and stuart 67		1	editor/re porter	later analogy	0
			1682	ib. 267		ante/post citations		editor/re porter	later analogy	0
1 chancery reports 174	Cooper v Tragonwe l	21 ER 541	1659							
3 common bench 963	Fletcher v Tanner	136 ER 386	1847	6 Dowl. P. C. 155		non-ER citation		counsel	analogy	0
			1847	Archbold's Practice (7th edit., by Chitty, p. 994		non-ER citation		counsel	analogy	0
			1847	6 Ed. 1, c. 8	6 edw. 1 c. 8		1	counsel	analogy	0
			1847	1 Mann. & R. 321		non-ER citation		counsel	analogy	0
			1847	3 Dowl. P. C. 294		non-ER citation		counsel	analogy	0
3 de gex and smale 347	Davies v Thorns	64 ER 510	1849	18 L. J. Ch. 212		non-ER citation		ER editor	same case (reported)	0
			1849	13 Jur. 383		non-ER citation		ER editor	same case (reported)	0
			1849	Wills Act of 1837	statute of wills		1	editor/re porter	analogy	0

			1849	2 Mer. 533	2 merivale 533		1	counsel	analogy	0
			1849	1 Swanst. 66	1 swanston 66		1	counsel	analogy	0
			1849	3 Mer. 437	3 merivale 437		1	counsel	analogy	0
			1849	2 Id., 533		ante/post citations		counsel	analogy	0
			1849	1 Y. & J. 445	1 younge and jervis 445		1	counsel	analogy	0
			1849	8 Sim. 561	8 simons 561		1	counsel	analogy	0
			1849	9 Sim. 447	9 simons 447		1	counsel	analogy	0
			1849	5 Ves. 399	5 vesey junior 399		1	counsel	analogy	0
			1849	2 Phil. 635	2 phillips 635		1	counsel	analogy	0
2 strange 716	Rex v Reeks	93 ER 803	1726	1 N. R. 277		non-ER citation		ER editor	later analogy	0
			1726	9 & 10 W. 3, c. 25	10 will. 3 ch. 25		1	editor/re porter	analogy	0
			1726	L. Raym. 1445	raymond sir t 1445		1	editor/re porter	same case (reported)	0
			1726	1 Barn. B. R. 8, S. C.		non-ER citation		editor/re porter	same case (reported)	0
			1726	ante, 624		ante/post citations		court	analogy	0
			1726	Doug. 217	1 douglas 21		0	OCR error editor/re porter	later analogy	0

			1726	ante, 584		ante/post citations		editor/re porter	analogy	0
			1726	post, 1105		ante/post citations		editor/re porter	analogy	0
			1726	L.R. 7 Q. B. 21	7 queen's bench 21		1	ER editor	later analogy	0
			1726	L. Raym. 1423	raymond sir t 1423		1	editor/re porter	same case (reported)	0
			1726	1 Sess. Ca. 272, pl. 213, S. C.	sessions cases 272		1	editor/re porter	same case (reported)	0
			1726	1 Vent. 59	1 ventris 59		1	editor/re porter	analogy	0
			1726	Cro. Car. 350	croke car 350		1	editor/re porter	analogy	0
			1726	2 Bulst. 355	2 bulstrode 355		1	editor/re porter	analogy	0
4 beavan 225	In re Fowey Charities	49 ER 325	1841	S. C. 10 L. J. Ch. 368.		non-ER citation		ER editor	same case (reported)	0
			1841	2 W. 4, c. 57	2 will. 4 ch. 57		1	counsel	analogy	0
			1841	(Reg. Lib. 1840, B. 885)		non-ER citation		court	analogy	0
			1841	Act of 59 G. 3, c. 91			0	OCR error editor/re porter	analogy	0
			1841	52 G. 3, c. 101. (Sir Samuel Romilly's Act.)			0	OCR error court	analogy	0

10 bingham 406	Smith v Smyth	131 ER 961	1834	2 B. & Ald. 304	2 barnewall and alderson 304	1		court	analogy	0
carthew 213	Jones v Bew	90 ER 728	1692	4 Mod. 16, S. C.	4 modern 16	1		editor/re porter	same case (reported)	0
			1692	1 Show. 288, S. C.		0	OCR error	editor/re porter	same case (reported)	0
			1692	11 Rep. 1		0	OCR error	editor/re porter	analogy	0
			1692	Cro. 258.		0	abbreviation ambiguous	editor/re porter	analogy	0
			1692	Bridg. 29	bridgman j 29	1		editor/re porter	analogy	0
			1692	Cro.Car. 47	croke car 47	1		editor/re porter	analogy	0
			1692	10 Rep. 58	10 coke report 58	1		editor/re porter	analogy	0
			1692	Comb. 305	comberba ch 305	1		editor/re porter	analogy	0
3 barnewall and cresswell 658	Spenceley v Robinson	107 ER 877	1825	17 G. 3, c. 3	17 geo. 3 ch.3	1		editor/re porter	analogy	0
			1825	S. C. 5 D. & R. 572			non-ER citation	ER editor	same case (reported)	0
			1825	17 G. 2, c. 3	17 geo. 2 ch.3	1		counsel	analogy	0
			1825	17 G. 2, c. 38	17 geo. 2 ch.38	1		counsel	analogy	0
			1825	41 G. 3, c. 28	41 geo. 3 ch. 28	1		counsel	analogy	0

Table 4: Summary statistics of data reliability variables in random sample with 25 case reports

variable	number in original ER report	number extracted	extraction rate	comments
citing_nomcite	38	38	100%	
citing_date	38	38	100%	
citations to non-ER documents	48	0	0%	
citations to ER cases (ante/post format)	26	0	0%	
citations to ER cases (nominate format) or statutes	160			
correctly extracted ER cases (nominate format) or statutes		132	82.5%	
incorrectly extracted ER cases (nominate format) or statutes		3	1.8%	wrong page numbers due to OCR error
not extracted ER cases (nominate format) or statutes		25	15.7%	9 not in standard format 8 with OCR error 4 ambiguous reporter abbreviations 3 abbreviation not in dictionary 1 error in original ER

Table 5: Summary statistics of citation content variables in random sample with 25 case reports

	pre-1700	post-1700	total
person citing			
counsel	0 (0%)	43 (54.4%)	43
court	1 (1.3%)	20 (25.3%)	21
editor/reporter	74 (93.7%)	13 (16.5%)	89
ER editor	4 (5.1%)	3 (3.8%)	7
citation type			
analogy	32 (40.5%)	67 (82.7%)	99
later analogy	32 (40.5%)	3 (3.7%)	35
analogy (same case cited)	6 (7.6%)	5 (6.2%)	11
same case (reported)	9 (11.4%)	6 (7.4%)	15
citation negative			
negative	0	0	0

Table 6: List of the 20 most cited common law case reports (citations between the years 1700 and 1865)

cited_nomcitematched	cited_date	cites
1 wms saunders 319	1669	87
1 coke report 93	1581	64
1 burrow 38	1756	60
6 adolphus and ellis 469	1837	59
8 coke report 66	1608	59
3 coke report 25	1591	56
1 ventris 225	1672	54
2 lord raymond 909	1703	54
2 wms saunders 380	1671	53
3 coke report 19	1587	52
3 term reports 51	1789	50
1 wms saunders 228	1669	50
8 coke report 121	1610	49
3 coke report 80	1601	49
6 coke report 16	1595	49
8 coke report 146	1610	49
cases temp hardwicke 28	1734	48
2 douglas 684	1781	47
1 salkeld 13	1698	47
2 wms saunders 47	1670	45

Table 7: Estimations of exponential model to capture overall time depreciation; English case precedents, U.S. case precedents, English statutes

	(1) logcites	(2) uslogcites	(3) statutelgcites
timediff	-0.0142*** (0.000382)	-0.0405*** (0.000378)	-0.00710*** (0.000151)
_cons	7.287*** (0.0623)	8.984*** (0.0427)	5.338*** (0.0531)
<i>N</i>	282	195	606
<i>R</i> ²	0.83	0.98	0.78

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Modularity scores for the 2 different community detection algorithms and 3 different predetermined community sizes

number of communities	modularity spinglass	modularity louvain
2	0.41	0.37
3	0.53	0.47
4	0.59	0.53

Table 9: Time profile correlations between cited semi-decades of select citing decades
(compare Figure 26)

	1700	1720	1740	1760	1780	1800	1820	1840	1860
1700	1.00								
1720	0.93	1.00							
1740	0.91	0.94	1.00						
1760	0.87	0.91	0.96	1.00					
1780	0.95	0.92	0.90	0.68	1.00				
1800	0.85	0.93	0.95	0.81	0.53	1.00			
1820	0.89	0.85	0.90	0.81	0.45	0.90	1.00		
1840	0.90	0.90	0.84	0.83	0.53	0.85	0.77	1.00	
1860	0.87	0.93	0.90	0.90	0.63	0.83	0.78	0.86	1.00

Table 10: Overlaps between members of the two detected spinglass and Louvain communities

	louvain community 1	louvain community 2	total
spinglass community 1	15,465 74.0%	5,443 26.0%	20,908
spinglass community 2	3,311 15.5%	18,062 84.5%	21,373
total	18,776	23,505	42,281

Figures

Figure 1: Stylized view on the Court of King's Bench (back left), the Court of Chancery (back right), and the Court of Common Pleas (right), and the surrounding life in Westminster Hall in the year 1797 (excerpt from a satirical pamphlet)¹³²



¹³² The source of the illustration is http://www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=3300618&partId=1

Figure 2: Reproduction from English Reports of the first volume of Taunton's Court of Common Pleas reports: page 210; the nominate citation is 1 Taunton 210, the English Reports citation is 127 ER 813

1 TAUNT. 210.

FINLAY v. SEATON

813

that his subsequent occupation, though continued for more than thirty years, cannot vary the right to it.

Williams, *contra*, observed that in *Barwick v. Thompson* the lease was still subsisting at the time of the ejection brought, and contended that according to the doctrine [210] recognized in the case of *Blake v. Foster*, 8 T. R. 496, the estoppel determined by the expiration of the lease.

The Court thought that the affidavits suggesting circumvention were not sufficiently positive; and observed, that if the Defendant could substantiate those facts, she might recover in another ejection: and without intimating that they saw cause to be dissatisfied with the verdict, or the direction of the Judge, on any other of the grounds taken, they

Discharged the Rule.

FINLAY v. SEATON. May 5, 1808.

[Applied, *Reeve v. Gibson*, [1891] 1 Q. B. 658. Discussed, *North Metropolitan Tramways Company v. London County Council*, [1898] 2 Ch. 145.]

Neither a certificate from the Judge, nor a suggestion on the roll, is necessary to entitle a Defendant to double costs, under 11 G. 2, c. 19, s. 21.

Trespass for seizing a cable. The Defendant pleaded the general issue; and upon the trial proved in evidence that he had taken it as a distress for rent due from a third person, on whose premises it had been placed by the Plaintiff. Double costs having been taxed for the Defendant under the directions of the statute 11 Geo. 2, c. 19, s. 21, Vaughan, Serjt. had obtained a rule nisi that the prothonotary might review his taxation. Being called upon to support his rule, he contended that to authorize the allowance of double costs, it was necessary, either that the Defendant should previously obtain from the Judge who tried the cause, a certificate that the case came within this act; or that a suggestion should first be entered on the record, whereby the nature of the action might appear. He urged, that the prothonotary could not again try the cause at the taxation of costs; he could only look at the roll; and upon the roll the circumstances of the cause of action do not appear. If a certificate was necessary, it was now too late to obtain it, [211] according to the doctrine laid down in the case of *Grindley v. Holloway*, 1 Doug. 308, which arose on the statute 7 Jac. 1, c. 5. He also contended, that the owner of the cable not being the lessee, this could not be considered as a question between landlord and tenant.

MANSFIELD C. J. This act gives the Judge no authority to certify, therefore the omission to apply to the Judge cannot in this case deprive the landlord of his remedy. There is no question but that the double costs are to be paid: the only remaining question then is, whether a suggestion upon the record is requisite to shew on what ground they are given. But it does not appear on the record that the Defendant has double costs; therefore it is not necessary to suggest on the record, that there is a cause for double costs. It is not necessary that the judgment should specify more than that a certain sum is allowed for costs, and then all will be right; and it is admitted that no precedent of such a suggestion is to be found. No fact was in dispute between the parties before the prothonotary; it was not denied that the action was brought against the landlord for a distress, so that the prothonotary had sufficient information for his guidance.

HEATH J. observed, that in cases on the small debt acts the courts have allowed a suggestion to be made on the record, although no suggestion is given in the acts.

LAWRENCE J. [Adverting to Vaughan's last argument]. This case clearly comes within the act, the purpose of which is to enable landlords the better to recover their rents.

Shepherd, Serjt. *contra*.
Rule discharged.

Figure 3: Reproduction of case report 1 Taunton 210 after export from Juta Law database (compare with previous page); targeted case information is shaded in dark gray, targeted case citations and statute citations are shaded in light gray

Finlay v Seaton 1 Taunton 210, 127 ER 813

Report Date: 1808

FINLAY v SEATON. May 5, 1808.

[Applied, Reeve v Gibson, [1891] 1 Q. B. 658. Discussed, North. Metropolitan Tramways Company v London County Council, [1898] 2 Ch 145.]

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HEATH J. observed, that in cases on the small debt acts the courts have allowed a suggestion to be made on the record, although no suggestion is given in the acts.

LAWRENCE J. [Adverting to Vaughan's last argument]. This case clearly comes within, the act, the purpose of which is to enable landlords the better to recover their rents.

Shepherd, Serjt. contra.

Rule discharged,

Figure 4: Reproduction from the English Reports of two case reports with the same nominate citation 1 Taunton 64

[64] BALL *v.* ADRIAN. Nov. 28, 1807.

If an action be brought without the knowledge of the Plaintiff, who is out of the realm, the Court will require security for the costs to be given on the part of the Plaintiff.

The Plaintiff went to America before the cause of this action arose, leaving a power of attorney to dispose of her effects here to one Guest, who employed the Defendant to sell some goods by auction, and directed this action to be brought for the proceeds. The Defendant had obtained a rule nisi that the Plaintiff might give security for the costs, and that the Plaintiff's attorney might produce the authority under which he sued. The Court discharged that part of the rule which required the production of the authority, but as to the security for costs, made the
Rule absolute.

SCHOLEY AND ANOTHER *v.* MANSELL POWELL. Nov. 28, 1807.

Notice of applying to a wrong Court for discharge of an insolvent is not cured by the Plaintiff's opposing his discharge.

Vaughan Serjt. opposed the discharge of the Defendant, an insolvent debtor, on the ground that his notice was, "that he intended to petition his Majesty's Court of King's Bench for relief." The Court were at first inclined to think the irregularity was cured by the Plaintiff's appearing to oppose him; but on the consideration that he would certainly have been discharged if the Plaintiff had not appeared, they remanded the prisoner.

Figure 5: Part of citation network that is a depiction of the case reports (nodes) and citations (links) mentioned in the ER case report 1 taunton 210

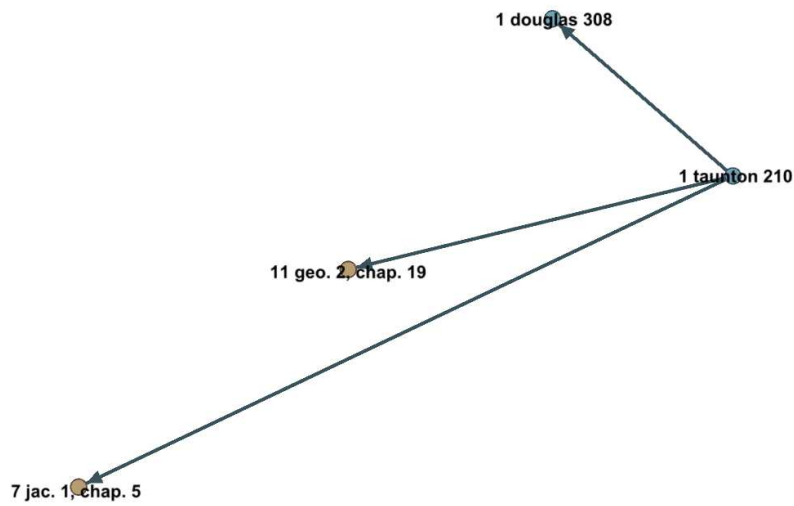


Figure 6: Illustration of how cumulative cultural evolution is reflected in a citation network; cases (numbered nodes) build on cases of previous periods to construct new legal rules; citations (links) point to the nodes used in the innovation process

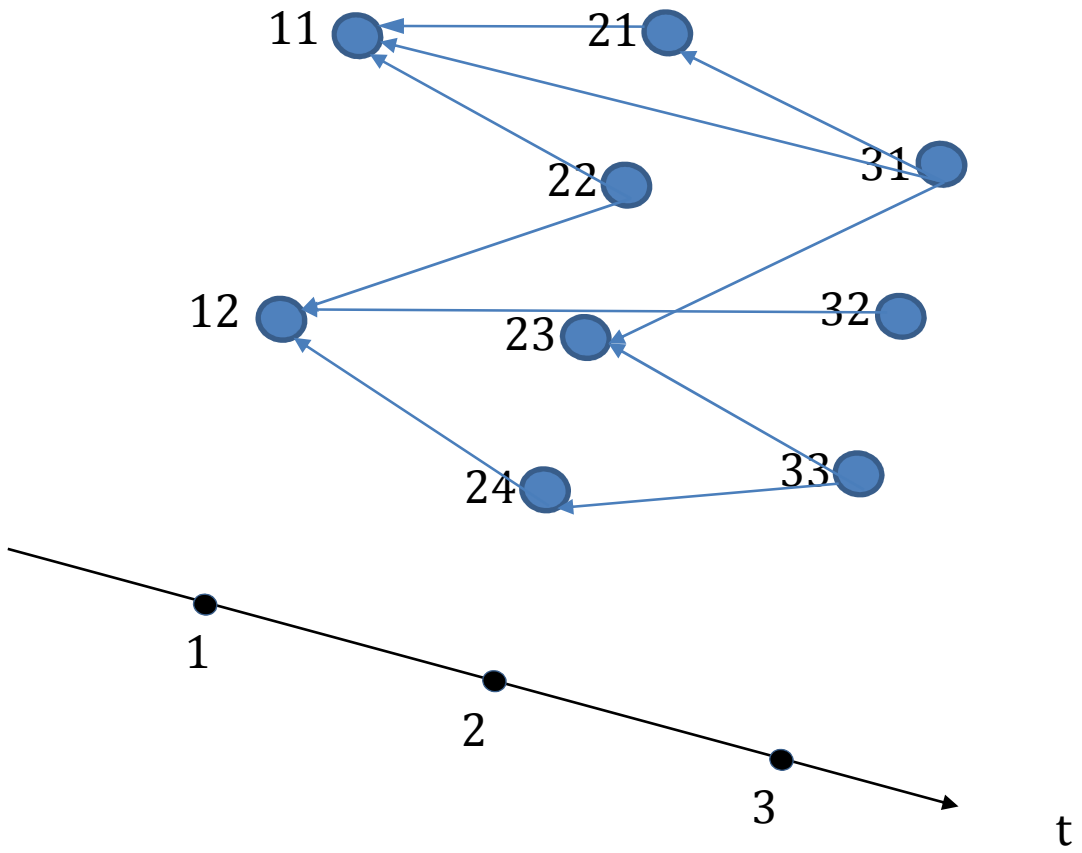


Figure 7: Annual number of ER case reports for common law and equity law courts; the red line lowess-smoothes the data

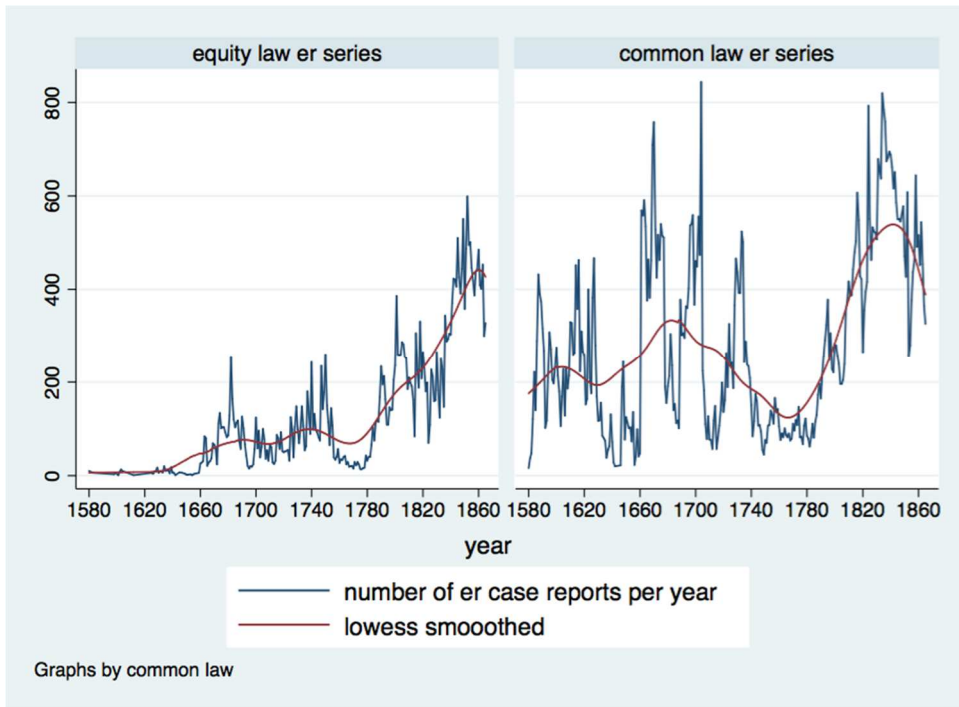


Figure 8: Cases in advanced stages in King’s Bench and Common Pleas, 1640-1830; reproduced from Brooks (1989, p. 68)

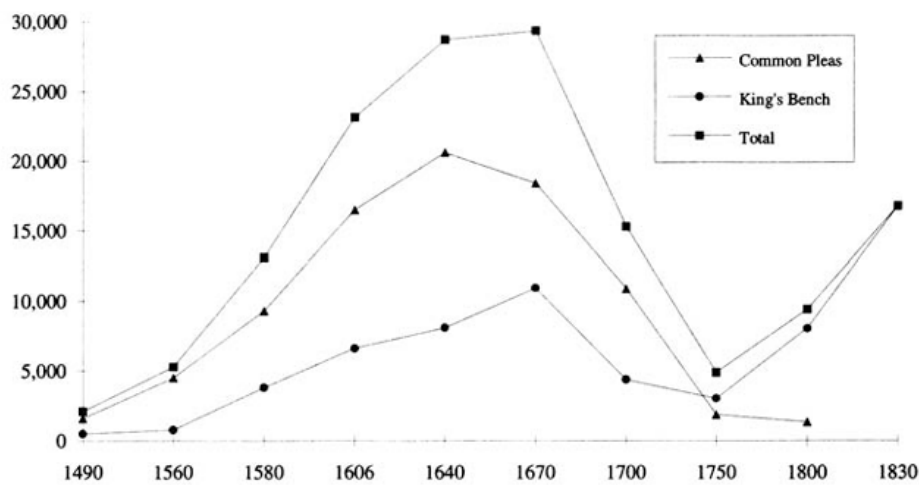


Figure 9: Relative distribution of citations between equity law and common law; dashed lines represent predictions from a random citing model; English case precedents

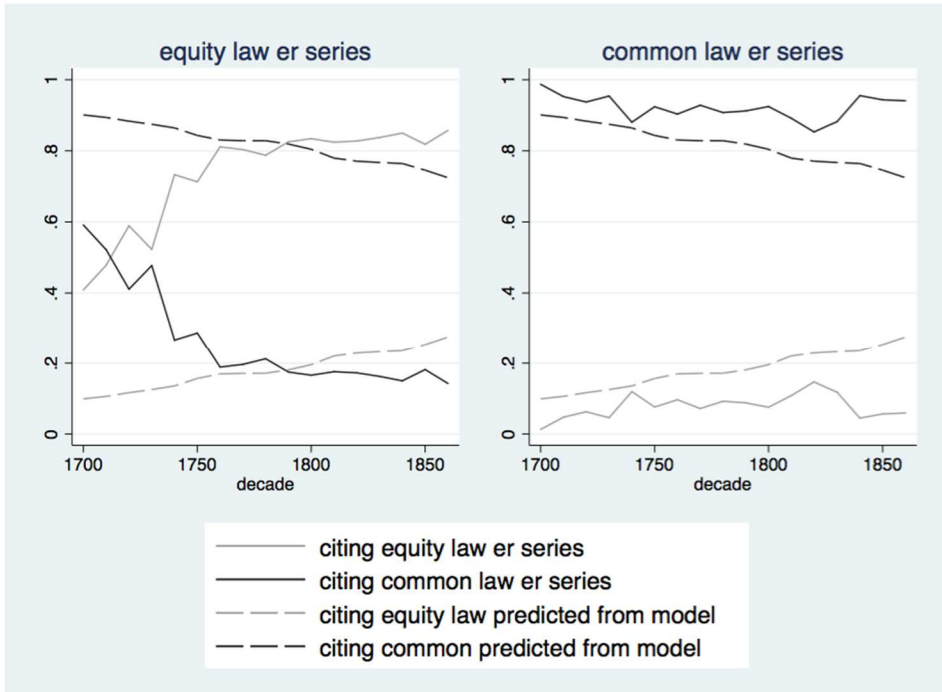


Figure 10: Relative distribution of citations between common law's courts of King's Bench, Common Pleas and Exchequer; dashed lines represent predictions from a random citing model; English case precedents

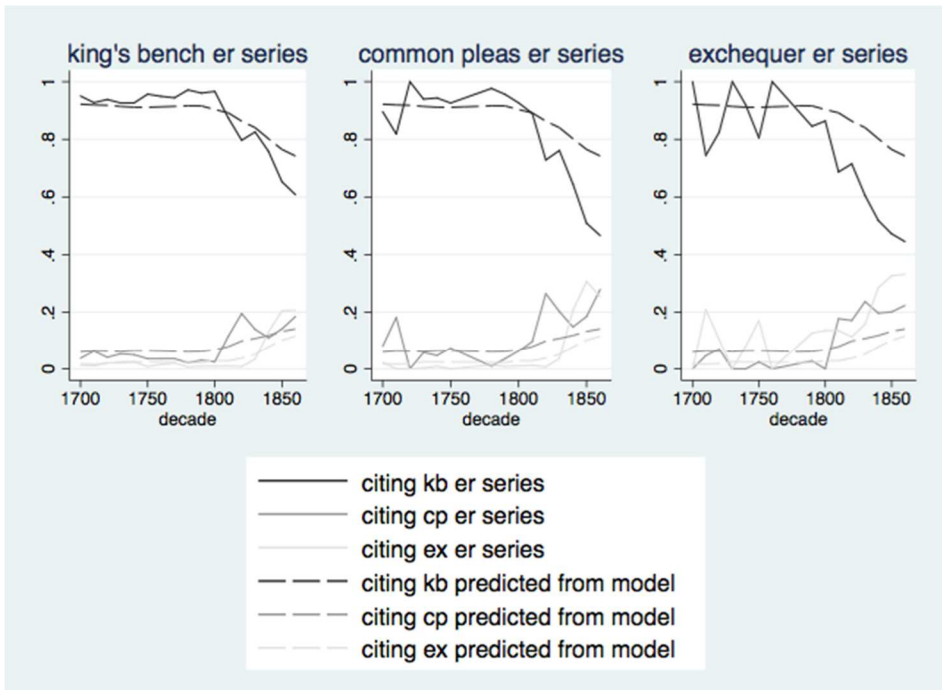


Figure 11: Frequency distribution of citing dates of the 5 most cited common law cases; the red line lowess-smoothes the data; English case precedents

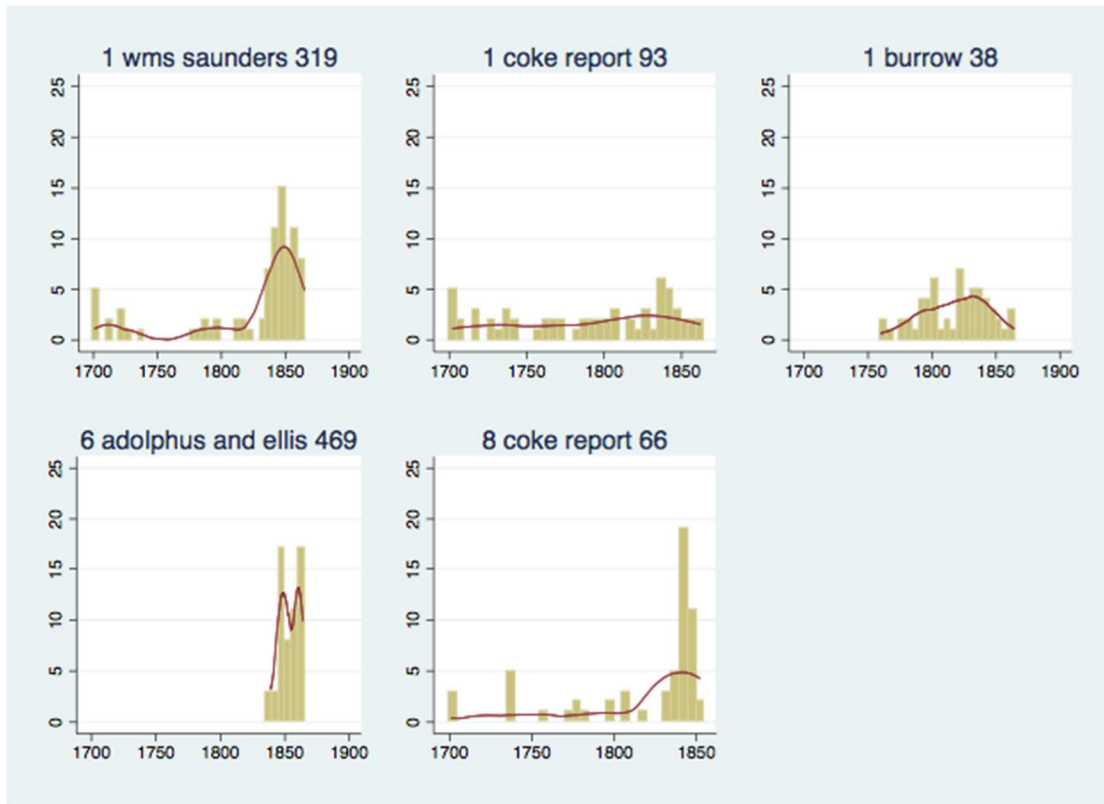


Figure 12: Frequency distribution of citations by the age of cited cases (age is the time difference between the date of the citing case and the date of the cited case); predictions from random citing model appear as red line; English case precedents

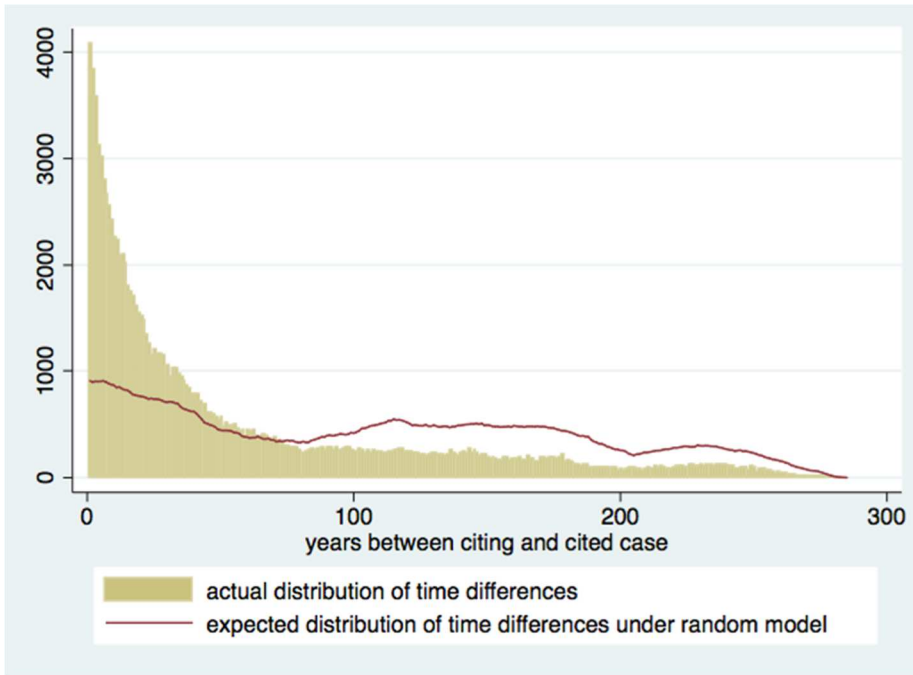


Figure 13: Log frequency distribution of citations by the age of cited cases (age is the time difference between the date of the citing case and the date of the cited case); predictions from simple exponential model appear as red line; English case precedents

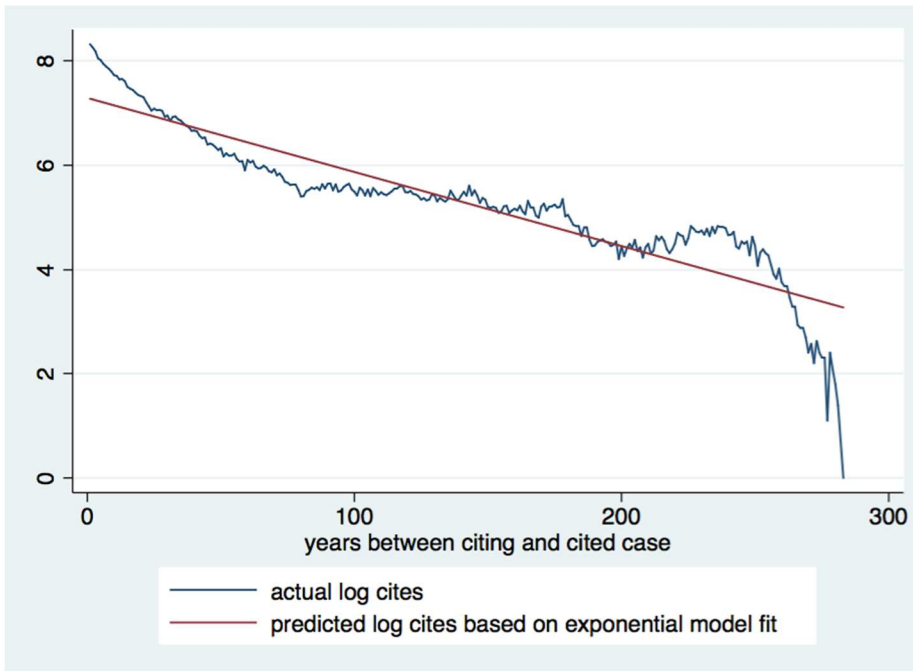


Figure 14: Frequency distribution of cases by number of received citations, also known as indegree distribution (complete on the left side, restricted enlarged on the right side); English case precedents

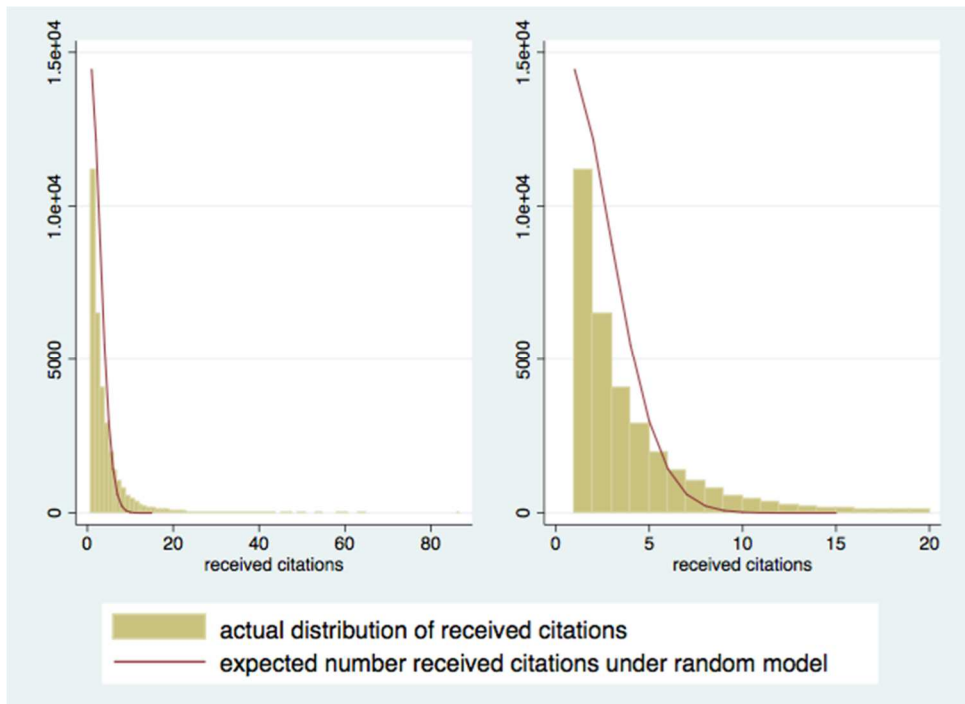


Figure 15: Decade average number of new citations relative to previously accumulated citations (weighted by citations and averaged over decades); English case precedents

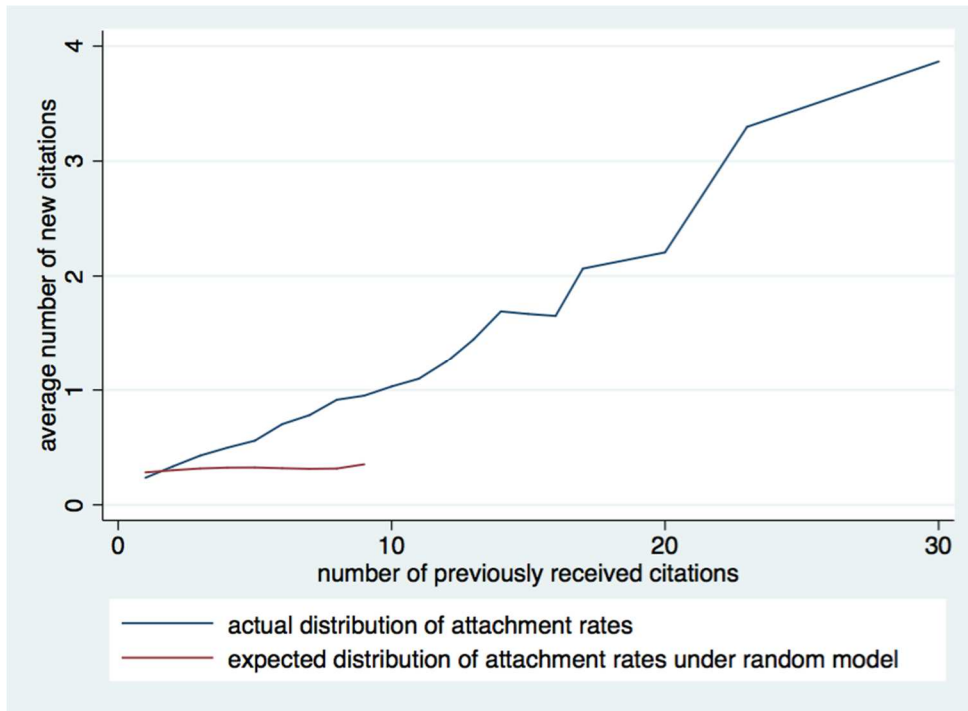


Figure 16: Degree of long-term persistence of case rulings for two representative decades (1580-1589 and 1700-1709); the degree of long term-persistence is the time difference between the trial date of a case and its most recent citing date; actual observations on the left (589 cases from the 1580's were cited at least once in the 18th and 19th centuries; analogously, 1353 cases from the 1700's were cited at least once in the 18th and 19th centuries); on the right appear the predictions from a random citing model; English case precedents

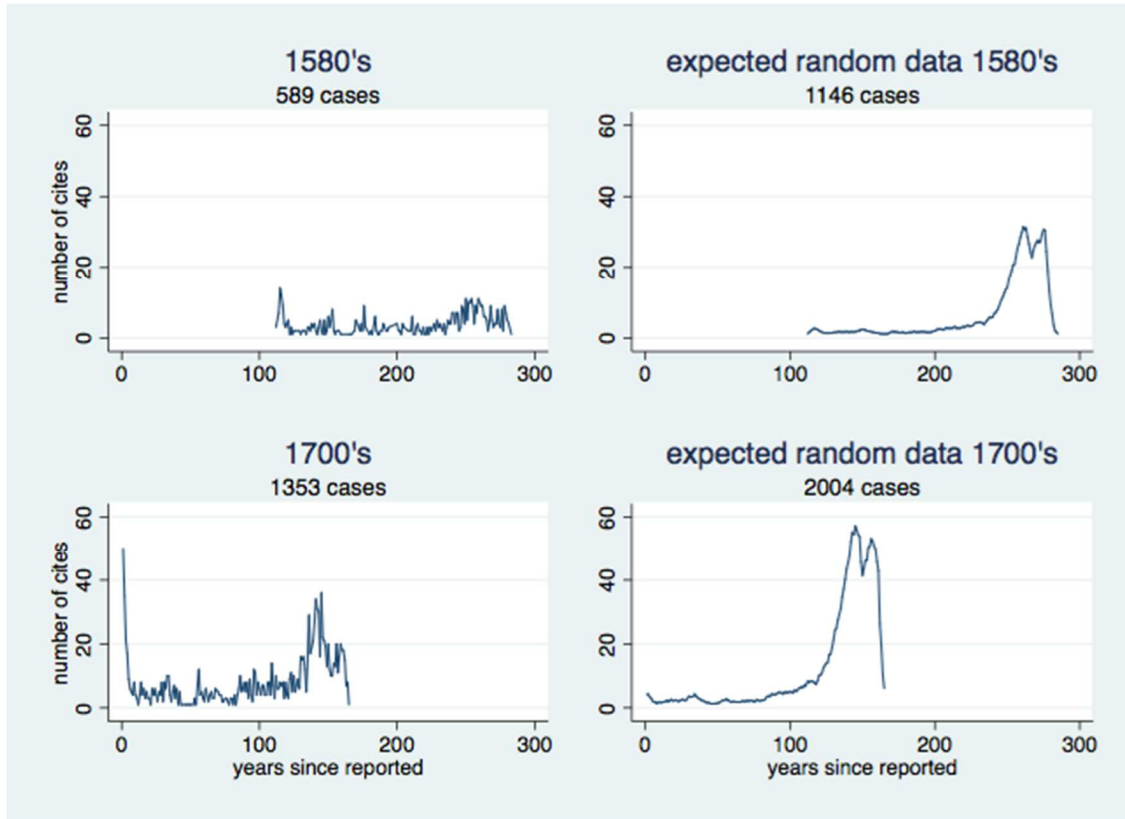


Figure 17: Degree of long-term persistence of case rulings for all decades between 1580 to 1700; the degree of long term-persistence is the time difference between the trial date of a case and its most recent citing date; English case precedents

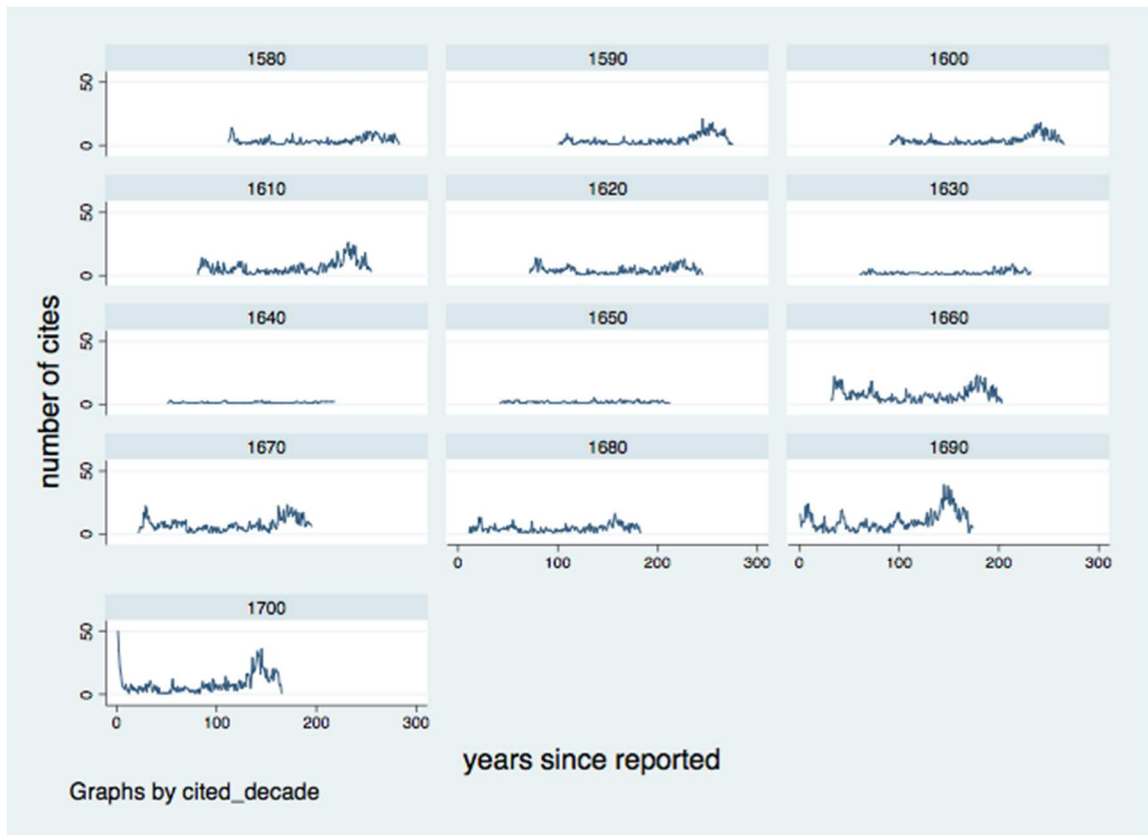


Figure 18: Means and standard deviations of annual age composition of common law's top authorities (1700-1865); means and standard deviations are for 4 different groups: top 10 authorities, top 50 authorities, top 100 authorities and top 500 authorities; English case precedents

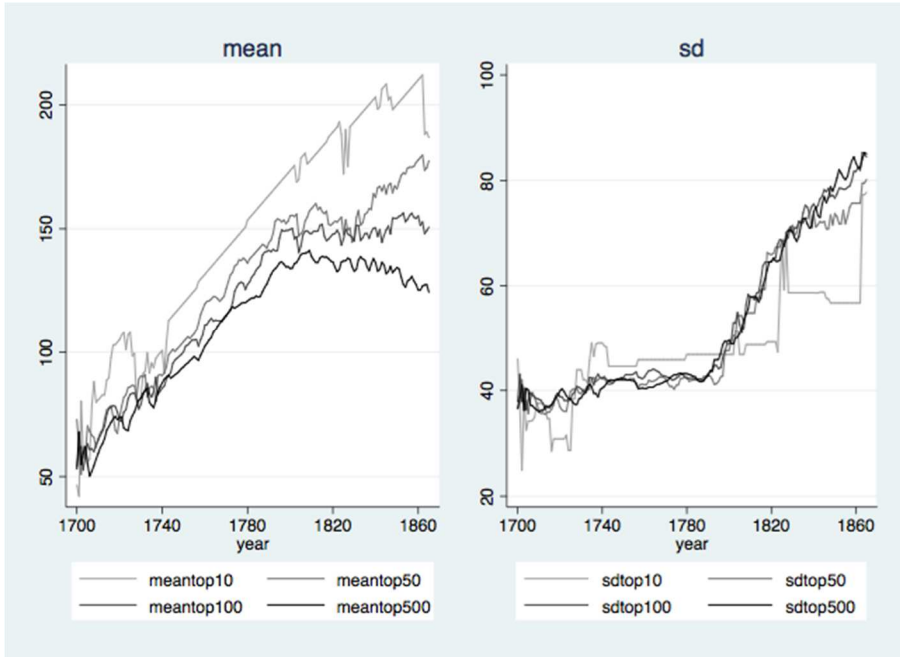


Figure 19: Medians and median absolute deviations of annual age composition of common law's top authorities (1700-1865); medians and median absolute deviations are for 4 different groups: top 1% authorities, top 5% authorities, top 10% authorities and top 20% authorities; English case precedents

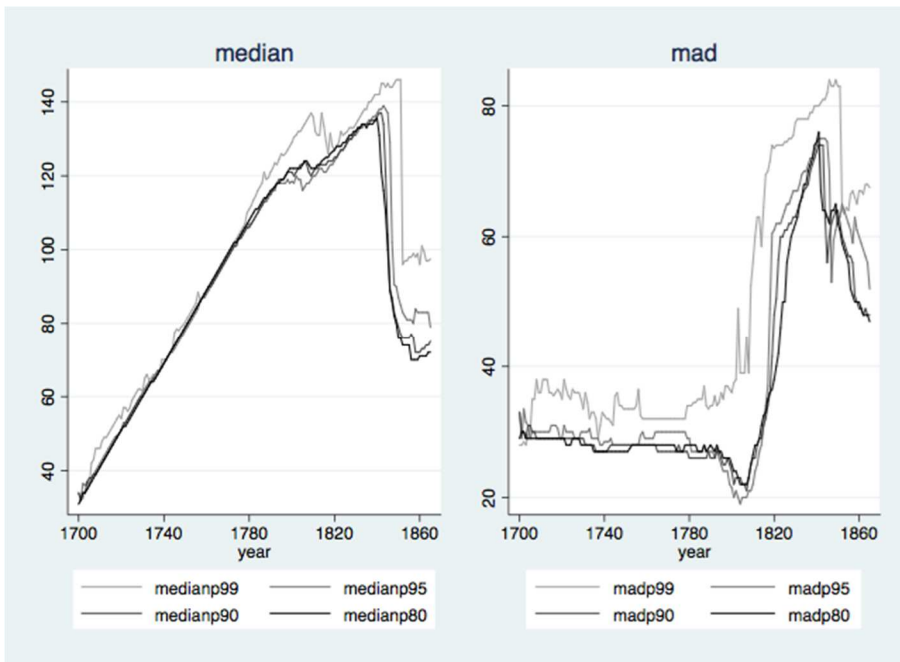


Figure 20: Means and standard deviations, medians and median absolute deviations of annual age composition model top authorities of data that was generated based on the random citing model (1700-1865); means and standard deviations are for 4 different groups: top 10 authorities, top 50 authorities, top 100 authorities and top 500 authorities; medians and median absolute deviations are for 4 different groups: top 1% authorities, top 5% authorities, top 10% authorities and top 20% authorities; English case precedents

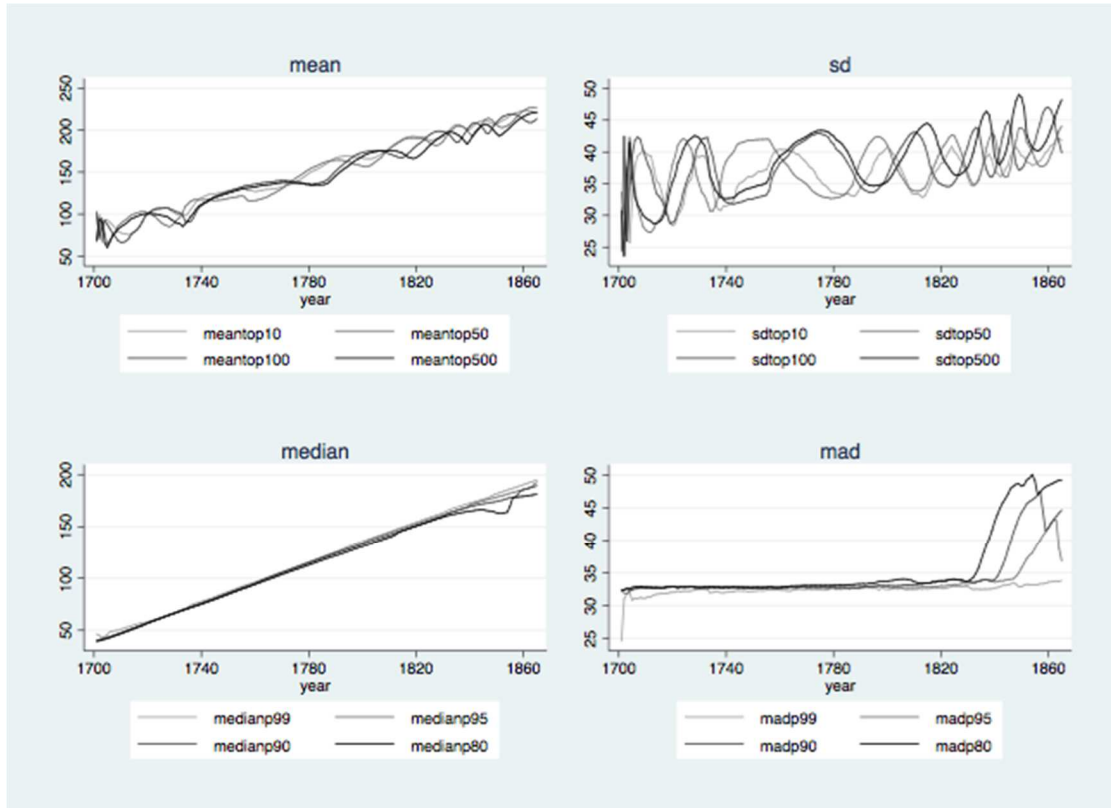


Figure 21: Annual age composition of common law's top 100 authorities in 4 different years; English case precedents

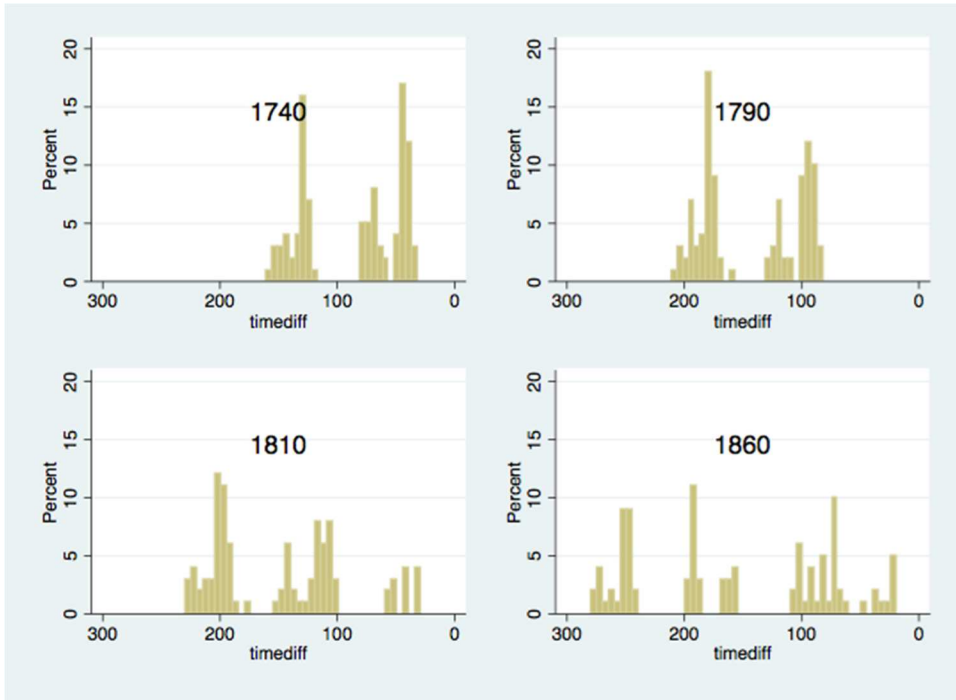


Figure 22: Annual temporal composition of common law's top 100 authorities during 4 different tri-decades (only citations occurring during the tri-decades are taken into consideration); English case precedents

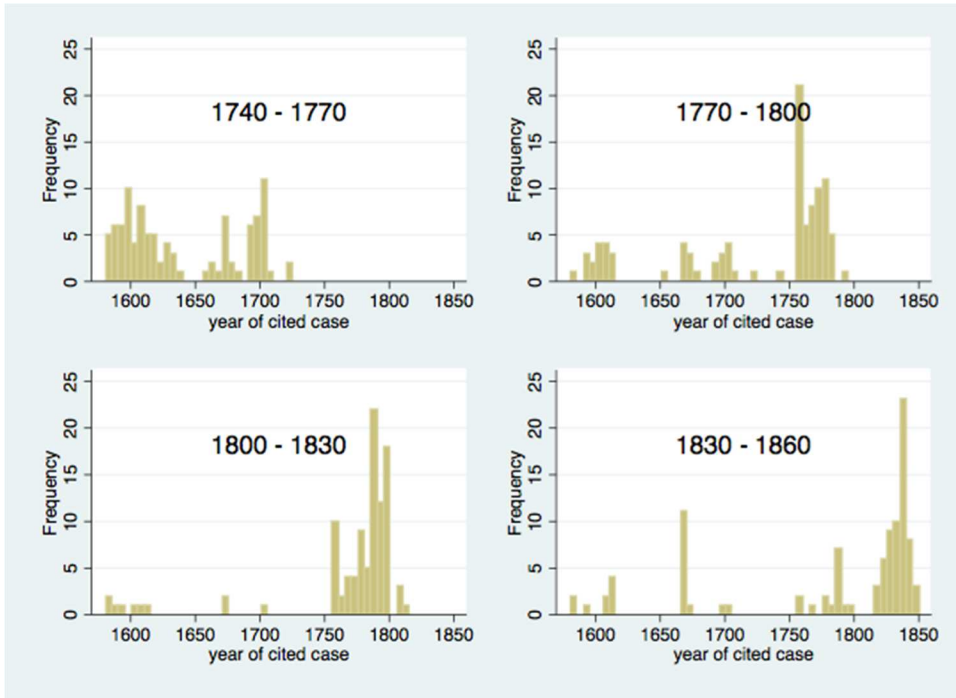


Figure 23: Common law's case precedent time profile of the year 1780; English case precedents

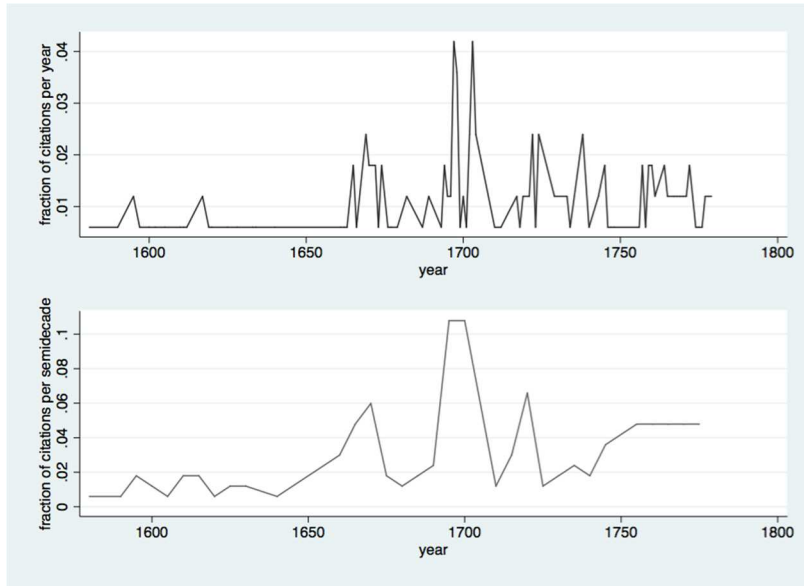


Figure 24: Comparison between actual common law's case precedent time profile of the year 1780 and two model predictions: one model is the random citing model, the other model is the representative courtroom model (on the left time profiles by cited year; on the right time profiles by cited semidecade); English case precedents

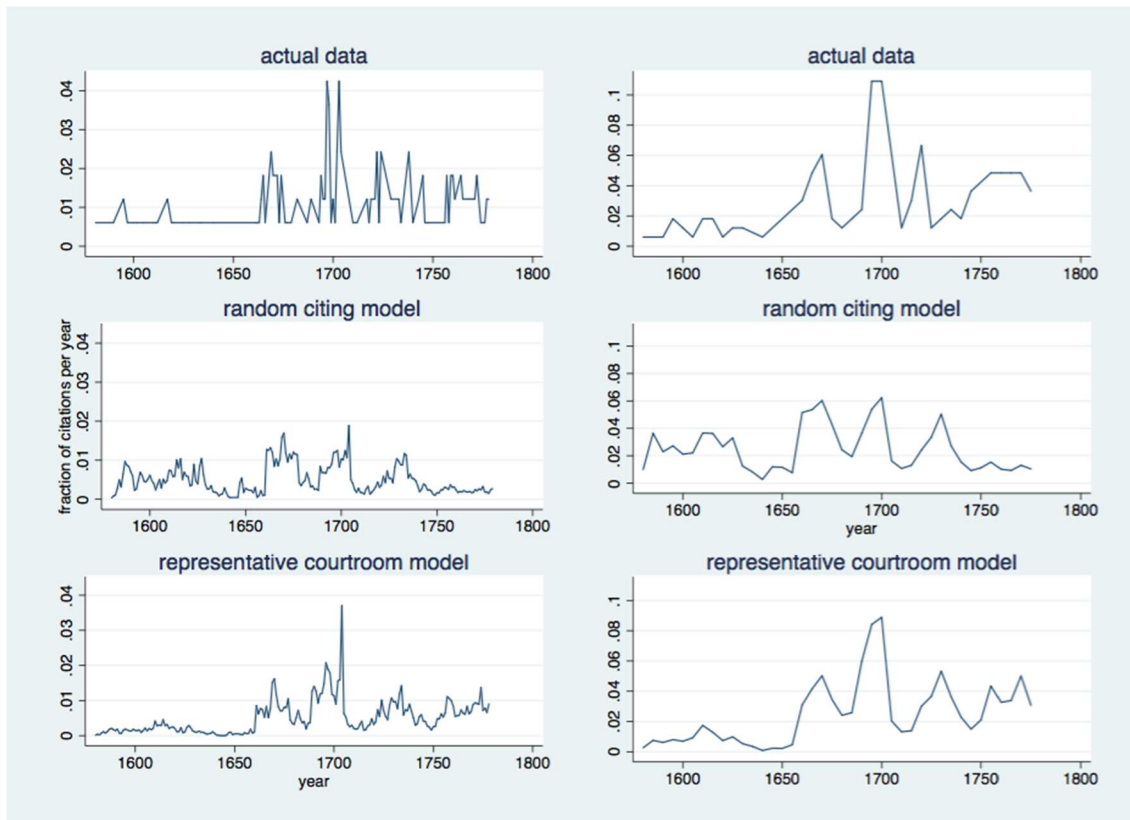


Figure 25: Time profile pairwise scatter plots between cited semi-decades of select citing decades; English case precedents

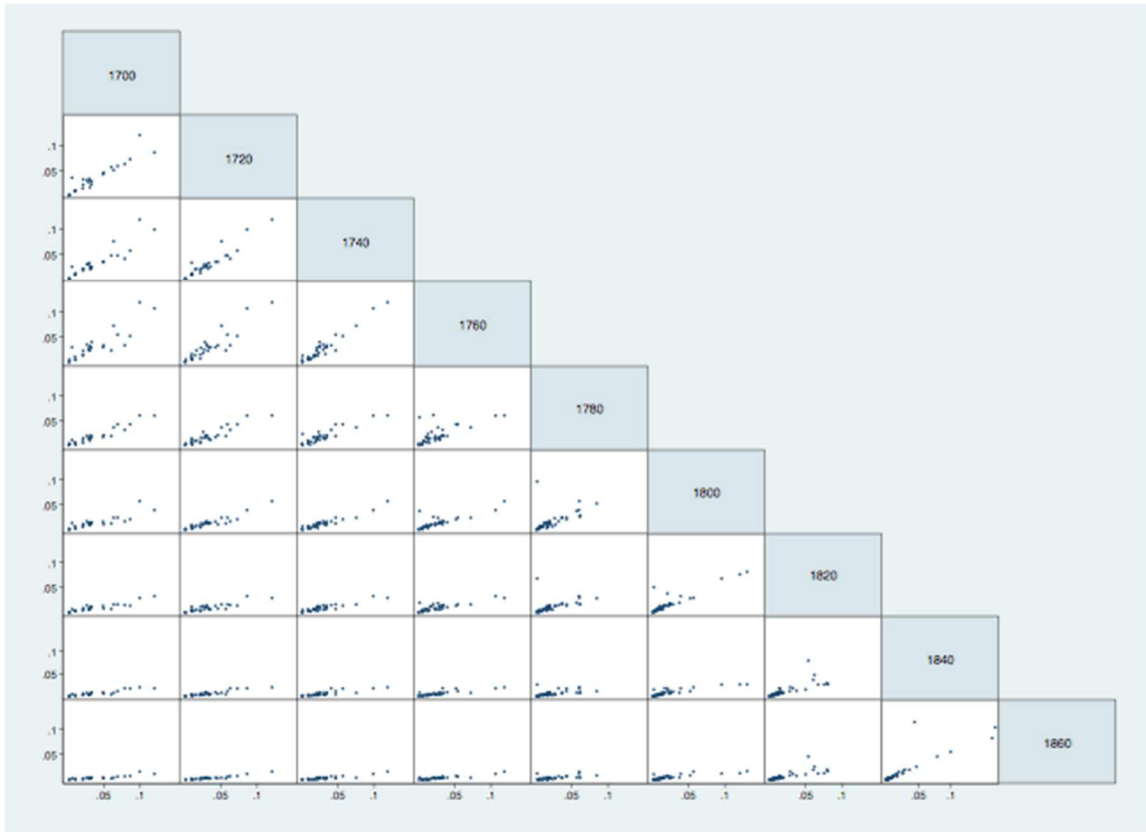


Figure 26: Time profiles for the years 1700-1850; cited years are aggregated by semi-decade (x-axis) and citing years by decade (boxes); English precedents

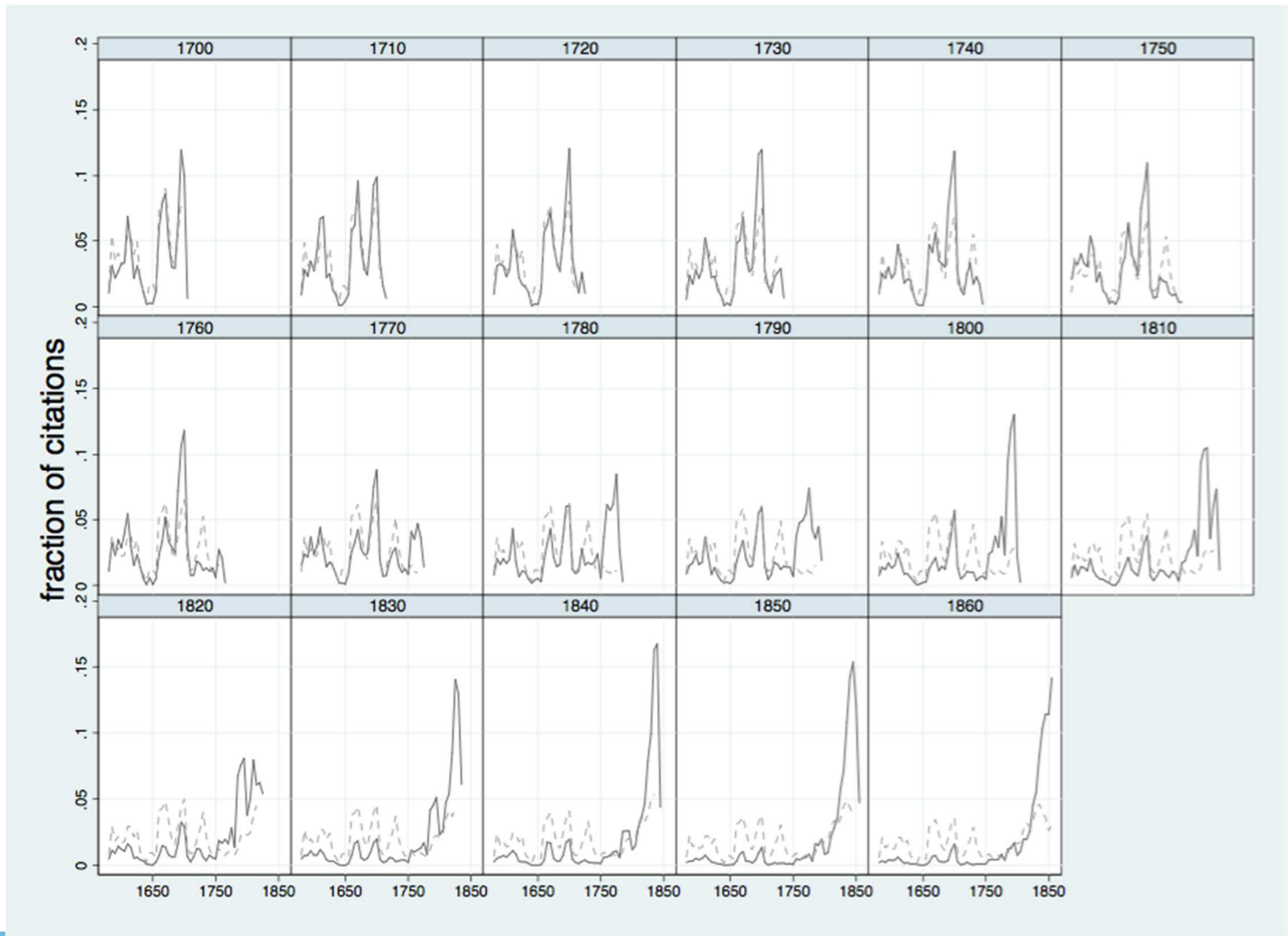


Figure 27: Time trajectories of cited decades; citing years are aggregated by citing semi-decades (x-axis); ; English precedents

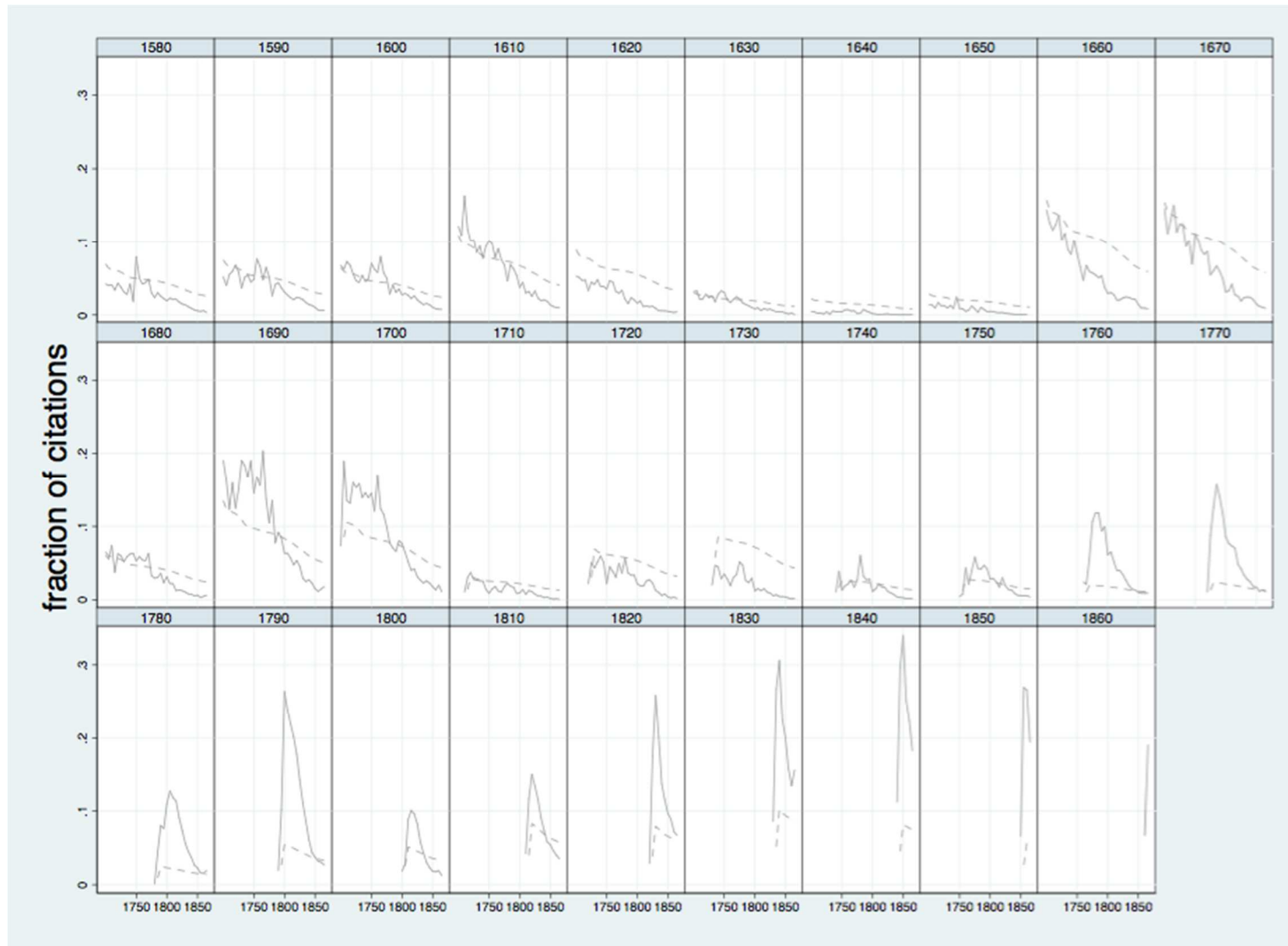


Figure 28: Estimation of year-aggregated, standard representative court room model: year-dependent parameter estimates of depreciation rate and 95% confidence intervals for the; English case precedents

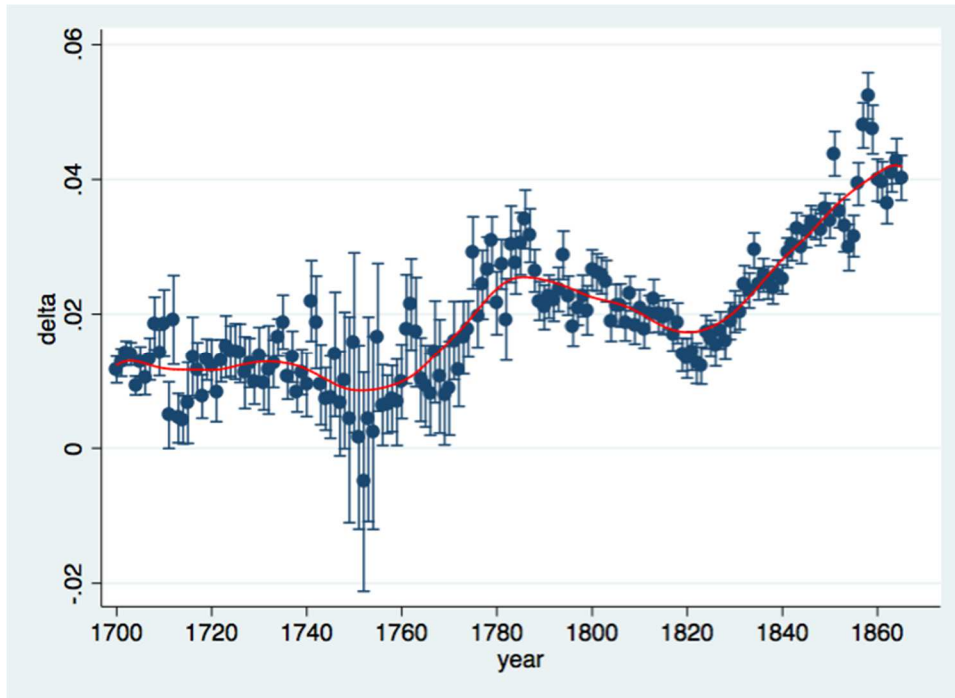


Figure 29: Estimation of year-aggregated, generalized representative court room model: year-dependent parameter estimates of depreciation rate and scaling parameter and 95% confidence intervals for the; English case precedents

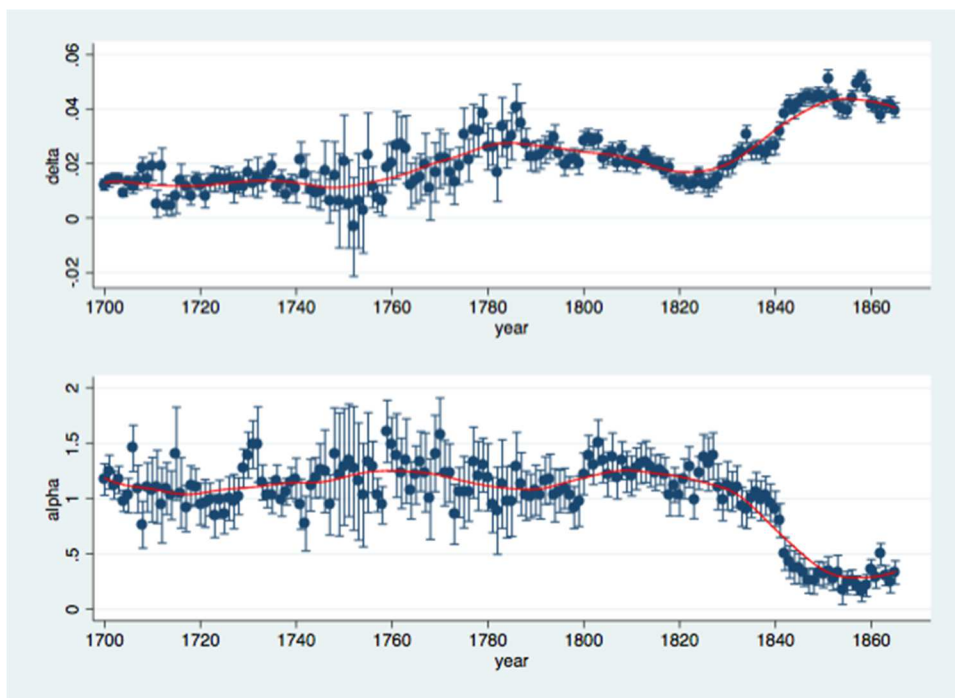


Figure 30: Example case citation network with 2 non-overlapping communities

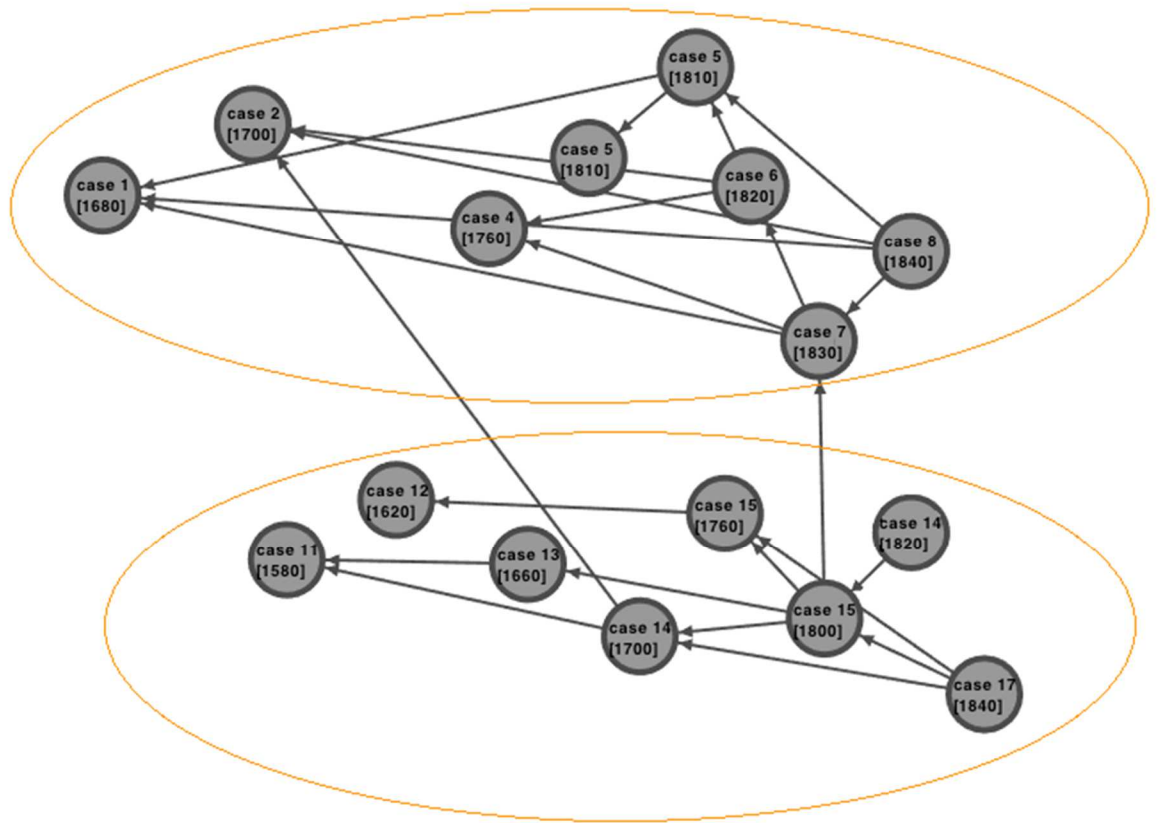


Figure 31: Temporal composition of two communities detected with spinglass and Louvain algorithms; English case precedents

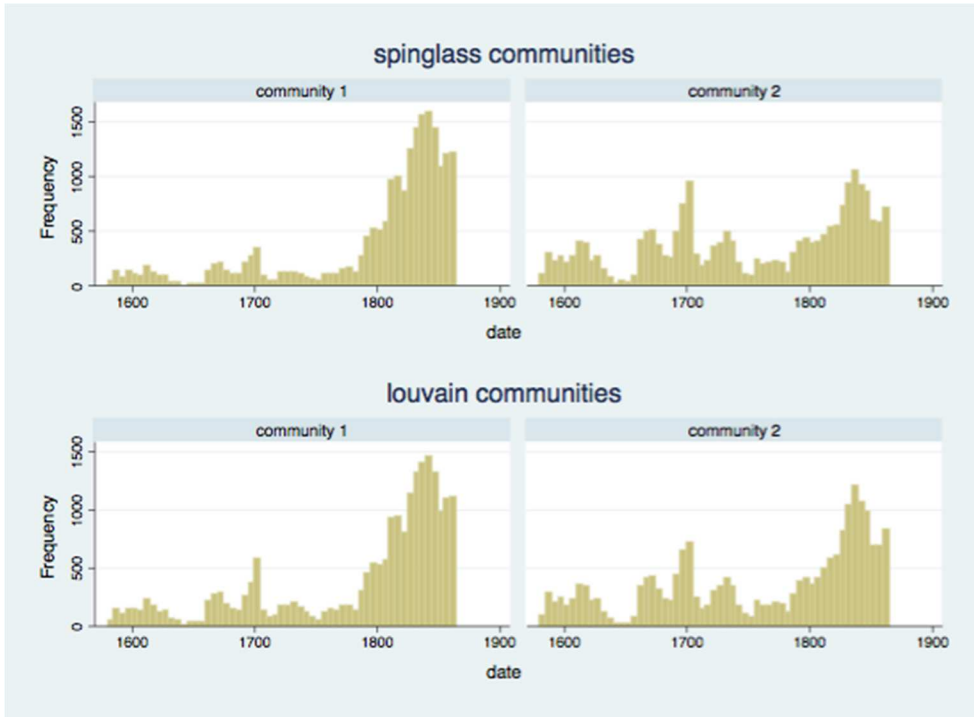


Figure 32: Relative temporal compositions of two communities detected with spinglass and Louvain algorithms; English case precedents

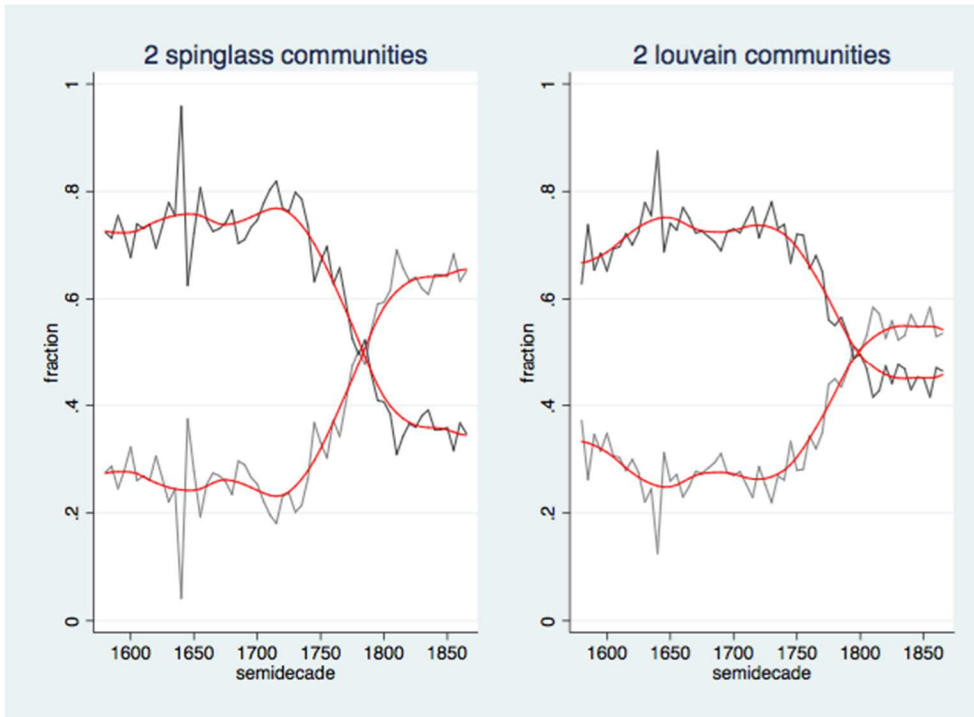


Figure 33: Relative temporal compositions of two, three and four communities detected with spinglass and Louvain algorithms; English case precedents

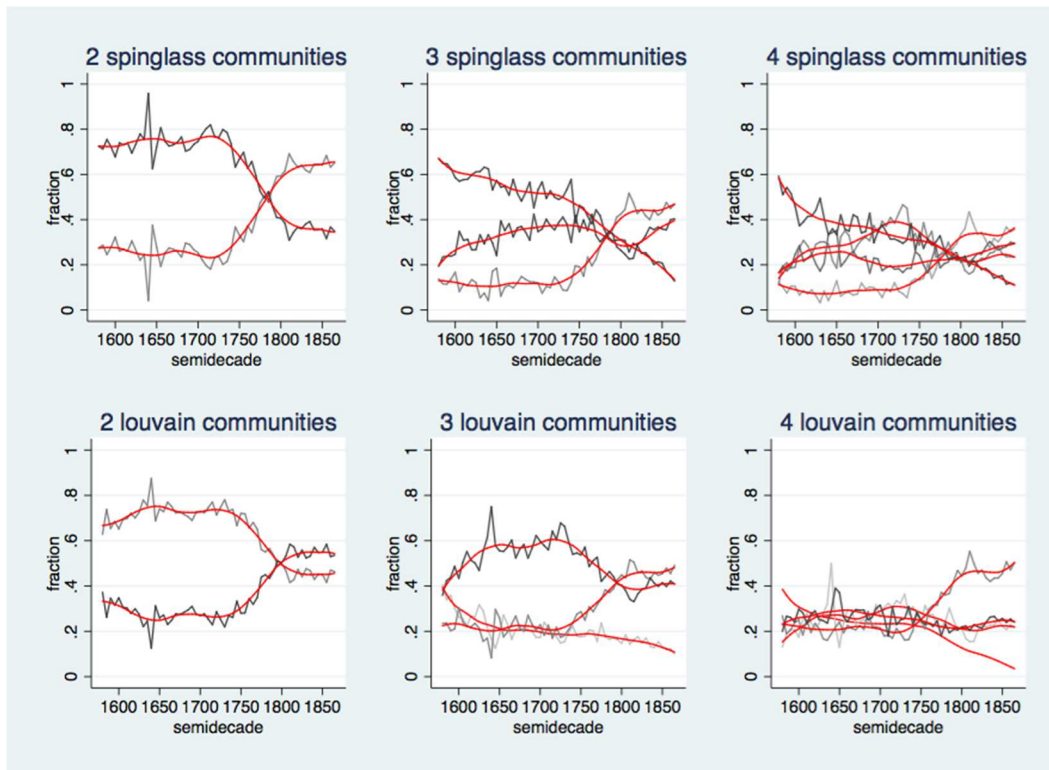


Figure 34: Simulated (based on random citing model) temporal composition of two communities detected with spinglass and Louvain algorithms; English case precedents

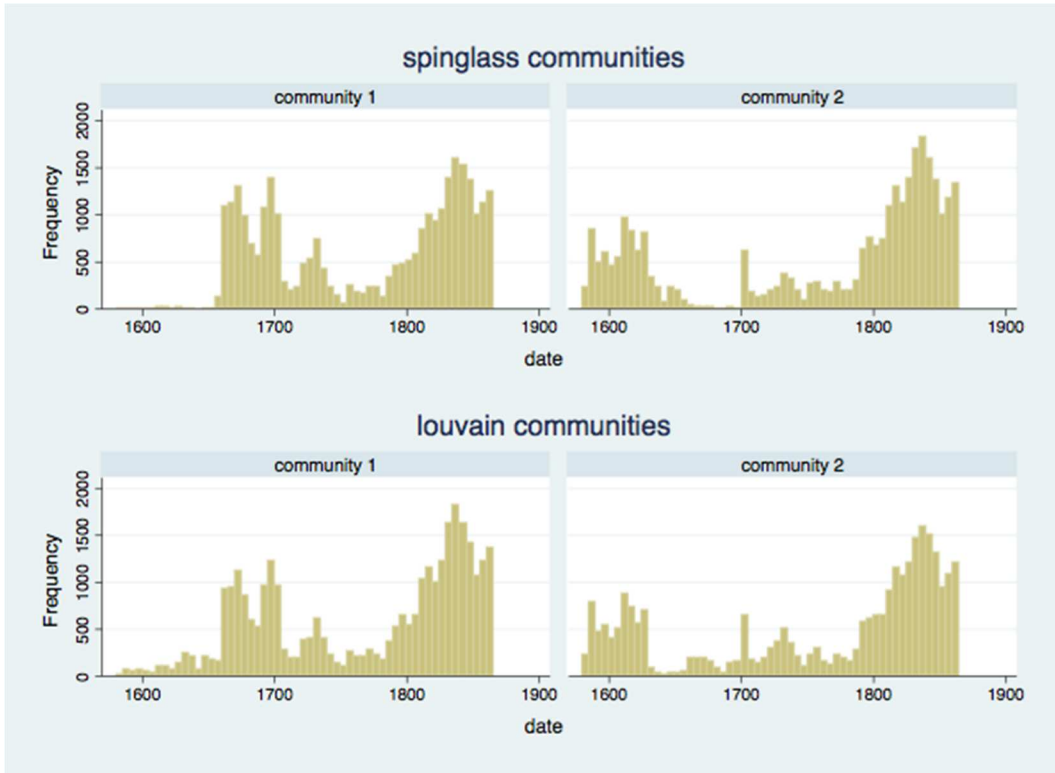


Figure 35: Simulated (based on random citing model) relative temporal composition of two communities detected with spinglass and Louvain algorithms; English case precedents

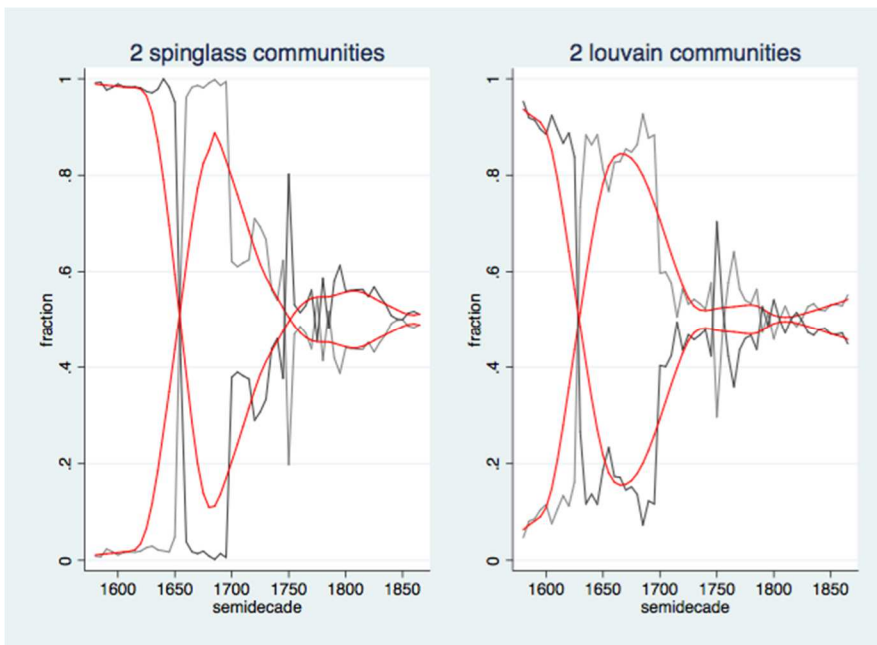


Figure 36: Relationship between number of words in ER case report and number of received citations (subset of case reports; jitter added)

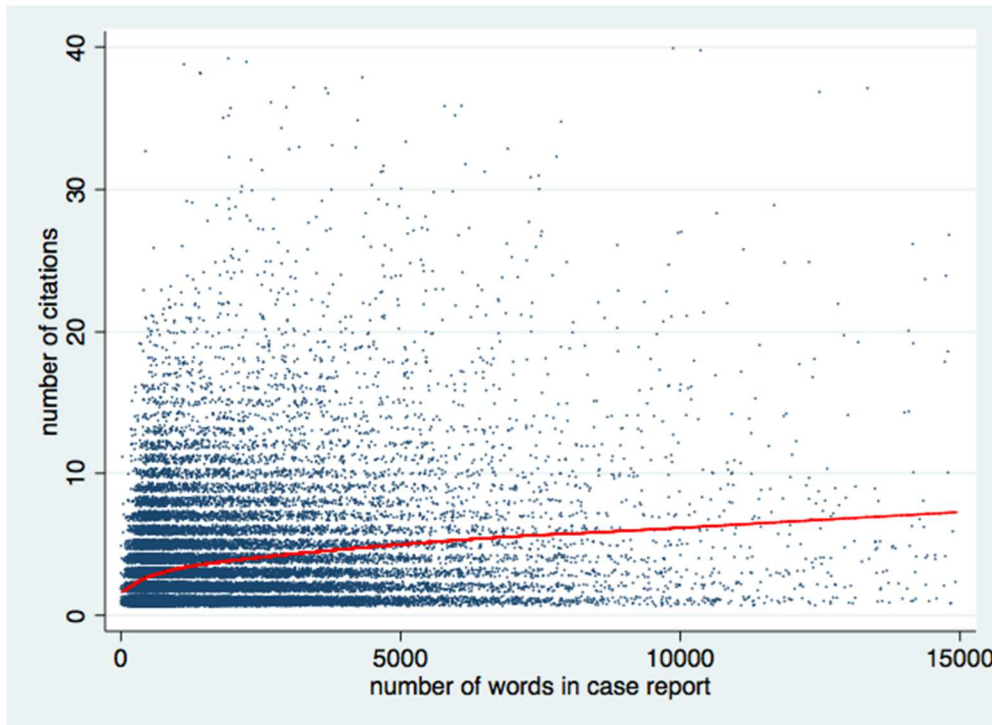


Figure 37: Number of words in ER case report by year and annual averages (subset of case reports)

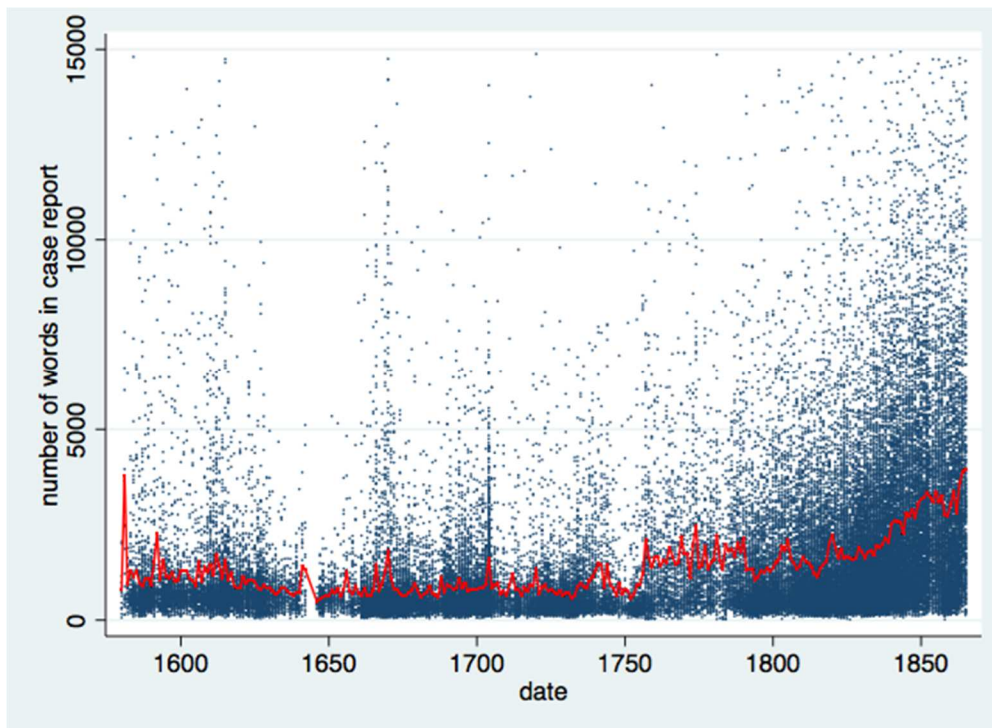


Figure 38: Annual number of ER case reports and U.S. Supreme Court majority opinions

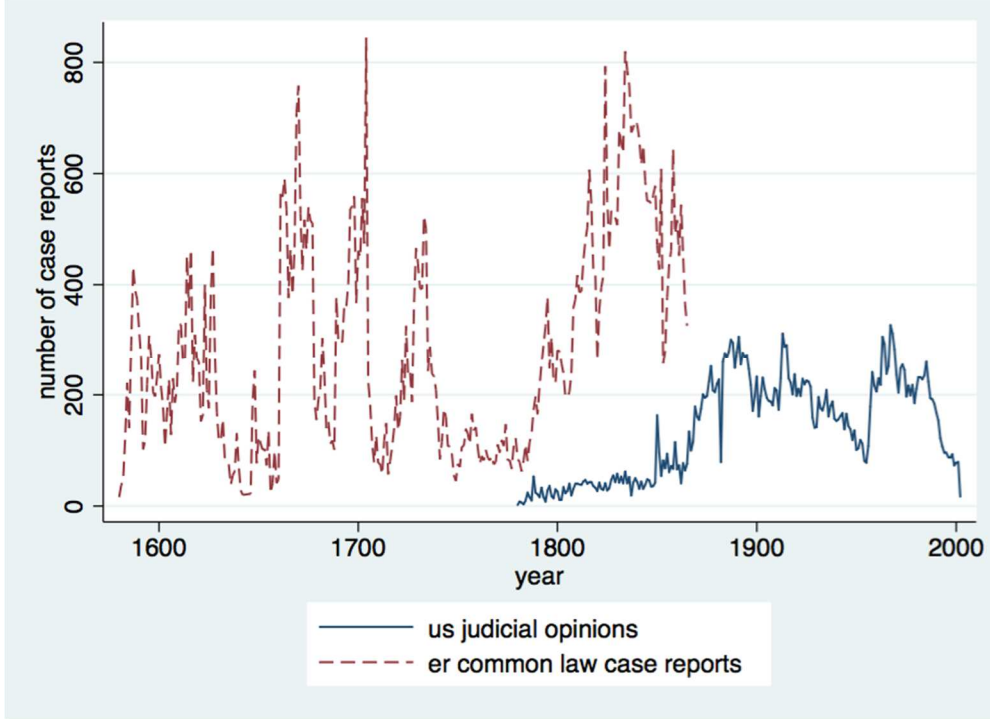


Figure 39: Log frequency distribution of citations by the age of cited cases (age is the time difference between the date of the citing case and the date of the cited case); predictions from simple exponential model appear as red line; the analogous English data appear as dashed lines for comparison; U.S. case precedents

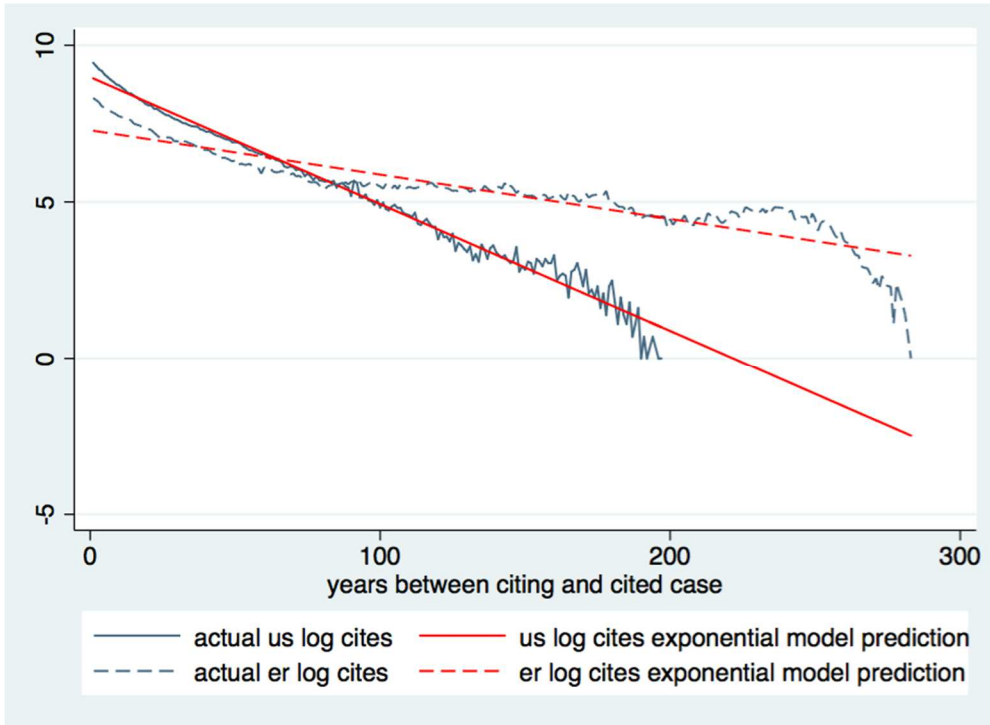


Figure 40: Frequency distribution of cases by number of received citations, also known as indegree distribution (complete on the left side, restricted enlarged on the right side); U.S. case precedents

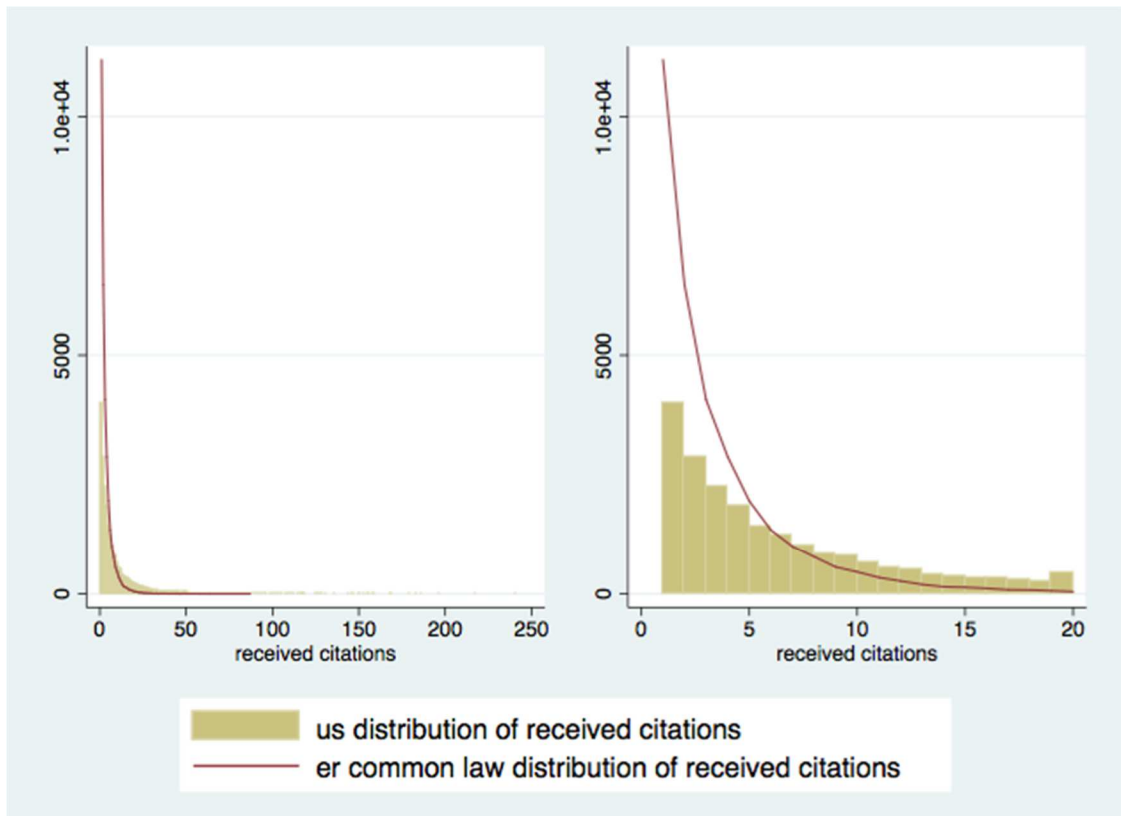


Figure 41: Degree of long-term persistence of case rulings for two representative decades (1800-1809 and 1840-1849); the degree of long term-persistence is the time difference between the trial date of a case and its most recent citing date; actual observations on the left (136 cases from the 1800's were cited at least once in the 19th and 20th centuries; analogously, 291 cases from the 1840's were cited at least once in the 19th and 20th centuries); on the right appear the predictions from a random citing model; U.S. case precedents

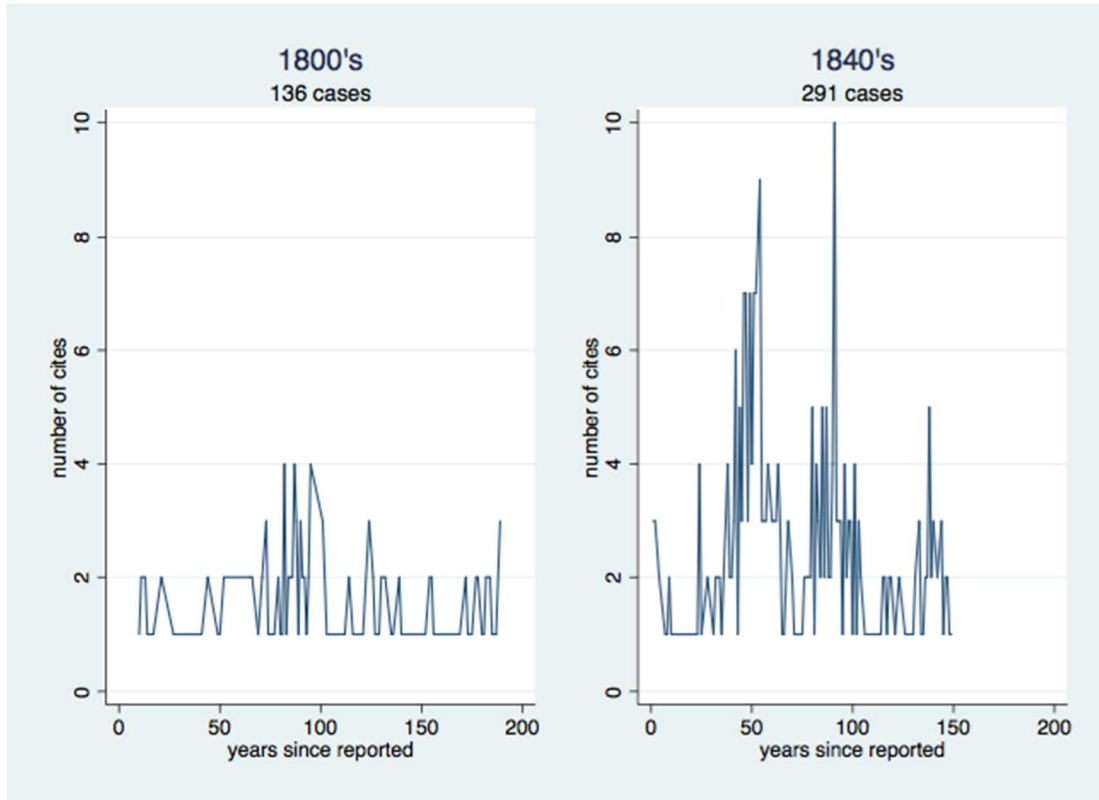


Figure 42: Means and standard deviations of annual age composition of U.S. Supreme Court's top authorities (1780-2000); means and standard deviations are for 4 different groups: top 10 authorities, top 50 authorities, top 100 authorities and top 500 authorities; U.S. case precedents

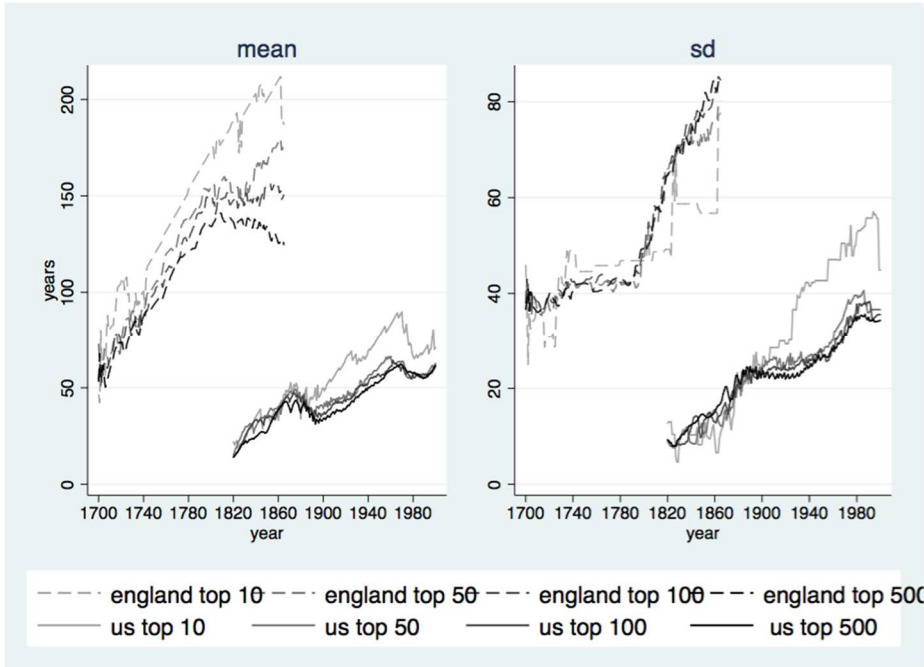


Figure 43: Medians and median absolute deviations of annual age composition of U.S. Supreme Court's top authorities (1780-2000); medians and median absolute deviations are for 4 different groups: top 1% authorities, top 5% authorities, top 10% authorities and top 20% authorities; U.S. case precedents

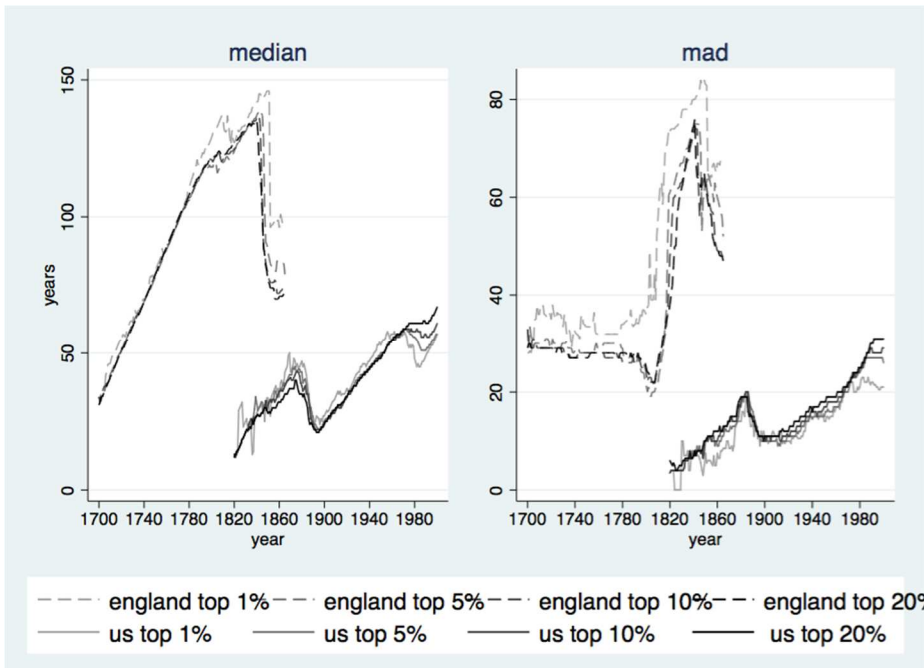


Figure 44: Annual age composition of U.S. Supreme Court's top 100 authorities in 4 different years; U.S. case precedents

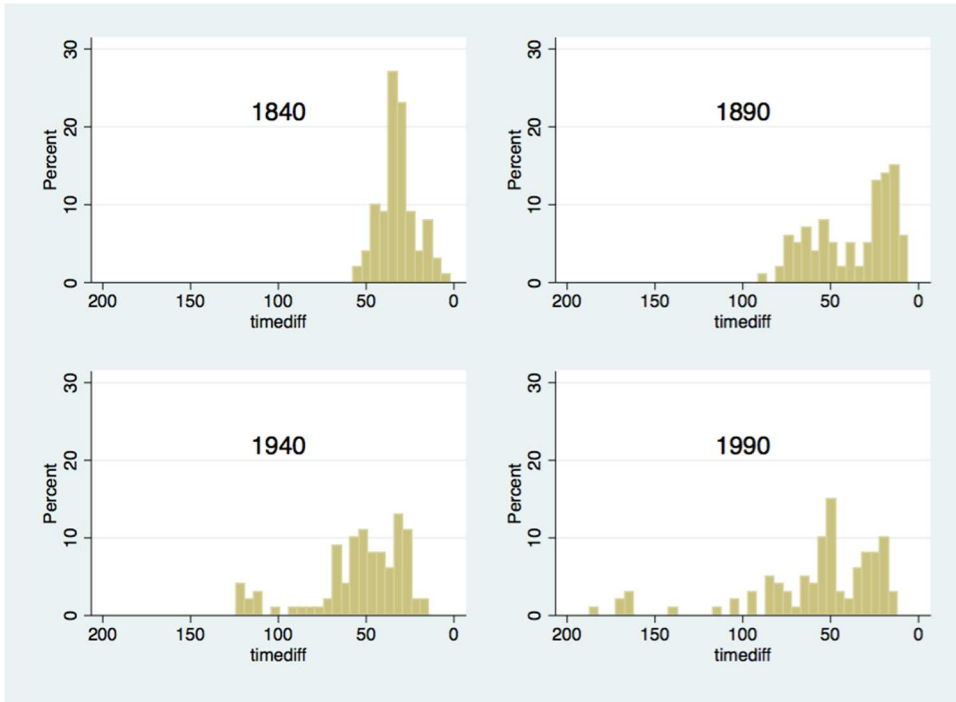


Figure 45: Annual temporal composition of U.S. Supreme Court's top 100 authorities during 4 different tri-decades (only citations occurring during the tri-decades are taken into consideration); U.S. case precedents

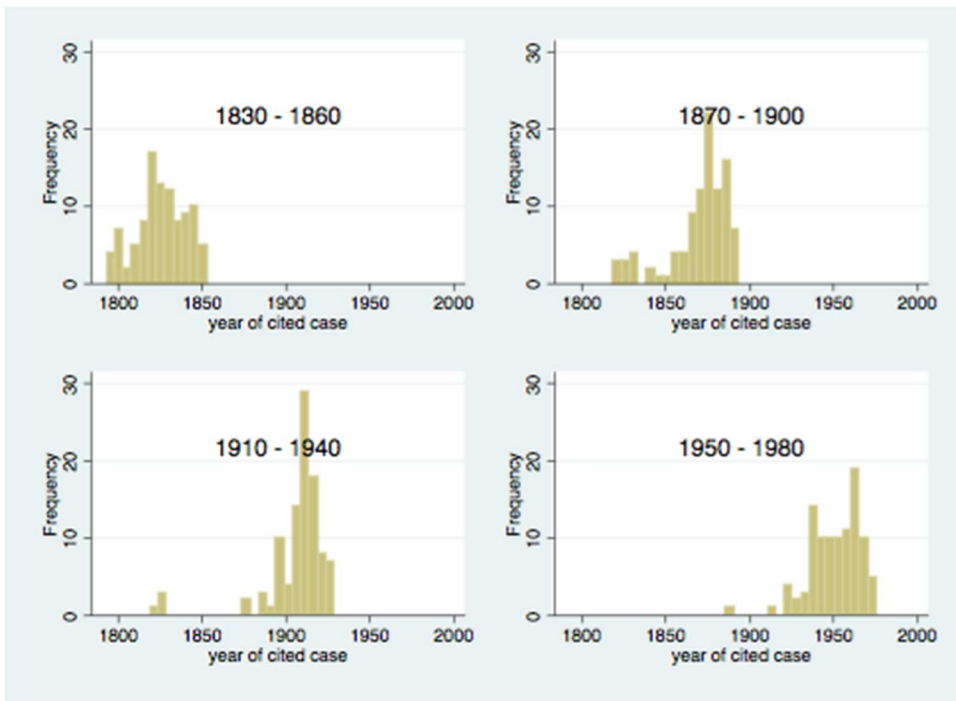


Figure 46: Time profiles for the years 1700-1850; cited years are aggregated by semi-decade (x-axis) and citing years by decade (boxes); U.S. case precedents

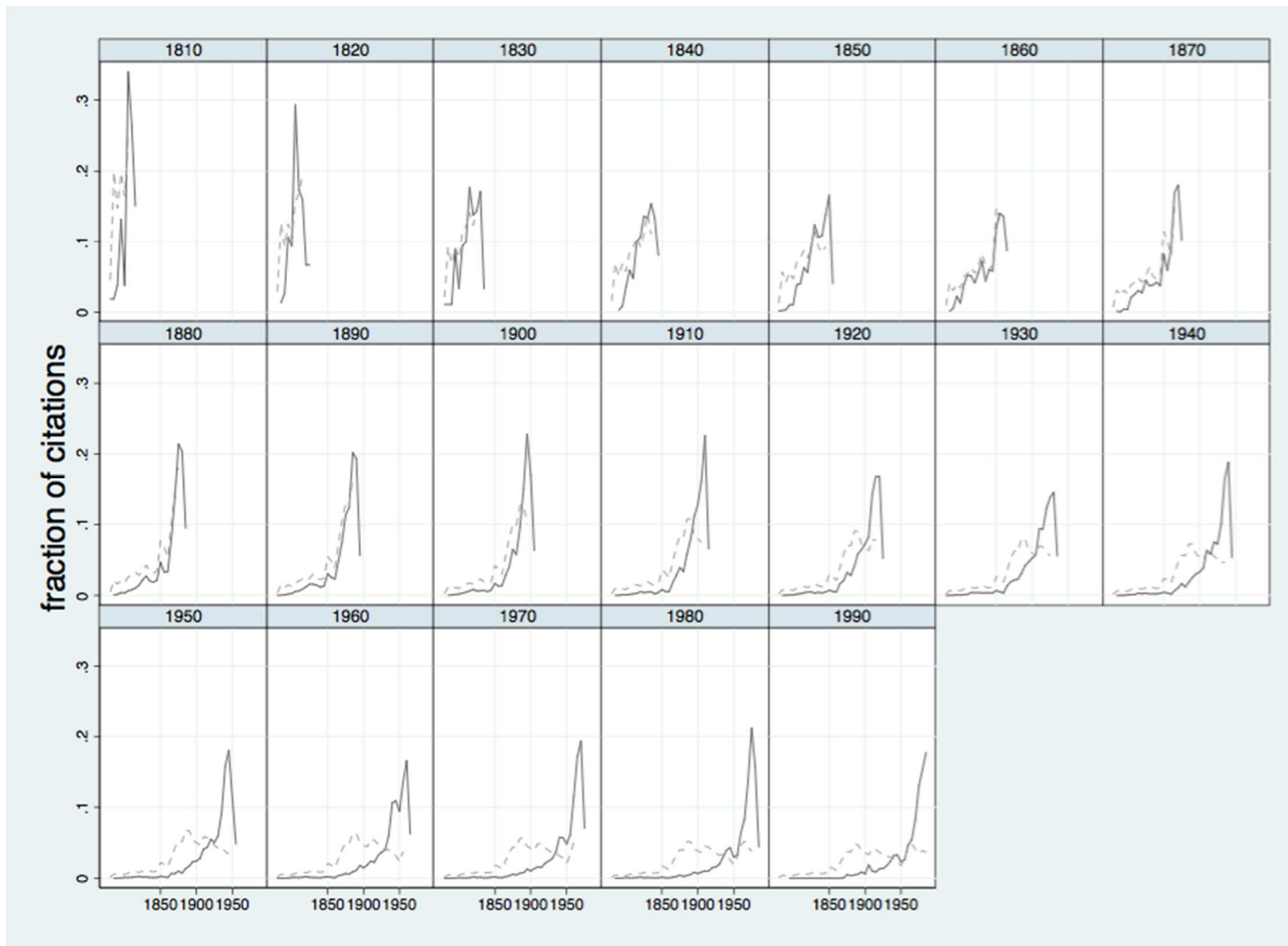


Figure 47: Estimation of year-aggregated, standard representative court room model: year-dependent parameter estimates of depreciation rate and 95% confidence intervals for the; U.S. case precedents

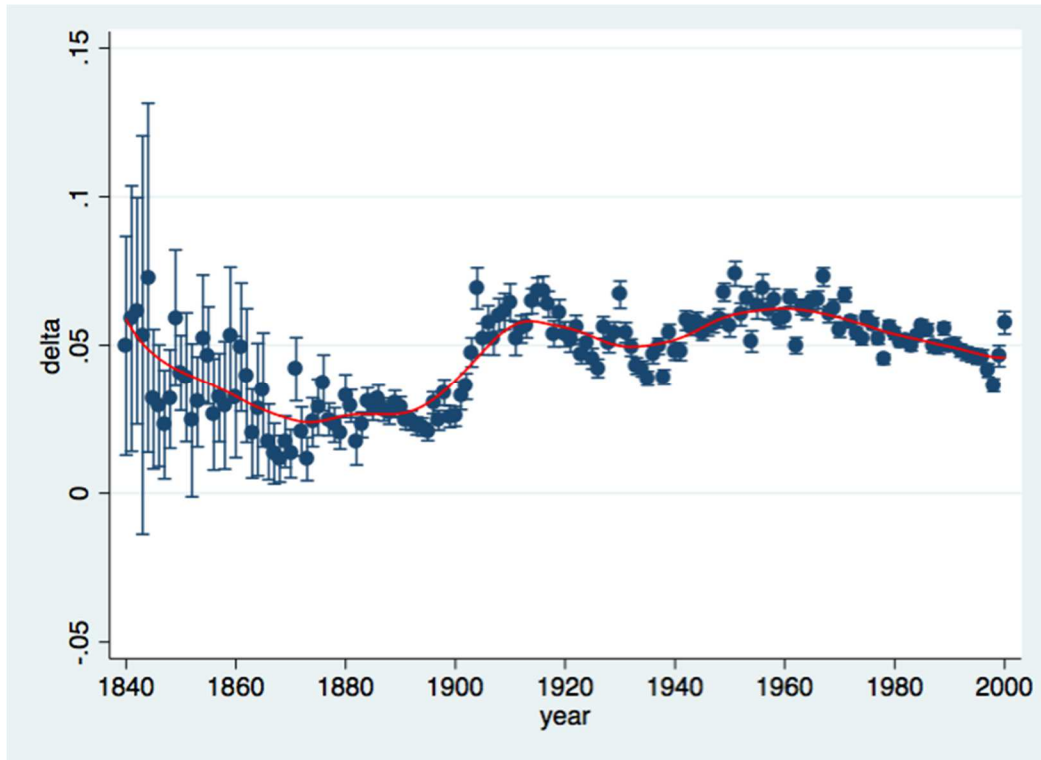


Figure 48: Temporal composition of two communities detected with spinglass and Louvain algorithms; U.S. case precedents

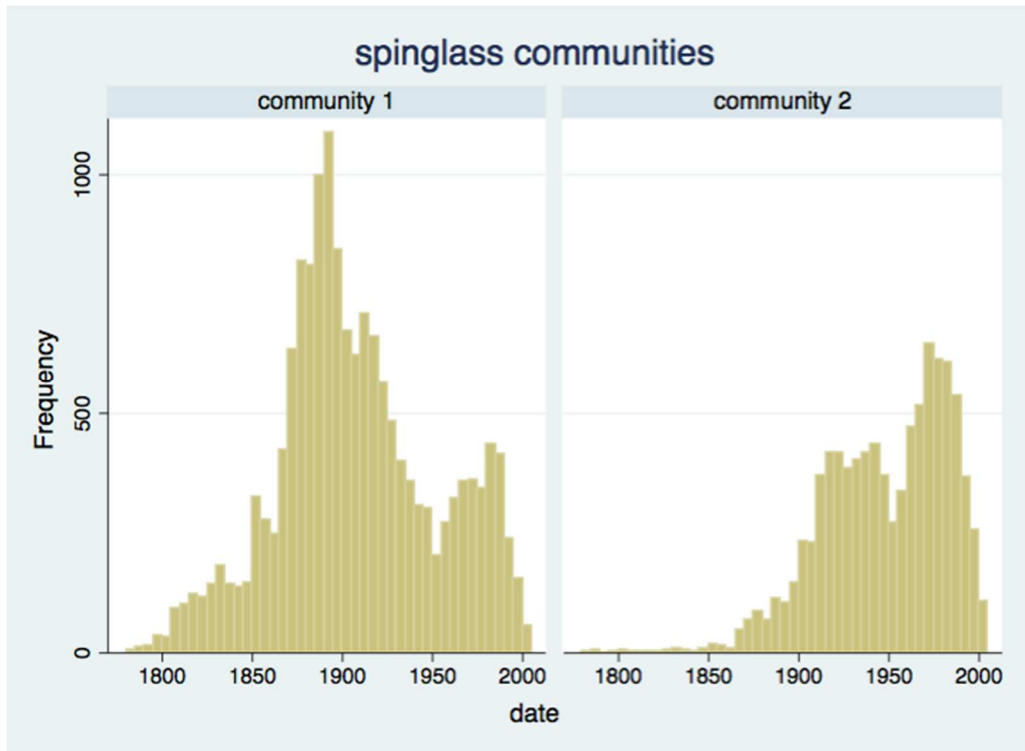


Figure 49: Relative temporal compositions of two communities detected with spinglass algorithm; U.S. case precedents

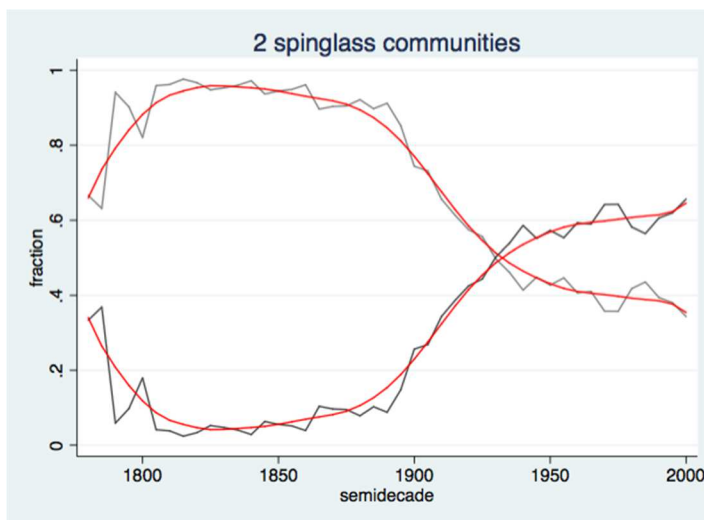


Figure 50: Annual number of English enacted statutes

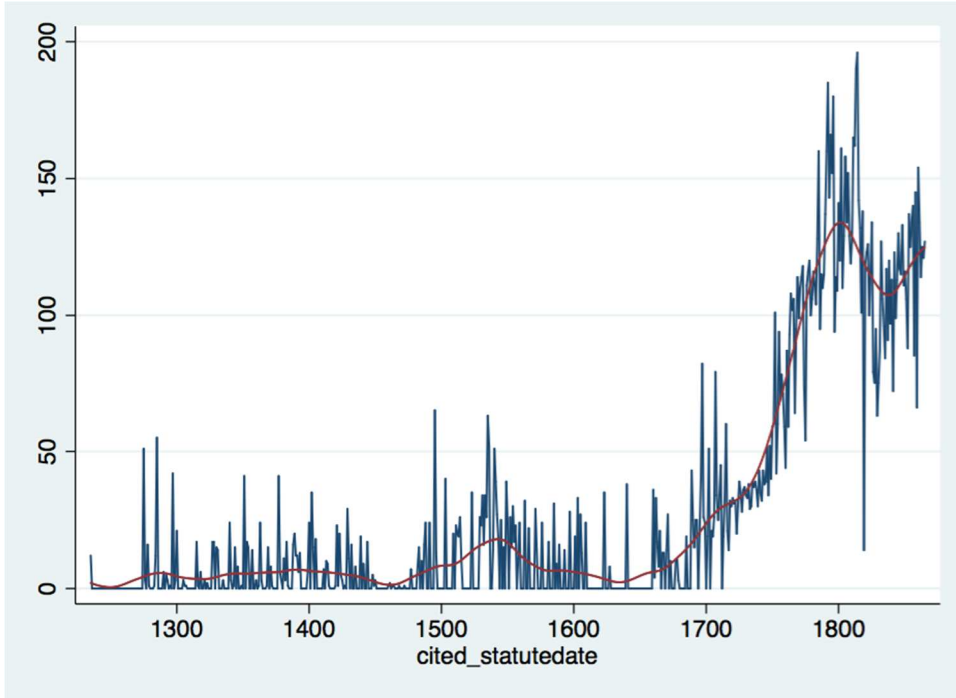


Figure 51: Log frequency distribution of citations by the age of cited statutes (age is the time difference between the date of the citing case and the date of the cited statute); predictions from simple exponential model appear as red line; English statutes

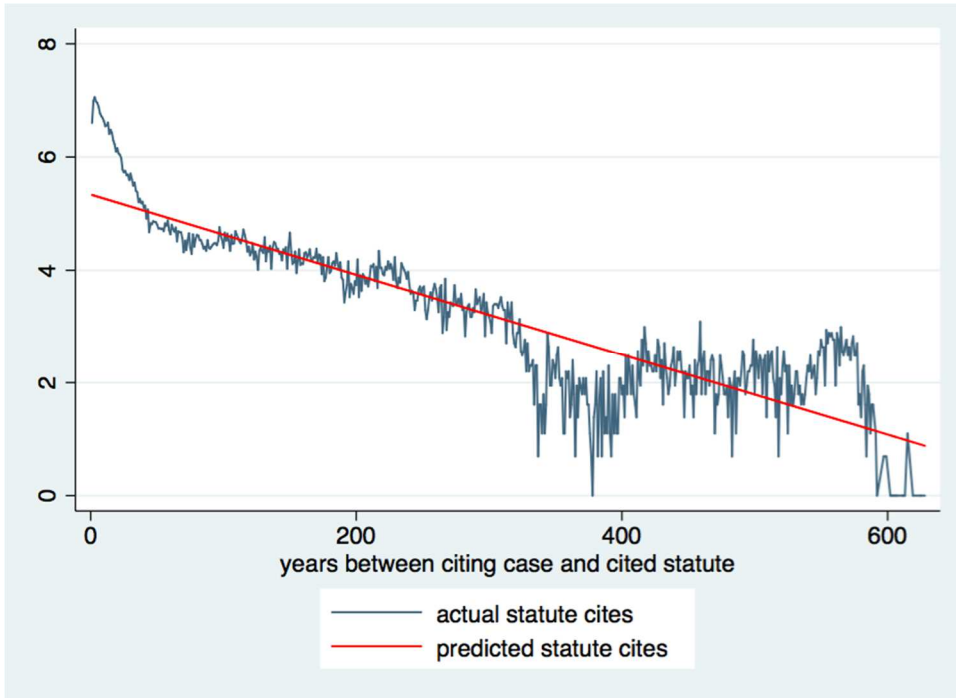


Figure 52: Frequency distribution of statutes by number of received citations, also known as indegree distribution (complete on the left side, restricted enlarged on the right side); English statute precedents

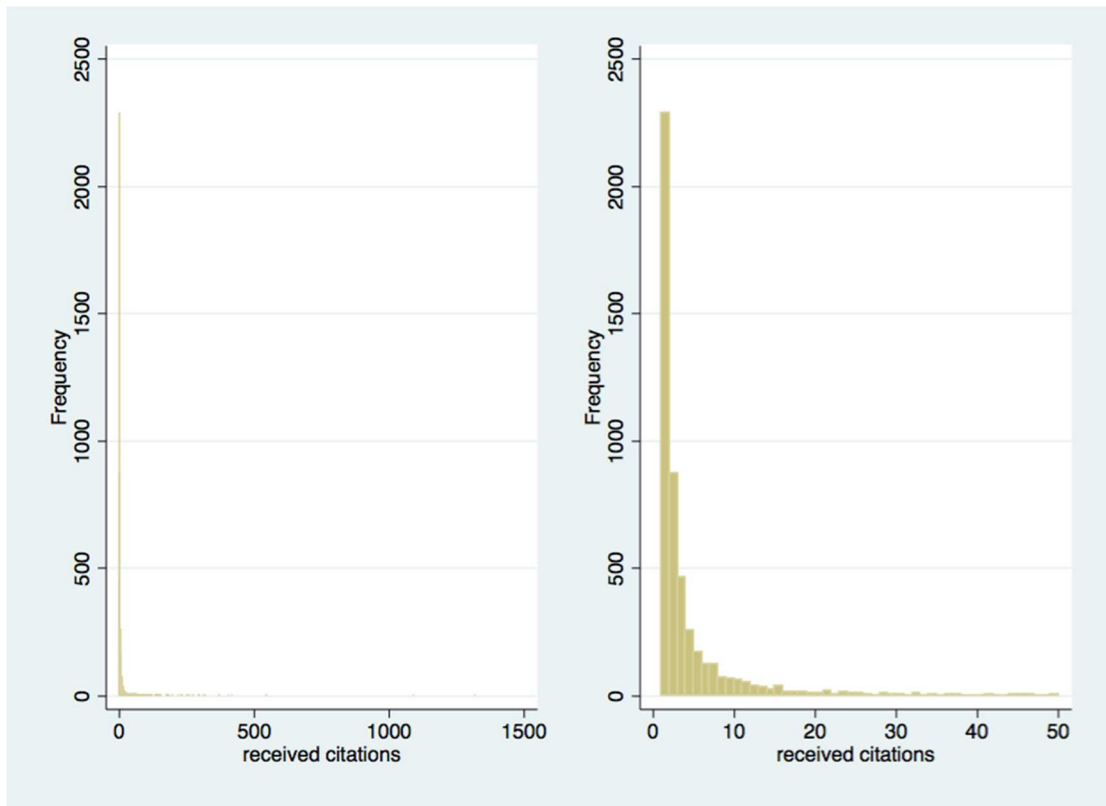


Figure 53: Degree of long-term persistence of statutes for two representative decades (1580-1589 and 1700-1709); the degree of long term-persistence is the time difference between the trial date of a case and its most recent citing date; actual observations on the left (38 statutes from the 1580's were cited at least once in the 18th and 19th centuries; analogously, 115 statutes from the 1700's were cited at least once in the 18th and 19th centuries); on the right appear the predictions from a random citing model; English statutes

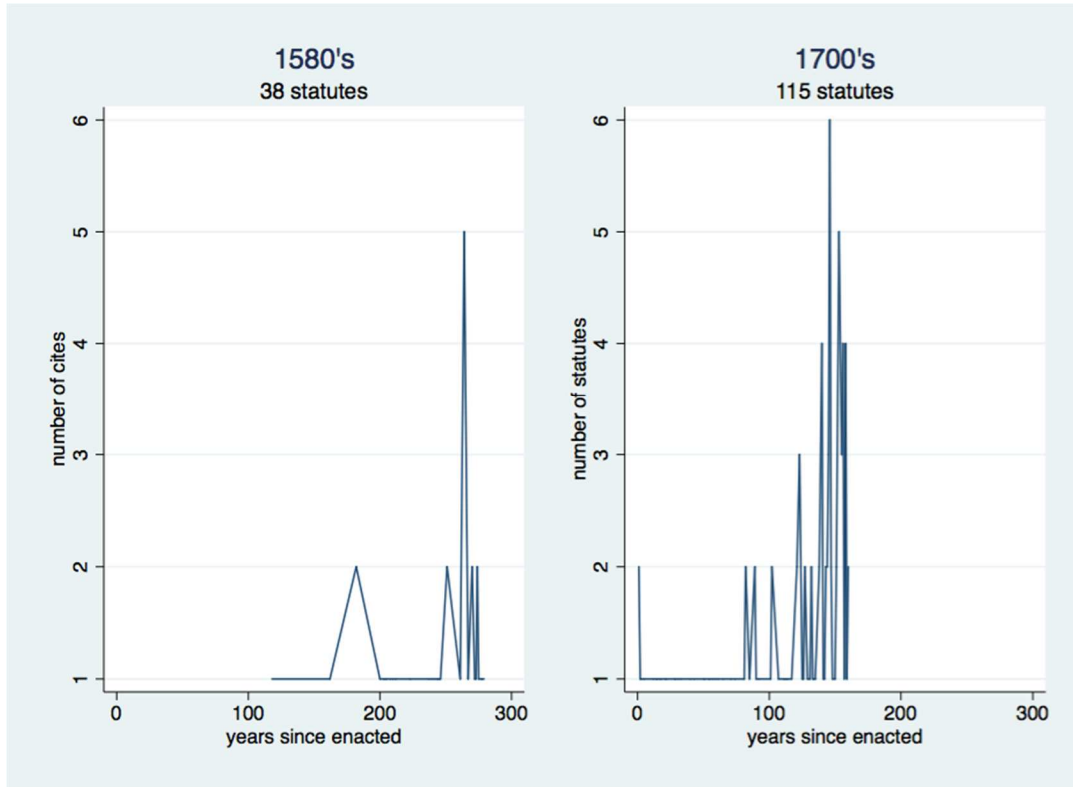


Figure 54: Means and standard deviations of annual age composition of top statute authorities (1700-1865); means and standard deviations are for 4 different groups: top 10 authorities, top 50 authorities, top 100 authorities and top 500 authorities; English statutes

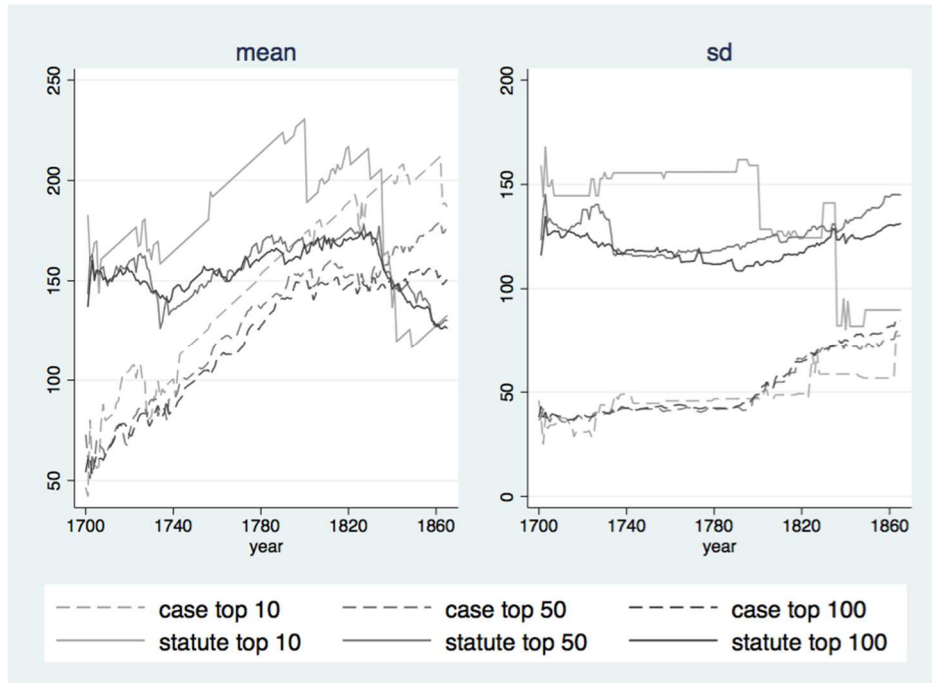


Figure 55: Medians and median absolute deviations of annual age composition of top statute authorities (1700-1865); medians and median absolute deviations are for 4 different groups: top 1% authorities, top 5% authorities, top 10% authorities and top 20% authorities; English statutes

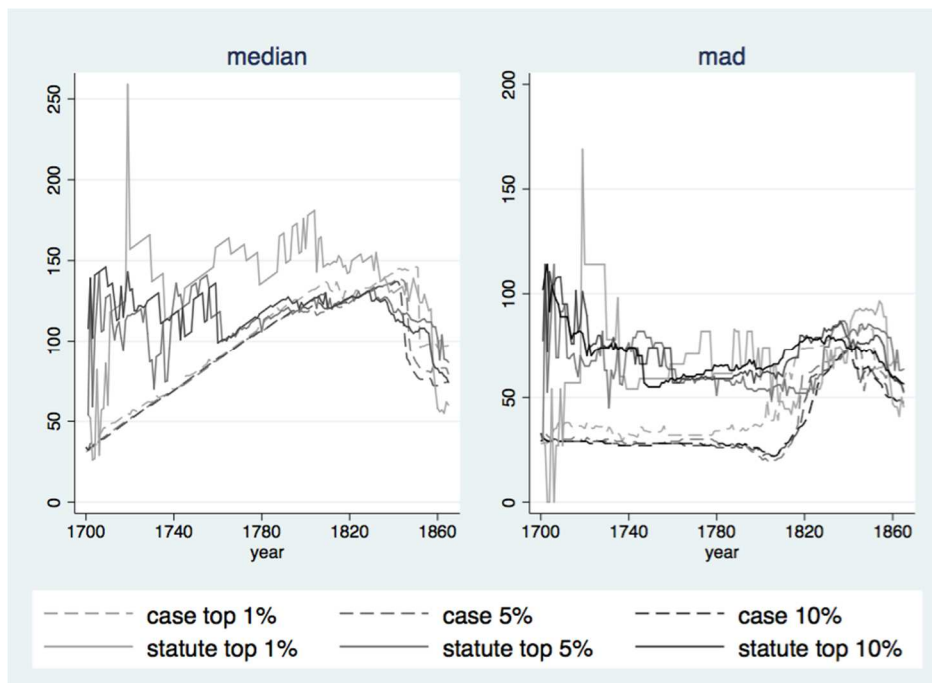


Figure 56: Annual age composition of top 100 statute authorities in 4 different years; English statutes

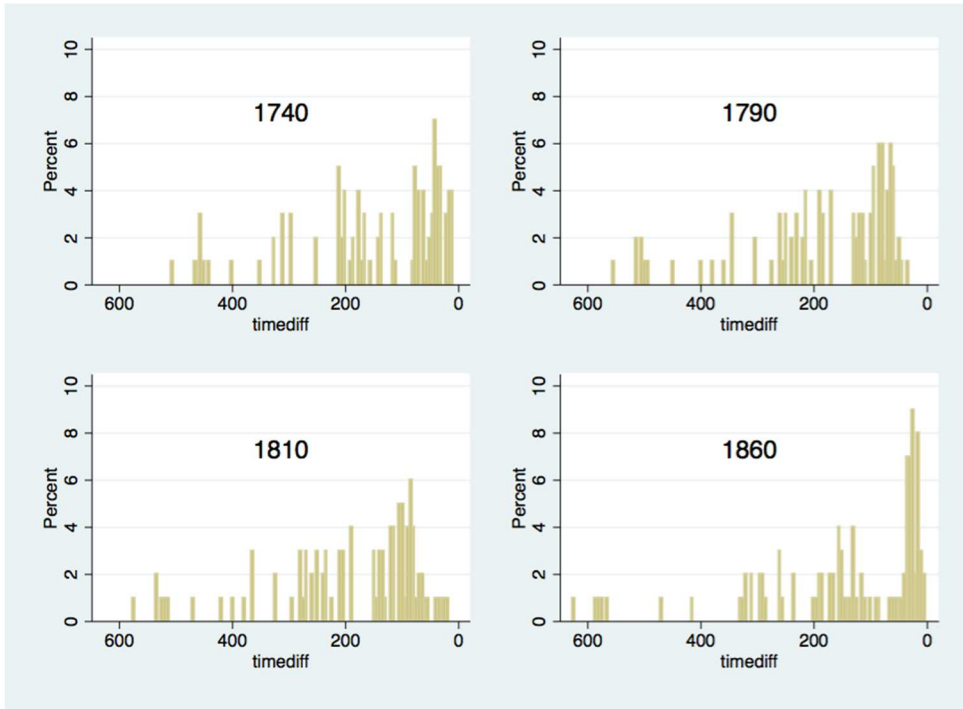


Figure 57: Annual temporal composition of top 100 statute authorities during 4 different tri-decades (only citations occurring during the tri-decades are taken into consideration); English statutes

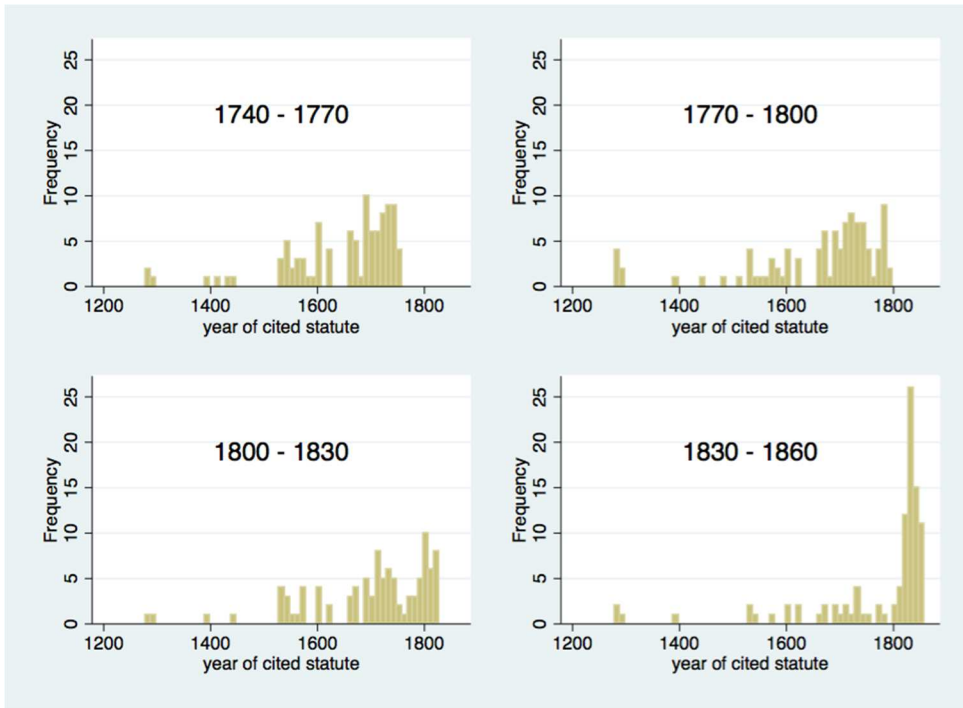


Figure 58: Time profiles for the years 1700-1850; cited years are aggregated by semi-decade (x-axis) and citing years by decade (boxes); English statutes

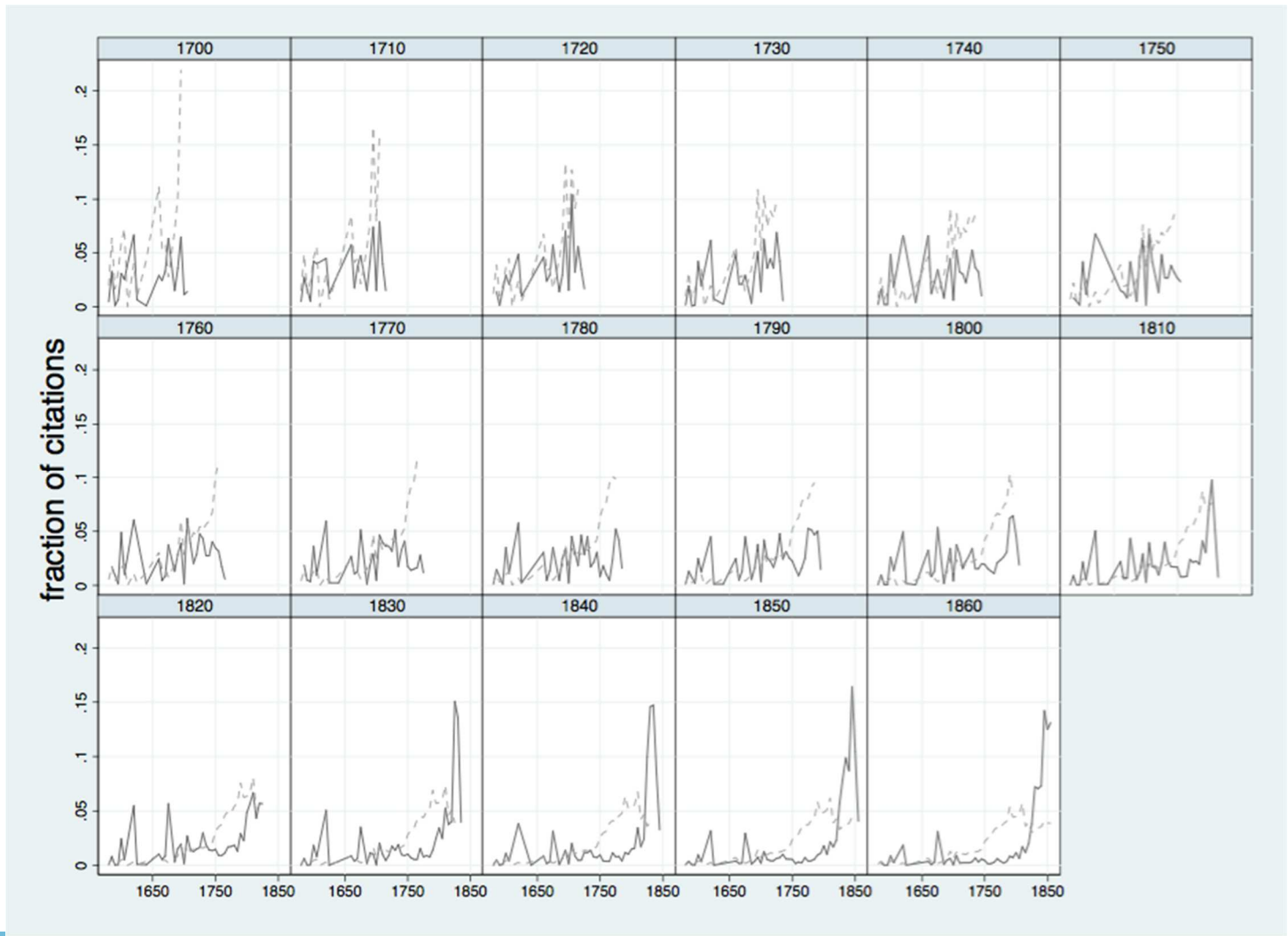


Figure 59: Estimation of year-aggregated, standard representative court room model: year-dependent parameter estimates of depreciation rate and 95% confidence intervals for the; English statutes

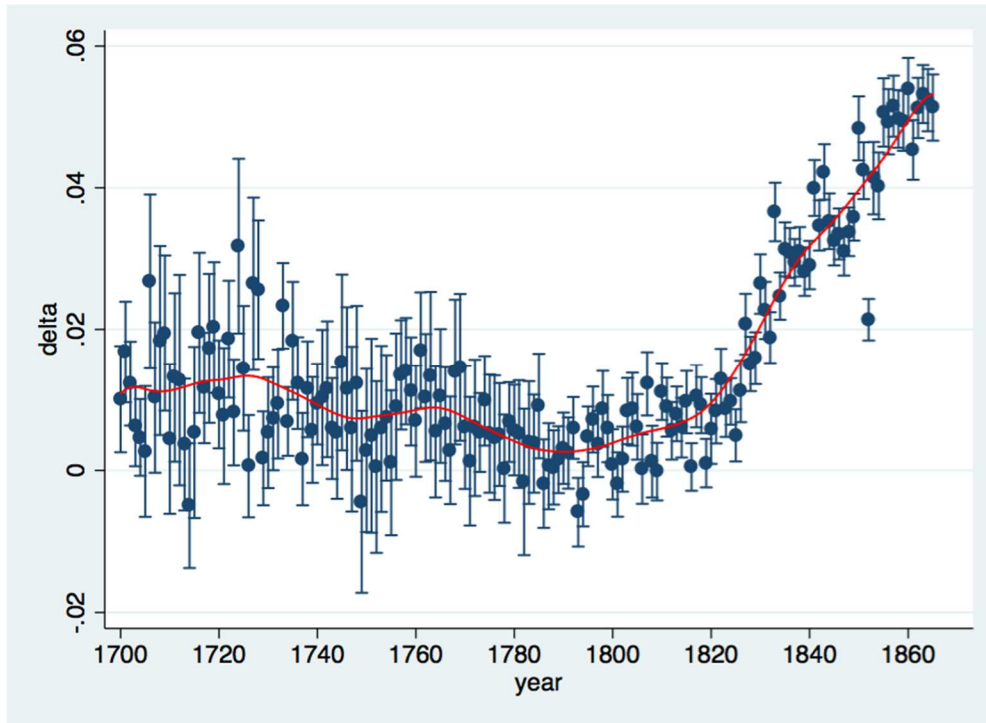
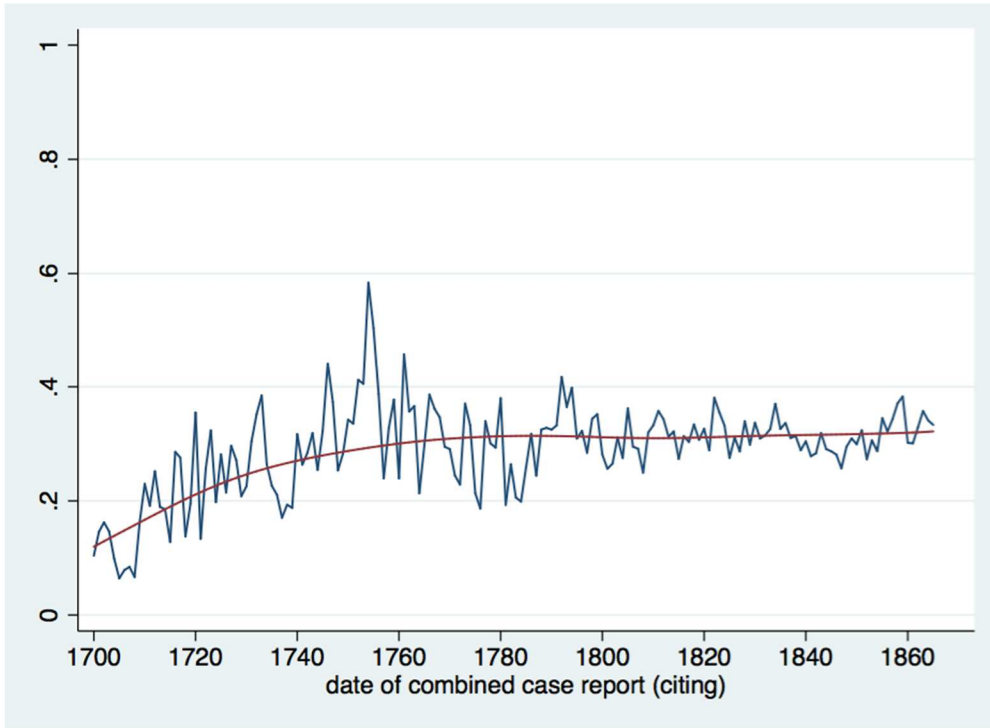


Figure 60: Yearly average relative share of ER statute citations in common law courtrooms



Appendix A: Python code for citation extraction

ER search

```
##### main code that creates database, applies manual corrections, calls matching
patterns, separates combined text files, extracts case report information, calls functions
detecting case and statute citations, and records information to database
# -*- coding: utf-8 -*-

# import libraries
import time
import os
import re
import itertools
import csv
import sqlite3
import search_statutes
import search_cases

# set start time
time_start = time.asctime(time.localtime(time.time()))

# decide if ER files need to be recopied and recorrected (datainstall = 1)
datainstall = 1

### delete and recreate sqlite database
# open volume attributes input file
input_volumes = '/Users/M/Documents/Research/ER paper/Python/input/table
volumes.csv'
input_csv_volumes = csv.reader(open('%s' % input_volumes, 'rU'))

# delete existing database
try:
    os.remove('/Users/M/Documents/Research/ER paper/Python/db/ER.sqlite')
except:
    pass

# create new database
ER_db = sqlite3.connect('/Users/M/Documents/Research/ER paper/Python/db/ER.sqlite')
ER_db.text_factory = str
ER_db_cursor = ER_db.cursor()

ER_db_cursor.execute("""CREATE TABLE "case_attributes"
("uid" INTEGER PRIMARY KEY NOT NULL UNIQUE,
"nom_cite_raw" TEXT,
```

```
"nom_cite" TEXT,  
"nom_cite_letter" TEXT,  
"case_name" TEXT,  
"ER_cite" TEXT, "date" INTEGER, "num_words" INTEGER,  
"case_text" TEXT)""")
```

```
ER_db_cursor.execute("""CREATE TABLE "statute_citations"  
("uid" INTEGER NOT NULL,  
"stat_cite_year" INTEGER NOT NULL,  
"stat_cite_regnyear" TEXT NOT NULL,  
"stat_cite_context" TEXT NOT NULL,  
"stat_cite_chapter" TEXT,  
"stat_cite_name" TEXT)""")
```

```
ER_db_cursor.execute("""CREATE TABLE "case_citations"  
("uid" INTEGER NOT NULL,  
"case_cite" TEXT NOT NULL,  
"case_context" TEXT NOT NULL)""")
```

```
ER_db_cursor.execute("""CREATE TABLE "volume_attributes"  
("RID" INTEGER PRIMARY KEY NOT NULL UNIQUE,  
"rep_vol" TEXT NOT NULL UNIQUE, "rep_vol_num" INTEGER,  
"rep" TEXT, "court" TEXT NOT NULL, "ER_vol" INTEGER,  
"vol_year_start" INTEGER, "vol_year_end" INTEGER,  
"vol_page_start" INTEGER, "vol_page_end" INTEGER,  
"law_french" INTEGER NOT NULL)""")
```

```
ER_db.commit()
```

```
for v in input_csv_volumes:
```

```
ER_db_cursor.execute("""INSERT INTO volume_attributes  
(RID, rep_vol, rep_vol_num, rep, court, ER_vol, vol_year_start,  
vol_year_end, vol_page_start, vol_page_end, law_french)  
VALUES(?, ?, ?, ?, ?, ?, ?, ?, ?, ?)""",  
[v[0], v[1], v[2], v[3], v[4], v[5], v[6],  
v[7], v[8], v[9], v[10]])
```

```
ER_db.commit()
```

```
### copy and correct ER text files  
if datainstall == 1:
```

```
# copy ER text files to target directory  
from shutil import copytree, ignore_patterns
```



```

source = '/Users/M/Documents/Research/ER paper/ER'
destination = '/Users/M/Documents/Research/ER paper/Python/ER'
copytree(source, destination, ignore=ignore_patterns('* .pdf', '* .xlsx'))

# apply desired data corrections to ER text files
input_ER_corrections = '/Users/M/Documents/Research/ER paper/Python/input/ER
corrections.csv'
input_ER_corrections = csv.reader(open('%s' % input_ER_corrections, 'rU'))

# apply corrections to the different input files
vol = 0
for c in input_ER_corrections:

    if int(c[0]) == 1:
        instr = '%s' % c[4]
        exec instr
        text = textin.read()

        outstr = '%s' % c[5]
        exec outstr

    if int(c[0]) != vol and int(c[0]) != 1:
        textout.write(text)
        textout.close()
        outstr = '%s' % c[5]
        exec outstr

        textin.close()
        instr = '%s' % c[4]
        exec instr
        text = textin.read()

    print c[6]
    substr = '%s' % c[6]
    exec substr

    vol = int(c[0])

textout.write(text)
textout.close()

### prepare matching patterns
#create pattern for nominative and explicit statute citations

```

```

rulers_pattern, rul_pattern, dict_rulers = search_statutes.create_statute_cite_pattern()
dict_rulers_years = search_statutes.create_dict_rulers_years()
statutenames_pattern, dict_statutenames_years =
search_statutes.create_statute_name_pattern()

# create pattern for nominative case citations
cases_nomcit_pattern, cas_nomcit_pattern, dict_cases_nomcit, cases_nomcit =
search_cases.create_case_nomcit_pattern()

# create regular expression pattern to extract nominative citations from Juta citations
rep_volumes_pattern = '[s\.\(\),;]' + cas_nomcit_pattern + '\.{0,1}\s{0-9}{1,4})\s{0,1}[a-zA-Z]{0,1}\Z'

# create regular expression pattern to split Juta case reports and extract information from
Juta header
reader = csv.reader(open('/Users/M/Documents/Research/ER paper/Python/input/dict
cases nomcit.csv', 'rU'))
jutanames = []
for row in reader:
    jutaname = re.sub('\.', '\.', row[0])
    jutanames.append(jutaname)
jutanames.sort(key = len, reverse = True)

juta_pattern = '(?:' + '|'.join(cases_nomcit) + ')'
juta_pattern = "(\\n.+? " + juta_pattern + " [0-9]{1,4})\s{0,1}[a-zA-Z]{0,1}, [0-9]{1,3} ER
[0-9]{1,4})\n"
juta_pattern2 = '(' + '|'.join(cases_nomcit) + ')'
juta_pattern2 = "\n(.+?)" + juta_pattern2 + " ([0-9]{1,4})\s{0,1}([a-zA-Z]{0,1}), ([0-
9]{1,3} ER [0-9]{1,4})\n"

#### define function that cuts reporter volumes into case chunks, extracts case specific
information, and calls statute/case search modules
# initialize unique case identifier and error uid
uid = 1

# define main function
def rep_volume_search(rep_volume):

    print rep_volume
    # set global scope of uid
    global uid

    # open reporter volume text file
    text = open(rep_volume, 'r')

```

```

text = text.read()

# split reporter volume into separate cases
chunks = re.split(juta_pattern, text)

# recombine case header and case text
casenames = chunks[1::2]
casetexts = chunks[2::2]
chunksnew = []
for zname, ztext in zip(casenames, casetexts):
    chunksnew.append('%s @@@ %s' % (zname,ztext))

# extract case-specific information (nominative citation, ER citation, report date)
# from each case chunk
for c in chunksnew:

    # print unique case identifier
    print '\nuid: ', uid

    # find juta citation that identifies beginning of case
    try:
        juta_path = re.search(juta_pattern2, c, re.IGNORECASE)
        juta_cite = juta_path.group(0)
        print juta_cite
    except:
        print '\nError: Could not extract Juta citation.'
        print c[0:250], '\n'

## extract case attributes from Juta header and text chunk
if juta_path:

    # extract and standardize nominative citation from juta header
    nom_cite_raw = juta_path.group(2) + ' ' + juta_path.group(3)
    print nom_cite_raw
    nom_cite_vol = juta_path.group(2)
    nom_cite_vol = re.sub('\.', "'", nom_cite_vol)
    nom_cite_vol = ".join(nom_cite_vol.split())
    nom_cite_vol = nom_cite_vol.lower()
    nom_cite_vol = dict_cases_nomcit[nom_cite_vol]
    nom_cite_page = juta_path.group(3)
    nom_cite_page = int(nom_cite_page)
    nom_cite = "%s %s" % (nom_cite_vol, nom_cite_page)
    print nom_cite

    # extract possible nominative citation letter from juta header

```

```

try:
    nom_cite_letter = juta_path.group(4)
except:
    pass

# extract case name from juta header
case_name = juta_path.group(1)
print case_name

# extract ER citation from juta header
ER_cite = juta_path.group(5)
print ER_cite

# extract report date from chunk
try:
    date = re.search('Report Date: ([0-9]{4})', c)
    date = date.group(1)
    print 'Report date: %s' % date
except:
    print 'Error: Could not extract report date.'
    print c[0:500], '\n'

# count number of words in text chunk
num_words = len(c.split())

## extract nominative case citations from text chunk
case_nomcites, case_nomcites_contexts =
search_cases.search_case_cites(c,nom_cite_vol)

## extract nominative statute citations from text chunk
statutenomcites_years, statutenomcites_regnyears, statutenomcites_contexts,
statutenomcites_chapters, statutenomcites_names =
search_statutes.search_statute_cites(c)

# extract explicit statute citations from text chunk
statutenames_years, statutenames_regnyears, statutenames_contexts,
statutenames_chapters, statutenames_names = search_statutes.search_statutenames(c)

# combine nominative and explicit statute citations
statute_years = statutenomcites_years + statutenames_years
statute_regnyears = statutenomcites_regnyears + statutenames_regnyears
statute_contexts = statutenomcites_contexts + statutenames_contexts
statute_chapters = statutenomcites_chapters + statutenames_chapters
statute_names = statutenomcites_names + statutenames_names

```

```

## write case attributes to database
ER_db_cursor.execute("""INSERT INTO case_attributes
(uid, nom_cite_raw, nom_cite, nom_cite_letter, ER_cite, case_name,
date, num_words, case_text)
VALUES(?, ?, ?, ?, ?, ?, ?, ?, ?)""",
[uid,nom_cite_raw, nom_cite, nom_cite_letter,
ER_cite, case_name, date, num_words,
c])

for st, strgy, sttxt, stcha, stnam in zip(statute_years, statute_regnyears,
statute_contexts, statute_chapters, statute_names):
    ER_db_cursor.execute("""INSERT INTO statute_citations
(uid, stat_cite_year, stat_cite_regnyear, stat_cite_context,
stat_cite_chapter, stat_cite_name)
VALUES(?, ?, ?, ?, ?, ?)""",
[uid, st, strgy, sttxt, stcha, stnam])

for ca, catxt in zip(case_nomcites, case_nomcites_contexts):
    ER_db_cursor.execute("""INSERT INTO case_citations
(uid, case_cite ,case_context)
VALUES(?, ?, ?)""",
[uid, ca, catxt])

# write to database
ER_db.commit()

# update unique case identifier and temporary nominative citation identifier
uid = uid + 1

#### run code on all file in target directory
tree = os.walk('/Users/M/Documents/Research/ER paper/Python/ER')
for dirs in tree:
    for filename in dirs[2]:
        if filename[-4:] == '.txt':
            rep_volume = dirs[0] + '/' + filename
            rep_volume_search(rep_volume)

# close database
ER_db.close()

```

```
# display end time
time_end = time.asctime(time.localtime(time.time()))
print time_start
print time_end
```

search cases

```
##### search_cases function that detects and extracts case citations
# import required libraries
#import regex as re
import re
import csv

# define input files
input_cases_nomcit = '/Users/M/Documents/Research/ER paper/Python/input/dict cases
nomcit.csv'

# create search pattern for nominative case citation search
# create dictionary for correspondence between possible ruler abbreviations and standard
def create_case_nomcit_pattern():
    # create needed empty lists and dictionaries
    global cases_nomcit_pattern
    global dict_cases_nomcit
    cases_nomcit = []
    dict_cases_nomcit = {}

# import all abbreviations of nominative reports
reader = csv.reader(open('%s' % input_cases_nomcit, 'rU'))
for row in reader:
    for i in range(len(row)):
        if row[i] != "":
            # create dictionary of case abbreviations
            dict_abb = re.sub('\.', ' ', row[i]) # replace dots with
whitespace
            dict_abb = ".join(dict_abb.split()) # remove all whitespaces
            dict_abb = dict_abb.lower() # lowercase dict entries
            dict_cases_nomcit['%s' % dict_abb] = row[0].lower()

# create basic search pattern components
rep_abb = re.sub('\.\{0,1\}\s{0,1}', row[i]) # allow missing/existing
dot with or without space
rep_abb = re.sub('\(\.\{0,1\}', rep_abb) # allow empty space
behind opening bracket
```

```

        rep_abb = re.sub('\s{0,1}\s', rep_abb)           # allow empty space
before closing bracket
        cases_nomcit.append(rep_abb)

# check for double entries in list with nominative citations
cases_nomcit.sort()
for i, c_n in enumerate(cases_nomcit):
    if c_n == cases_nomcit[i-1]:
        print 'Warning: duplicate enpty in case dictionary: ', c_n

# create search pattern for nominative case citations
cases_nomcit.sort(key = len, reverse = True)
cas_nomcit_pattern = '(' + '|'.join(cases_nomcit) + ')'
cases_nomcit_pattern = '[\s\.\-\(\)\[\],;]\s{0,1}' + cas_nomcit_pattern +
'\. {0,1}\s{0,1}([0-9]{1,4})'

return cases_nomcit_pattern, cas_nomcit_pattern, dict_cases_nomcit, cases_nomcit

# define function that searches string for pattern of nominative case citations
def search_case_cites(string,rep_vol):
    # remove white space occuring more than 1 times in a row
    string = ''.join(string.split())

    case_nomcites = []
    case_nomcites_contexts = []
    #determine and write number of total words and pattern matches
    found_patterns = re.finditer(cases_nomcit_pattern, string)

    # extract and clean various contexts of matched patterns
    for pat in found_patterns:

        # clean found pattern & translate into standard format
        case_nomcite_vol = re.sub('\.', '', pat.group(1))
        case_nomcite_vol = ".join(case_nomcite_vol.split())
        case_nomcite_vol = case_nomcite_vol.lower()
        case_nomcite_vol = dict_cases_nomcit[case_nomcite_vol]
        case_nomcite_page = pat.group(2)
        case_nomcite_page = int(case_nomcite_page)
        case_nomcite = "%s %s" % (case_nomcite_vol, case_nomcite_page)
        if case_nomcite_vol != rep_vol:           # make sure that case references
artificially generated by the Juta Law website are not included
            case_nomcite_context = string[pat.start() - 50 : pat.end() + 50]
            print case_nomcite_vol, case_nomcite_page, ': ', case_nomcite_context

```

```

        case_nomcites.append(case_nomcite)
        case_nomcites_contexts.append(case_nomcite_context)

return case_nomcites, case_nomcites_contexts

```

search statutes

```

##### search_statute function that detects and extracts statute citations
# import required libraries
#import regex as re
import re
import csv

# define input files
input_rulers = '/Users/M/Documents/Research/ER paper/Python/input/dict rulers.csv'
input_statutes = '/Users/M/Documents/Research/ER paper/Python/input/stat names &
years.csv'
input_regnalyears = '/Users/M/Documents/Research/ER paper/Python/input/regnal
years.csv'

output_text_statutes =open('/Users/M/Documents/Research/ER
paper/Python/output/output_text_statutes.txt', 'w')

### create search pattern for nominative statute citation search
# create dictionary for correspondence between possible ruler abbreviations and standard
def create_statute_cite_pattern():
    # create needed empty lists and dictionaries
    global rul_pattern
    global rulers_pattern
    global dict_rulers
    rulers = []
    rulers_short = []
    dict_rulers = {}

# import abbreviations of rulers as list, create a dictionary of equivalent
# ruler abbreviations
reader = csv.reader(open('%s' % input_rulers, 'rU'))
for row in reader:
    for i in range(len(row)):
        if row[i] != "":
            dict_rulers['%s' % row[i]] = row[0]
            rul_abb = re.sub('\.', '\\.', row[i])
            rulers.append(rul_abb)
# create and append short forms of rulers like edw. 1 (= edw.), geo. 1 (= geo.), etc.

```



```

# and append at the end of ruler list to set priority in regular expression search
ruler_short = re.search('\. [1]\Z', row[0])
if ruler_short:
    ruler_short = row[0][ : ruler_short.start()]
    dict_rulers['%s' % ruler_short] = row[0]
    rulers_short.append(ruler_short)
rulers.extend(rulers_short)

# create search pattern for rulers
rul_pattern = '|'.join(rulers)
rulers_pattern = '[\s\.\-\\(\)\[\],;]s{0,1}((\[[0-9]{1,2}\)(th(\sof){0,1}){0,1}s' + '(' +
rul_pattern + ')' + '[\s\.\-\\(\)\[\],;])'
return rulers_pattern, rul_pattern, dict_rulers

#### create dictionary for correspondance between regnal years and calendar years
def create_dict_rulers_years():
    global dict_rulers_years
    dict_rulers_years = {}
    reader = csv.reader(open('%s' % input_regnalyears, 'rU'))
    for row in reader:
        row_temp = row[0] + ' ' + row[1]
        dict_rulers_years['|'.join(row_temp.split())] = int(row[2])
    return dict_rulers_years

#### create dictionary with maximum regnal year of rulers
def create_dict_rulers_years_max():
    global dict_rulers_years_max
    dict_rulers_years_max = {}
    reader = csv.reader(open('%s' % input_regnalyears, 'rU'))
    ruler_temp = ""
    year_temp = ""
    for row in reader:
        if ruler_temp != row[1] and ruler_temp != "":
            dict_rulers_years_max[ruler_temp] = int(year_temp)
            ruler_temp = row[1]
            year_temp = row[0]
        dict_rulers_years_max[ruler_temp] = int(year_temp)
    return dict_rulers_years_max

```

```

#### define function that searches string for nominative statute citations and checks their
validity
def search_statute_cites(string):
    statute_cites_years = []
    statute_cites_regyears = []
    statute_cites_contexts = []
    statute_cites_chapters = []
    statute_cites_names = []

    # regular expression search for nominative statute citations
    found_patterns = re.finditer(rulers_pattern, string, re.IGNORECASE)

    # extract and clean various contexts of matched patterns
    for pat in found_patterns:
        context1 = string[pat.start() - 20 : pat.end() + 20]
        context1 = ''.join(context1.split())
        context2 = string[pat.start() - 15 : pat.end()]
        context2 = ''.join(context2.split())
        context3 = string[pat.start() : pat.end() + 15]
        context3 = ''.join(context3.split())

        # rules to check if found pattern corresponds to statute
        #1: classified as statute
        #0: classified as non-statute

        # set initial classification
        statute_found = 0

        # check if variants of statute appear closeby
        if re.search('\s(statute|statutes|stat\.)\s', context1, re.IGNORECASE):
            statute_found = 1

        # check if the words Act or Acts appear closeby
        if re.search('\s(Act)s{0,1}\s', context1):
            statute_found = 1

        # check if variants of court session references appear shortly before
        if
re.search('(Mich|Michaelis|Michaelmas|Pasch|Paschie|Easter|East|Trin|Trinity|Hil|Hill|Hil
larii|Term)[\.\,]{0,1}\s', context2, re.IGNORECASE):
            statute_found = 0

        # check if variants of chap. or sect. appear closely behind
        if re.search('\s(c|ch|cap|chap}s|sec|sect)\.\s[0-9]{1,3}', context3, re.IGNORECASE):
            statute_found = 1

```

```

if statute_found == 1:
    output_text_statutes.write('\n-----\n')
    output_text_statutes.write('%s %s \n' % (pat.group(2), pat.group(5)))
    output_text_statutes.write('%s \n \n' % context1)
    #print pat.group(0), ":", context4

    ruler = pat.group(5)
    ruler = dict_rulers[ruler.lower()]
    regnal_year = pat.group(2)
    regnal_year_context = string[pat.start() - 30 : pat.end() + 30]
    print regnal_year, ruler, ":", regnal_year_context

    statutecites_regnalyears.append(' '.join([regnal_year, ruler]))
    statutecites_contexts.append(regnal_year_context)

    try:
        year = int(dict_rulers_years[' '.join([regnal_year, ruler])])
        output_text_statutes.write('Dictionary translation of ruler: %s \n' % ruler)
        output_text_statutes.write('Dictionary translation to year: %s \n' % year)
    except:
        year = 0
        output_text_statutes.write('Error: regnal year cannot be translated into calendar
year \n')
        print 'Error: regnal year cannot be translated into calendar year'
        print ' '.join([regnal_year, ruler])

    statutecites_years.append(year)

    try:
        chapter = re.search('[\s\.\-\/\(\)\[\]\,\;]\s{0,1}(c|ch|cap|chap)\.\.\{0,1}\s{0,1}([0-9]{1,3})',
context3, re.IGNORECASE)
        chapter = chapter.group(2)
    except:
        chapter = ""

    statutecites_chapters.append(chapter)

    statutecites_names.append("")

    return statutecites_years, statutecites_regnalyears, statutecites_contexts,
statutecites_chapters, statutecites_names

```

```

### import names of specific statues as list, create a dictionary of statutes names

```

```

# and corresponding year of origin
def create_statute_name_pattern():
    reader = csv.reader(open('%s' % input_statutes, 'rU'))
    global statutenames_pattern
    global dict_statutenames_years
    statutenames = []
    dict_statutenames_years = {}
    for row in reader:
        dict_statutenames_years[row[0]] = row[1]
        stat_name = re.sub('\.', '\\.', row[0])
        statutenames.append(stat_name)

# create search pattern for statutes
statutenames_pattern = '|'.join(statutenames)
statutenames_pattern = '((?:statute|statutes|stat\\.)(?:\s{0,1}\s(' +
statutenames_pattern + '))|(((' + statutenames_pattern + ')(?:\sAct\s' + '))|(' + 'Magna
Carta|Magna Charta|Bill of Rights|Act of Settlement)'
#statutenames_pattern = '(statute|statutes|stat\\.)(\s{0,1}\s{1,3}' + '(' +
statutenames_pattern + ')

return statutenames_pattern, dict_statutenames_years

# define function that searches string for pre-defined statute names
def search_statutenames(string):
    statutenames_years = []
    statutenames_regnalyears = []
    statutenames_contexts = []
    statutenames_chapters = []
    statutenames_names = []

#define dictionary with equivalent statute names
statute_name_dict = {'articulis cleri': 'articuli cleri', 'articulis super chartas': 'articuli
super chartas', 'charta forresta': 'charta forrest',
                    'circumspecte agatis': 'circumspect agatis', 'circumspectee agatis':
'circumspect agatis',
                    'conjunctim feoffatis': 'conjunctim feoffat', 'de donia': 'do nis' ,
'distribution': 'distributions', 'glocester': 'gloucester',
                    'jeofail': 'jeofails', 'limitation': 'limitations', 'magna carta': 'magna
charta', 'magna chara': 'magna charta',
                    'magna chart': 'magna charta', 'marlberge': 'marlbridge', 'modus
levandi': 'modus levandi fines',
                    'scandalum magnatum': 'scandalis magnatum', 'scandalo
magnatum': 'scandalis magnatum', 'scan. mag.': 'scandalis magnatum',

```

```

        'westminst.': 'westminster', 'westmin.': 'westminster', 'westm.':
'westminster'}

#determine and write number of total words and pattern matches
found_patterns = re.finditer(statutenames_pattern, string, re.IGNORECASE)

# extract and matched statute names
for pat in found_patterns:

    if pat.group(2):
        statute_name = pat.group(2)
    if pat.group(4):
        statute_name = pat.group(4)
    if pat.group(5):
        statute_name = pat.group(5)

    statute_name = statute_name.lower()
    try:
        statute_name = statute_name_dict[statute_name]
    except:
        pass

    statute_name_context = string[pat.start() - 30 : pat.end() + 30]
    print "%s: %s" % (statute_name, statute_name_context)

    try:
        year = int(dict_statutenames_years[statute_name])
    except:
        year = 0

    statutenames_years.append(year)
    statutenames_regnyears.append("")
    statutenames_contexts.append(statute_name_context)
    statutenames_chapters.append("")
    statutenames_names.append(statute_name)

    return statutenames_years, statutenames_regnyears, statutenames_contexts,
statutenames_chapters, statutenames_names

```

Appendix B: Stata code for data cleaning

1_prepare case information & volume attributes

```
clear
set mem 200m
set more off
global path "/Users/M/Documents/Research/ER paper/2_Cleaning"
cd "$path"

*** prepare datesets
** case_attributes
* extract reporter volume, page number, and ER volume
insheet using "$path/_db input/case_attributes.csv"

** generate or regenerate variables
ren nom_cite nomcite
ren nom_cite_letter nomcite_letter
ren case_name casename
ren er_cite ercite

* regenerate nominative citation volume
gen nomcite_vol = trim(regexs(1)) if regexm(nomcite,".*([0-9]+)$")

* generate nominative citation page
gen nomcite_page = trim(regexs(2)) if regexm(nomcite,".*([0-9]+)$")
destring nomcite_page, replace

* extract first party name from case name
gen casename_firstparty = trim(regexs(1)) if regexm(casename,"([a-zA-Z']+)( v )([a-zA-Z']+)")
replace casename_firstparty = "Rex" if casename_firstparty == "R"
replace casename_firstparty = "" if length(casename_firstparty) < 3

* extract second party name from case name
gen casename_secondparty = trim(regexs(3)) if regexm(casename,"([a-zA-Z']+)( v )([a-zA-Z']+)")
replace casename_secondparty = "" if length(casename_secondparty) < 3

* make sure both party names are present
replace casename_firstparty = "" if casename_secondparty == ""
replace casename_secondparty = "" if casename_firstparty == ""

* extract party name if there is only one party mentioned, and use as first party name
```

```

*gen casename_onepartyonly1 = trim(regexs(2)) if regexm(casename,"(In re |in re |Ex
parte |ex parte )([a-zA-Z']+)")
*gen casename_onepartyonly2 = trim(regexs(1)) if regexm(casename,"([a-zA-Z']+)( case|
Case)")
*replace casename_onepartyonly2 = subinstr(casename_onepartyonly2, "s", "", .)
*replace casename_onepartyonly2 = subinstr(casename_onepartyonly2, "s'", "s", .)
*gen casename_onepartyonly = casename_onepartyonly1
*replace casename_onepartyonly = casename_onepartyonly2 if casename_onepartyonly
== ""
*replace casename_firstparty = casename_onepartyonly if casename_firstparty == ""
*drop casename_onepartyonly*

* generate ER volume
gen ercite_vol = trim(regexs(1)) if regexm(ercite,"([0-9]+)( ER)")
destring ercite_vol, replace

* save file with informaton on all case reports
save "$path/case_attributes.dta", replace

*** combine case reports with identical nominative citations
* keep only relevant variables
keep uid nomcite nomcite_letter nomcite_vol nomcite_page casename
casename_firstparty casename_secondparty ercite ercite_vol date num_words
order uid nomcite nomcite_letter nomcite_vol nomcite_page casename
casename_firstparty casename_secondparty ercite ercite_vol date num_words

** generate attributes of combined case reports
* uid (first/lowest uid in group)
bysort nomcite (uid): egen UID = min(uid)

preserve
keep uid UID
save "$path/uid-UID.dta", replace
restore

* nominative citation (first in group)
bysort nomcite (uid): gen NOMCITE = nomcite[1]
bysort nomcite_vol (uid): gen NOMCITE_VOL = nomcite_vol[1]
bysort nomcite_page (uid): gen NOMCITE_PAGE = nomcite_page[1]

* date (most frequent or first date in group)
gsort nomcite -uid
gen DATEFIRST_temp = date

```

```

by nomcite: replace DATEFIRST_temp = DATEFIRST_temp[_n-1] if
DATEFIRST_temp >= .
by nomcite: gen DATEFIRST = DATEFIRST_temp[_N]
sort uid

bysort nomcite: egen DATEMODE = mode(date)

gen DATE = DATEFIRST
bysort nomcite: replace DATE = DATEMODE if DATEMODE != .

drop DATEFIRST_temp DATEFIRST DATEMODE

* word count (sum of all words in group)
bysort nomcite: egen WORDS = total(num_words)

* ER citation (first in group)
bysort nomcite (uid): gen ERCITE = ercite[1]
bysort nomcite (uid): gen ERCITE_VOL = ercite_vol[1]

* casename (first in group)
bysort nomcite (uid): gen CASENAME = casename[1]
bysort nomcite (uid): gen CASENAME_FIRSTPARTY = casename_firstparty[1]
bysort nomcite (uid): gen CASENAME_SECONDPARTY = casename_secondparty[1]

* drop redundand observations from combined cases
collapse (count) NOMCITE_NUM=uid, by(UID NOMCITE NOMCITE_VOL
NOMCITE_PAGE DATE WORDS ERCITE ERCITE_VOL CASENAME
CASENAME_FIRSTPARTY CASENAME_SECONDPARTY)
order UID NOMCITE NOMCITE_VOL NOMCITE_PAGE NOMCITE_NUM DATE
WORDS ERCITE ERCITE_VOL CASENAME CASENAME_FIRSTPARTY
CASENAME_SECONDPARTY
label var NOMCITE_NUM ""

ren UID uid
ren NOMCITE nomcite
ren NOMCITE_VOL nomcite_vol
ren NOMCITE_PAGE nomcite_page
ren NOMCITE_NUM nomcite_num
ren DATE date
ren WORDS num_words
ren ERCITE ercite
ren ERCITE_VOL ercite_vol
ren CASENAME casename
ren CASENAME_FIRSTPARTY casename_firstparty
ren CASENAME_SECONDPARTY casename_secondparty

```



```

*** add inferred dates
** add manually inferred dates
ren date date_juta
gen date = date_juta
merge m:1 nomcite using "/Users/M/Documents/Research/ER paper/2_cleaning/_dates
added/datesadded.dta", update
drop if _merge == 2
drop _merge

** fill in isolated dates based on neighboring cases
* calculate missing dates indicators
preserve
gen datemissing = 0
replace datemissing = 100 if date == .

bysort nomcite_vol: egen datemin = min(date)
by nomcite_vol: egen datemax = max(date)
gen daterange = datemax - datemin

gen dateincreasing = .
by nomcite_vol: replace dateincreasing = 100 if (date[_n-1] <= date[_n] | _n == 1) &
date[_n] != .
replace dateincreasing = 0 if dateincreasing == . & date != .

collapse (count) uid (mean) datemissing (mean) dateincreasing (mean) daterange,
by(nomcite_vol)
keep nomcite_vol datemissing daterange dateincreasing
save "$path/_temp/datesmissing.dta", replace
restore

/*

* merge missing dates indicators
merge m:1 nomcite_vol using "$path/_temp/datesmissing.dta"
drop _merge

* replace date with previous date if certain criteria are met
replace date = date[_n-1] if date[_n] == . & ///
                                                                    (nomcite_vol[_n] ==
nomcite_vol[_n-1]) & ///

```

```

(dateincreasing >= 70) & (daterange <= 30)
    (daterange <= 20)
*/

** count cases, and save file
* create variable with annual number of case reports
bysort date: egen numcasesyear = count(uid)
egen decade = cut(date), at(1500(10)1870)
bysort decade: egen numcasesdecade = count(uid)

* sort and save modified case attributes
sort nomcite_vol nomcite_page
order uid nomcite nomcite_vol nomcite_page nomcite_num ercite ercite_vol casename
casename_firstparty casename_secondparty date decade numcasesyear numcasesdecade
num_words
save "$path/case_attributes_combined.dta", replace

** volume_attributes
clear
insheet using "$path/_db input/volume_attributes.csv"
drop rid rep_vol_num er_vol
ren rep nomcite_rep
ren rep nomcite_vol
ren vol_year_start nomcite_volyearstart
ren vol_year_end nomcite_volyearend
ren vol_page_start nomcite_pagestart
ren vol_page_end nomcite_pageend
ren law_french nomcite_repvollawfrench
order nomcite_vol nomcite_rep court nomcite_volyearstart nomcite_volyearend
nomcite_pagestart nomcite_pageend nomcite_repvollawfrench

save "volume_attributes.dta", replace

```

2_merge cases data

```

clear
set mem 600m
set more off
global path "/Users/M/Documents/Research/ER paper/2_Cleaning"
cd "$path/_temp/"
!rm *
cd "$path"

```

```

*** merge case citations with case and volume attributes
clear
insheet using "$path/_db input/case_citations.csv"

*** extract information on cited case
ren case_cite nomcite
ren case_context citecontext

* generate volume and page number of cited case
gen nomcite_rep = regexs(2) if regexm(nomcite,"([0-9]?)([a-zA-Z' ]+) ([0-9]+)$")
gen nomcite_vol = regexs(1) if regexm(nomcite,"(.*) ([0-9]+)$")
gen nomcite_page = regexs(2) if regexm(nomcite,"(.*) ([0-9]+)$")
destring nomcite_page, replace

* drop erroneous case citations that were extracted from case header
drop if citecontext == ""

* drop erroneous case citations that result from volumes with common names
gen temp1 = "(re |v\?.?)"
gen temp2 = proper(nomcite_rep)
egen temp3 = concat(temp1 temp2)
gen mismatch = regexm(citecontext,temp3)
drop if mismatch == 1
drop nomcite_rep temp1 temp2 temp3 mismatch

* correct volume assignments based on page numbers (dyer, plowden, salkeld, lord
raymond, strange, blackstone, burrow, cowper, douglas, lutwyche)
replace nomcite_vol = "1 dyer" if nomcite_vol == "dyer" & inrange(nomcite_page,1,106)
replace nomcite_vol = "2 dyer" if nomcite_vol == "dyer" &
inrange(nomcite_page,107,252)
replace nomcite_vol = "3 dyer" if nomcite_vol == "dyer" & nomcite_page > 252
replace nomcite_vol = "1 plowden" if nomcite_vol == "plowden" &
inrange(nomcite_page,1,401)
replace nomcite_vol = "2 plowden" if nomcite_vol == "plowden" & nomcite_page > 401
replace nomcite_vol = "1 salkeld" if nomcite_vol == "salk" &
inrange(nomcite_page,1,410)
replace nomcite_vol = "2 salkeld" if nomcite_vol == "salk" & nomcite_page > 410
replace nomcite_vol = "1 lord raymond" if nomcite_vol == "ld.raym" &
inrange(nomcite_page,1,750)
replace nomcite_vol = "2 lord raymond" if nomcite_vol == "ld.raym" & nomcite_page >
750
replace nomcite_vol = "1 strange" if nomcite_vol == "str" &
inrange(nomcite_page,1,676)
replace nomcite_vol = "2 strange" if nomcite_vol == "str" & nomcite_page > 676

```

```

replace nomcite_vol = "1 blackstone w" if nomcite_vol == "blackstone w" &
inrange(nomcite_page,1,681)
replace nomcite_vol = "2 blackstone w" if nomcite_vol == "blackstone w" &
nomcite_page > 681
replace nomcite_vol = "1 burrow" if nomcite_vol == "burrow" &
inrange(nomcite_page,1,652)
replace nomcite_vol = "2 burrow" if nomcite_vol == "burrow" &
inrange(nomcite_page,653,1234)
replace nomcite_vol = "3 burrow" if nomcite_vol == "burrow" &
inrange(nomcite_page,1235,1924)
replace nomcite_vol = "4 burrow" if nomcite_vol == "burrow" &
inrange(nomcite_page,1925,2584)
replace nomcite_vol = "5 burrow" if nomcite_vol == "burrow" & nomcite_page > 2584
replace nomcite_vol = "1 cowper" if nomcite_vol == "cowper" &
inrange(nomcite_page,1,419)
replace nomcite_vol = "2 cowper" if nomcite_vol == "cowper" & nomcite_page > 419
replace nomcite_vol = "1 douglas" if nomcite_vol == "douglas" &
inrange(nomcite_page,1,411)
replace nomcite_vol = "2 douglas" if nomcite_vol == "douglas" & nomcite_page > 411
replace nomcite_vol = "1 lutwyche" if nomcite_vol == "lutwyche" &
inrange(nomcite_page,1,912)
replace nomcite_vol = "2 lutwyche" if nomcite_vol == "lutwyche" & nomcite_page >
912
replace nomcite_vol = "1 anstruther" if nomcite_vol == "anstruther" &
inrange(nomcite_page,1,342)
replace nomcite_vol = "2 anstruther" if nomcite_vol == "anstruther" &
inrange(nomcite_page,343,626)
replace nomcite_vol = "3 anstruther" if nomcite_vol == "anstruther" & nomcite_page >
626

```

* cut off strings behind case citation

```
gen citecontext2 = substr(citecontext,1,length(citecontext)-50)
```

* extract first party name from case name and delete party names that are too short, artificial or non-capitalized

```
gen casename_firstparty = trim(regexs(2)) if regexm(citecontext2,"([a-zA-Z]+ v [a-zA-Z]+.*)*([a-zA-Z]+) (v |v\.|v\.) ([a-zA-Z]+)")
```

```
gen casename_firstpartylen = length(casename_firstparty)
```

```
replace casename_firstparty = "" if casename_firstpartylen < 3
```

```
replace casename_firstparty = "" if inlist(casename_firstparty, "The", "Sir", "Non", "All")
```

```
gen casename_firstpartywrong = 1 if regexm(casename_firstparty,"^[a-z]")
```

```
replace casename_firstparty = "" if casename_firstpartywrong == 1
```

```

* extract second party name from case name and delete party names that are too short,
artificial or non-capitalized
gen casename_secondparty = trim(regexs(4)) if regexm(citecontext2,"([a-zA-Z']+ v [a-
zA-Z]+.*)*([a-zA-Z]'+) (v |v\.|v\.) ([a-zA-Z]'+)")

gen casename_secondpartylen = length(casename_secondparty)
replace casename_secondparty = "" if casename_secondpartylen < 3

replace casename_secondparty = "" if inlist(casename_secondparty, "The", "Sir", "Non",
"All")

gen casename_secondpartywrong = 1 if regexm(casename_secondparty,"^[a-z]")
replace casename_secondparty = "" if casename_secondpartywrong == 1

* drop variables detecting extraction errors
drop casename_firstpartylen casename_secondpartylen casename_firstpartywrong
casename_secondpartywrong

* drop shortened case context
drop citecontext2

* save citing information and added case cite information
save "$path/_temp/case_citations_allcitedinfo.dta", replace

*** match nominative citations to case attributes in dataset
** save case citations without explicit case parties
preserve
keep if casename_firstparty == ""
save "$path/_temp/case_citations_caseciteready_nocaseparty.dta", replace
restore

** match case citations based on explicit case parties
cd "$path/_temp/casecite matches"
!rm *

keep if casename_firstparty != ""
gen nomcite_matching = .
gen uid_temp = _n

qui levelsof nomcite_vol, local(nomcite_vols)
foreach n of local(nomcite_vols) {
    display "`n'"
}

```

```

* keep only case_attributes of reporter volume to be matched, remove duplicates
preserve
use "$path/case_attributes.dta", clear
keep if nomcite_vol == "`n'"
ren uid uid_partymatched
ren nomcite_page nomcite_pagematched
gsort nomcite_pagematched casename_firstparty casename_secondparty -
num_words
duplicates drop nomcite_pagematched casename_firstparty
casename_secondparty, force
keep uid_partymatched nomcite_pagematched casename_firstparty
casename_secondparty
save "$path/_temp/case_attributes_temp.dta", replace
restore

* keep only case cites of reporter volume to be matched, match case cites, remove
duplicates
preserve
keep if nomcite_vol == "`n'"
relink casename_firstparty casename_secondparty using
"$path/_temp/case_attributes_temp.dta", gen(mscore) idm(uid_temp)
idu(uid_partymatched) wmatch(1 1) wnomatch(1 1) minscore(0.6) minbigram(0.6)
duplicates drop uid_temp, force
gen nomcite_partymatched = nomcite_vol + " " + string(nomcite_pagematched) if
_merge == 3
replace nomcite_matching = 1 if _merge == 3
drop uid_temp nomcite_pagematched Ucasename_firstparty
Ucasename_secondparty mscore_merge
save "$path/_temp/casecite_matches/`n'.dta", replace
restore
}

drop *
set obs 1
gen nomcite = "xxx"
foreach n of local nomcite_vols {
    append using "$path/_temp/casecite_matches/`n'.dta"
}
drop if _n == 1

* append case citations without explicite case parties
append using "$path/_temp/case_citations_casemiteready_nocaseparty.dta"
save "$path/case_citations_stage1.dta", replace

```

*** match case citations with exactly corresponding nominative citations (in case attributes)

* prepare reduced case attributes

preserve

use "\$path/case_attributes_combined.dta", clear

ren uid uid_pagematched

keep uid_pagematched nomcite

save "\$path/_temp/case_attributes_combinedtemp.dta", replace

restore

* exact nomcite merge with case attributes

sort nomcite_vol nomcite_page

merge m:1 nomcite using "\$path/_temp/case_attributes_combinedtemp.dta"

drop if _merge == 2

gen nomcite_pagematched = nomcite if _merge == 3

replace nomcite_matching = 2 if _merge == 3

drop _merge

save "\$path/case_citations_stage2.dta", replace

*** match case citations to nominative citation with closest lower page number (in case attributes)

* prepare reduced case attributes

preserve

use "\$path/case_attributes_combined.dta", clear

ren uid uid_lowerpagematched

keep uid_lowerpagematched nomcite_vol nomcite_page

save "\$path/_temp/case_attributes_combinedtemp.dta", replace

restore

* lower page merge with case attributes

nearmrg nomcite_vol using "\$path/_temp/case_attributes_combinedtemp.dta", lower

nearvar(nomcite_page) genmatch(nomcite_pagelowermatched)

drop if _merge == 2

gen nomcite_lowerpagematched = nomcite_vol + " " +

string(nomcite_pagelowermatched) if _merge == 3

replace nomcite_matching = 3 if _merge == 3 & nomcite_matching == .

drop nomcite_pagelowermatched _merge

* label nomcite matching method variable

replace nomcite_matching = 4 if nomcite_matching == .

label define nomcite_matching 1 "matched on fuzzy case parties (most reliable)" 2

"matched on exact nominative citation (not on case parties)" 3 "matched only on lower

page nominative citation" 4 "not matched"

label values nomcite_matching nomcite_matching

* generate ultimate matched uid (party matching > exact page matching > nearest page matching)

gen uidmatched = uid_partymatched if nomcite_matching == 1

replace uidmatched = uid_pagematched if nomcite_matching == 2

replace uidmatched = uid_lowerpagematched if nomcite_matching == 3

* generate ultimate matched nomcite (party matching > exact page matching > nearest page matching)

gen nomcite_matched = nomcite_partymatched if nomcite_matching == 1

replace nomcite_matched = nomcite_pagematched if nomcite_matching == 2

replace nomcite_matched = nomcite_lowerpagematched if nomcite_matching == 3

gen nomcite_matchedvol = regexs(1) if regexm(nomcite_matched, "(.*) ([0-9]+)\$")

gen nomcite_matchedpage = regexs(2) if regexm(nomcite_matched, "(.*) ([0-9]+)\$")

destring nomcite_matchedpage, replace

* save dataset after matching is complete

save "\$path/case_citations_stage3.dta", replace

*** combine case citations from case reports with identical nominative citations and case citations to case reports with identical nominative citations

*** citing

** merge combined case UID's for citing case

merge m:1 uid using "\$path/uid-UID.dta"

keep if _merge == 3

drop _merge

** rename and order citing uids

ren uid citing_uid

ren UID citing_uidcombined

order citing_uid citing_uidcombined

*** cited

** merge combined case UID's for cited case

ren uidmatched uid

merge m:1 uid using "\$path/uid-UID.dta"

drop if _merge == 2

drop _merge

save "\$path/case_citations_stage4.dta", replace


```

** merge cited with volume attributes
merge m:1 nomcite_vol using "$path/volume_attributes.dta"
keep if _merge == 3
drop _merge

** rename cited variables
ren uid cited_uid
label var cited_uid "uid of single or combined case report (cited)"
ren UID cited_uidcombined
label var cited_uidcombined "uid of combined case report (cited)"
ren nomcite_matched cited_nomcitematched
label var cited_nomcitematched "nominative citation by best matching method (cited)"
ren nomcite_matchedvol cited_nomcitematchedvol
label var cited_nomcitematchedvol "nominative citation volume by best matching method (cited)"
ren nomcite_matchedpage cited_nomcitematchedpage
label var cited_nomcitematchedpage "nominative citation page by best matching method (cited)"
ren court cited_court
label var cited_court "court where reported case is presented (cited)"

ren nomcite_matching cited_nomcitematching
label var cited_nomcitematching "matching method used for nominative citation (cited)"

ren citecontext cited_citecontext
label var cited_citecontext "context of nominative citation (cited)"
ren uid_partymatched cited_uidpartymatched
label var cited_uidpartymatched "uid by party matching method (cited)"
ren uid_pagematched cited_uidpagematched
label var cited_uidpagematched "uid by page matching method (cited)"
ren uid_lowerpagematched cited_uidlowerpagematched
label var cited_uidlowerpagematched "uid by lower page matching method (cited)"
ren nomcite_partymatched cited_nomcitempartymatched
label var cited_nomcitempartymatched "nominative citation by party matching method (cited)"
ren nomcite_pagematched cited_nomcite_pagematched
label var cited_nomcite_pagematched "nominative citation by page matching method (cited)"
ren nomcite_lowerpagematched cited_nomcite_lowerpagematched
label var cited_nomcite_lowerpagematched "nominative citation by lower page matching method (cited)"
ren nomcite cited_nomciteoriginal
label var cited_nomciteoriginal "nominative citation unmatched (cited)"
ren nomcite_vol cited_nomciteoriginalvol

```

```
label var cited_nomciteoriginalvol "nominative citation volume unmatched (cited)"
ren nomcite_page cited_nomciteoriginalpage
label var cited_nomciteoriginalpage "nominative citation page unmatched (cited)"
```

```
ren nomcite_rep cited_nomciterep
label var cited_nomciterep "reporter volume (cited)"
ren nomcite_volyearstart cited_nomcitevolyearstart
label var cited_nomcitevolyearstart "starting year of reporter volume (cited)"
ren nomcite_volyearend cited_nomcitevolyearend
label var cited_nomcitevolyearend "ending year of reporter volume (cited)"
ren nomcite_pagestart cited_nomcitepagestart
label var cited_nomcitepagestart "starting page of reporter volume (cited)"
ren nomcite_pageend cited_nomcitepageend
label var cited_nomcitepageend "ending year of reporter volume (cited)"
ren nomcite_repvollawfrench cited_nomcitelawfrench
label var cited_nomcitelawfrench "law french used (cited)"
```

```
drop casename_firstparty casename_secondparty
```

```
** merge cited with combined case attributes
```

```
ren cited_uidcombined uid
merge m:1 uid using "$path/case_attributes_combined.dta"
drop if _merge == 2
drop _merge
ren uid cited_uidcombined
```

```
ren date cited_date
label var cited_date "date of combined case report (cited)"
ren decade cited_decade
label var cited_decade "decade of combined case report (cited)"
ren numcasesyear cited_numcasesyear
label var cited_numcasesyear "number of report cases during year of combined case
report (cited)"
ren numcasesdecade cited_numcasesdecade
label var cited_numcasesdecade "number of reported cases during decade of combined
case report (cited)"
ren num_words cited_numwords
label var cited_numwords "number of words in combined case report (cited)"
ren ercite cited_ercite
label var cited_ercite "ER citation of combined case report (cited)"
ren ercite_vol cited_ercitevol
label var cited_ercitevol "ER citation volume of combined case report (cited)"
ren nomcite_num cited_nomcitenum
label var cited_nomcitenum "number of case reports in combined case report (cited)"
```

```

ren casename cited_casename
label var cited_casename "name of combined case report (cited)"
ren casename_firstparty cited_casenamefirstparty
label var cited_casenamefirstparty "first party, i.e. plaintiff, of combined case report (cited)"
ren casename_secondparty cited_casenamessecondparty
label var cited_casenamessecondparty "second party, i.e. defendant, of combined case report (cited)"
drop nomcite nomcite_vol nomcite_page

```

```

*** citing
** merge citing with combined case attributes
ren citing_uidcombined uid
merge m:1 uid using "$path/case_attributes_combined.dta"
drop if _merge == 2
drop _merge
ren uid citing_uidcombined

```

```

** merge citing with volume attributes
merge m:1 nomcite_vol using "$path/volume_attributes.dta"
keep if _merge == 3
drop _merge

```

```

** rename citing variables
label var citing_uidcombined "unique id number of combined case report (citing)"
label var citing_uid "unique id number of single case report (citing)"
ren nomcite citing_nomcite
label var citing_nomcite "nominative citation (citing)"
ren nomcite_vol citing_nomcitevol
label var citing_nomcitevol "nominative citation volume (citing)"
ren nomcite_page citing_nomcitepage
label var citing_nomcitepage "nominative citation page (citing)"

```

```

ren date citing_date
label var citing_date "date of combined case report (citing)"
ren decade citing_decade
label var citing_decade "decade of combined case report (citing)"
ren numcasesyear citing_numcasesyear
label var citing_numcasesyear "number of report cases during year of combined case report (citing)"
ren numcasesdecade citing_numcasesdecade

```

```

label var citing_numcasesdecade "number of reported cases during decade of combined
case report (citing)"
ren num_words citing_numwords
label var citing_numwords "number of words in combined case report (citing)"
ren nomcite_num citing_nomcitenum
label var citing_nomcitenum "number of case reports in combined case report (citing)"
ren ercite citing_ercite
label var citing_ercite "ER citation of combined case report (citing)"
ren ercite_vol citing_ercitevol
label var citing_ercitevol "ER citation volume of combined case report (citing)"
ren casename citing_casename
label var citing_casename "name of combined case report (citing)"
ren casename_firstparty citing_casenamefirstparty
label var citing_casenamefirstparty "first party, i.e. plaintiff, of combined case report
(citing)"
ren casename_secondparty citing_casenamessecondparty
label var citing_casenamessecondparty "second party, i.e. defendant, of combined case
report (citing)"

ren court citing_court
label var citing_court "court where reported case is presented (citing)"
ren nomcite_rep citing_nomciterep
label var citing_nomciterep "reporter volume (citing)"
ren nomcite_volyearstart citing_nomcitevolyearstart
label var citing_nomcitevolyearstart "starting year of reporter volume (citing)"
ren nomcite_volyearend citing_nomcitevolyearend
label var citing_nomcitevolyearend "ending year of reporter volume (citing)"
ren nomcite_pagestart citing_nomcitepagestart
label var citing_nomcitepagestart "starting page of reporter volume (citing)"
ren nomcite_pageend citing_nomcitepageend
label var citing_nomcitepageend "ending year of reporter volume (citing)"
ren nomcite_repvollawfrench citing_nomcitelawfrench
label var citing_nomcitelawfrench "law french used (citing)"

*** drop duplicates of combined case citations
duplicates drop citing_uidcombined cited_uidcombined, force

** calculate number of cited case reports (for a given combined case report)
egen citing_numcites = count(citing_uidcombined), by(citing_uidcombined)
label var citing_numcites "number of cited case reports in combined case report (citing)"

** order and save dataset

```

```

order citing_uidcombined citing_uid citing_nomcite citing_nomcitevol
citing_nomcitepage ///
    citing_casename citing_casenamefirstparty citing_casenamessecondparty
citing_ercite citing_ercitevol ///
    citing_date citing_decade citing_court citing_nomcitenum citing_numcites
citing_numcasesyear citing_numcasesdecade citing_numwords ///
    citing_nomcitevolyearstart citing_nomcitevolyearend citing_nomcitepagestart
citing_nomcitepageend citing_nomcitelawfrench citing_nomciterep

order citing_* cited_uidcombined cited_uid cited_nomcitematched*
cited_nomcitematching ///
    cited_casename cited_casenamefirstparty cited_casenamessecondparty cited_ercite
cited_ercitevol ///
    cited_date cited_decade cited_court cited_nomcitenum cited_numcasesyear
cited_numcasesdecade cited_numwords ///
    cited_nomcitevolyearstart cited_nomcitevolyearend cited_nomcitepagestart
cited_nomcitepageend cited_nomcitelawfrench cited_nomciterep ///
    cited_citecontext cited_nomciteoriginal cited_nomciteoriginalvol
cited_nomciteoriginalpage

save "$path/case_citations_combined_final.dta", replace

*** clean case citations
gen cited_citecontext2 = substr(cited_citecontext,1,length(cited_citecontext)-50)

* drop artificial self-cites
drop if citing_nomcite == cited_nomcitematched

* drop case citations if their page number is outside plausible range
drop if cited_nomciteoriginalpage > cited_nomcitepageend & cited_nomcitematching !=
1
drop if cited_nomciteoriginalpage < cited_nomcitepagestart & cited_nomcitematching !=
1

* drop non-matched case citations
drop if cited_nomcitematching == 4

* remove ambiguities due to identical citations of queen's bench reports and queen's
bench law reports
gen queenexchequer = 1 if regexm(cited_citecontext2, "[18[0-9][0-9]\]") &
(cited_nomciterep == "queen's bench" | cited_nomciterep == "exchequer")
replace queenexchequer = 1 if regexm(cited_citecontext2, " L\.?R\.? ?[0-9]") &
(cited_nomciterep == "queen's bench" | cited_nomciterep == "exchequer")
drop if queenexchequer == 1
drop queenexchequer

```

```

* remove misidentified coke on littleton citations
gen cokelittleton = 1 if cited_nomcitematchedvol == "littleton" &
  regexm(cited_citecontext2,"C[oO]?k?e?[,\.\.]? ?Lit")
drop if cokelittleton == 1
drop cokelittleton

* remove incorrect cases temp hardwicke citations
gen casestemphardwickeincorrect = 1 if cited_nomciterep == "cases temp hardwicke" &
  regexm(cited_citecontext2,"B\\.? ?R\\.? ?H\\.? ?[0-9]")
drop if casestemphardwickeincorrect == 1
drop cited_citecontext2

* remove observations outside 1550 - 1865 date range
drop if !inrange(citing_date,1580,1865)
drop if !inrange(cited_date,1580,1865)

save "$path/case_citations_combined_final_cleaned.dta", replace

```

3_merge statutes data

```

clear
set mem 200m
set more off
global path "/Users/M/Documents/Research/ER paper/2_Cleaning"
cd "$path"

```

```

** import statute citations
clear
insheet using "$path/_db input/statute_citations.csv"

```

```

*** combine statute citations from case reports with identical nominative citations
** merge combined case UID's for citing case
merge m:1 uid using "$path/uid-UID.dta"
keep if _merge == 3
drop _merge

```

```

** rename and order citing uids
ren uid citing_uid
ren UID citing_uidcombined
order citing_uid citing_uidcombined

```

```

** correct william & mary regnal years and dates
replace stat_cite_year = 1696 if stat_cite_regnyear == "8 will. & mary"
replace stat_cite_regnyear = "8. will.3" if stat_cite_regnyear == "8 will. & mary"
replace stat_cite_year = 1697 if stat_cite_regnyear == "9 will. & mary"
replace stat_cite_regnyear = "9. will.3" if stat_cite_regnyear == "9 will. & mary"
replace stat_cite_year = 1698 if stat_cite_regnyear == "10 will. & mary"
replace stat_cite_regnyear = "10. will.3" if stat_cite_regnyear == "10 will. & mary"
replace stat_cite_year = 1699 if stat_cite_regnyear == "11 will. & mary"
replace stat_cite_regnyear = "11. will.3" if stat_cite_regnyear == "11 will. & mary"
replace stat_cite_year = 1700 if stat_cite_regnyear == "12 will. & mary"
replace stat_cite_regnyear = "12. will.3" if stat_cite_regnyear == "12 will. & mary"
replace stat_cite_year = 1701 if stat_cite_regnyear == "13 will. & mary"
replace stat_cite_regnyear = "13. will.3" if stat_cite_regnyear == "13 will. & mary"

```

```

** correct ambiguities of wills act
gen stat_cite_context2 = substr(stat_cite_context,round(length(stat_cite_context)/2,1)-
10,20)
gen willsact = 1 if regexm(stat_cite_context2, "(.*[Ww]ills [Aa]ct.*)") &
stat_cite_regnyear == ""
drop if willsact == 1
drop willsact stat_cite_context2

```

```

** correct geo 1 misattributions
gen stat_cite_context2 = substr(stat_cite_context,round(length(stat_cite_context)/2,1)-
10,20)
gen george1 = 1 if regexm(stat_cite_regnyear, "[0-9]+ geo. 1")
gen george1year = regexs(1) if regexm(stat_cite_regnyear, "[0-9]+ geo. 1")
gen george2 = 1 if regexm(stat_cite_context2, "(Ge?o?\.\.? 11[\.\,]+)|(Ge?o?\.\.? II[\.\,]+)|(Ge?o?\.\.? 2[\.\,]+)") & george1 == 1
gen george3 = 1 if regexm(stat_cite_context2, "(Ge?o?\.\.? 111)|(Ge?o?\.\.? III)|(Ge?o?\.\.? 3)|(Ge?o?\.\.? 11 I)") & george1 == 1
replace george2 = . if george3 == 1 & george2 == 1
gen george = 1 if george2 == 1 | george3 == 1

```

```

gen george2temp = " geo. 2"
egen george2stat_cite_regnyear = concat(george1year george2temp) if george2 == 1
replace stat_cite_regnyear = george2stat_cite_regnyear if george2 == 1
gen george3temp = " geo. 3"
egen george3stat_cite_regnyear = concat(george1year george3temp) if george3 == 1
replace stat_cite_regnyear = george3stat_cite_regnyear if george3 == 1
drop stat_cite_context2

```

```

preserve
clear

```

```

insheet using "/Users/M/Documents/Research/ER paper/1_Extraction/input/regnal
years.csv"
gen temp = " "
egen stat_cite_regnyear = concat(v1 temp v2)
ren v3 stat_cite_year
keep stat_cite_regnyear stat_cite_year
save "/Users/M/Documents/Research/ER paper/2_Cleaning/_temp/regnyears.dta",
replace
restore

preserve
drop if george == 1
drop george*
save "/Users/M/Documents/Research/ER paper/2_Cleaning/_temp/nogeorgetemp.dta",
replace
restore

keep if george == 1
drop george*
drop stat_cite_year
merge m:1 stat_cite_regnyear using "/Users/M/Documents/Research/ER
paper/2_Cleaning/_temp/regnyears.dta"
drop if _merge == 2
drop _merge
replace stat_cite_year = 0 if stat_cite_year == .
append using "/Users/M/Documents/Research/ER
paper/2_Cleaning/_temp/nogeorgetemp.dta"
!rm "/Users/M/Documents/Research/ER paper/2_Cleaning/_temp/nogeorgetemp.dta"

** merge number of enacted statutes in the cited year
preserve
clear
insheet using "$path/_statutes added/statute chapters.csv", comma
keep stat_cite_year chapterstotal chapterspublic
save "$path/_statutes added/statutenumbersadded.dta", replace
restore

merge m:1 stat_cite_year using "$path/_statutes added/statutenumbersadded.dta"
drop if _merge == 2
drop _merge

** merge chapters of statute citation with explicit names
preserve
clear

```



```

insheet using "/Users/M/Documents/Research/ER paper/1_Extraction/input/stat names &
years.csv", comma
ren v1 stat_cite_name
ren v3 stat_cite_regnalyear
ren v4 stat_cite_chapter
keep stat_cite_name stat_cite_regnalyear stat_cite_chapter
save "$path/_statutes added/statutechaptersadded.dta", replace
restore

```

```

merge m:1 stat_cite_name using "$path/_statutes added/statutechaptersadded.dta", update
drop if _merge == 3
drop _merge

```

```

** drop statute citations with duplicate years (prefer chapter over statute name over
regnal year only)
gsort citing_uidcombined stat_cite_year -stat_cite_name stat_cite_chapter
duplicates drop citing_uidcombined stat_cite_year stat_cite_chapter, force
duplicates tag citing_uidcombined stat_cite_year, gen(dup)
drop if stat_cite_chapter == . & dup > 0
drop dup

```

```

** merge citing with combined case attributes
ren citing_uidcombined uid
merge m:1 uid using "$path/case_attributes_combined.dta"
drop if _merge == 2
drop _merge
ren uid citing_uidcombined

```

```

** merge citing with volume attributes
merge m:1 nomcite_vol using "$path/volume_attributes.dta"
keep if _merge == 3
drop _merge

```

```

** rename citing variables
ren nomcite citing_nomcite
label var citing_nomcite "nominative citation (citing)"
ren nomcite_vol citing_nomcitevol
label var citing_nomcitevol "nominative citation volume (citing)"
ren nomcite_page citing_nomcitepage
label var citing_nomcitepage "nominative citation page (citing)"
egen citing_statutenumcites = count(citing_uidcombined), by(citing_uidcombined)
label var citing_statutenumcites "number of cited statutes in combined case report"

```

```

ren date citing_date
label var citing_date "date of combined case report (citing)"
ren date_juta citing_datejuta
label var citing_datejuta "unamended date of combined case report originally (citing)"
ren decade citing_decade
label var citing_decade "decade of combined case report (citing)"
ren numcasesyear citing_numcasesyear
label var citing_numcasesyear "number of reported cases during year of combined case
report (citing)"
ren numcasesdecade citing_numcasesdecade
label var citing_numcasesdecade "number of reported cases during decade of combined
case report (citing)"
ren num_words citing_numwords
label var citing_numwords "number of words in combined case report (citing)"
ren nomcite_num citing_nomcitenum
label var citing_nomcitenum "number of case reports in combined case report (citing)"
ren ercite citing_ercite
label var citing_ercite "ER citation of combined case report (citing)"
ren ercite_vol citing_ercitevol
label var citing_ercitevol "ER citation volume of combined case report (citing)"
ren casename citing_casename
label var citing_casename "name of combined case report (citing)"
ren casename_firstparty citing_casenamefirstparty
label var citing_casenamefirstparty "first party, i.e. plaintiff, of combined case report
(citing)"
ren casename_secondparty citing_casenamessecondparty
label var citing_casenamessecondparty "second party, i.e. defendant, of combined case
report (citing)"

ren court citing_court
label var citing_court "court where reported case is presented (citing)"
ren nomcite_rep citing_nomciterep
label var citing_nomciterep "reporter volume (citing)"
ren nomcite_volyearstart citing_nomcitevolyearstart
label var citing_nomcitevolyearstart "starting year of reporter volume (citing)"
ren nomcite_volyearend citing_nomcitevolyearend
label var citing_nomcitevolyearend "ending year of reporter volume (citing)"
ren nomcite_pagestart citing_nomcitepagestart
label var citing_nomcitepagestart "starting page of reporter volume (citing)"
ren nomcite_pageend citing_nomcitepageend
label var citing_nomcitepageend "ending year of reporter volume (citing)"
ren nomcite_repvollawfrench citing_nomcitelawfrench
label var citing_nomcitelawfrench "law french used (citing)"

```

```

*** cited
** rename cited variables
ren stat_cite_year cited_statutedate
label var cited_statutedate "date of cited statute"
ren stat_cite_context cited_statutecitecontext
label var cited_statutecitecontext "context of statute citation"
ren stat_cite_regnyear cited_statuteregnyear
label var cited_statuteregnyear "regnal year of cited statute (if available)"
ren stat_cite_chapter cited_statutechapter
label var cited_statutechapter "chapter reference of cited statute (if available)"
ren stat_cite_name cited_statutename
label var cited_statutename "name of cited statute (if available)"
ren chapterstotal cited_statutechapterstotal
label var cited_statutechapterstotal "number of total enacted statutes in year of cited
statute (if available)"
ren chapterspublic cited_statutechapterspublic
label var cited_statutechapterspublic "number of public enacted statutes in year of cited
statute (if available)"

** order and save dataset
order citing_uidcombined citing_uid citing_nomcite citing_nomcitevol
citing_nomcitepage ///
    citing_casename citing_casenamefirstparty citing_casenamessecondparty
citing_ercite citing_ercitevol ///
    citing_date citing_decade citing_court citing_nomcitenum citing_statutenumcites
citing_numcasesyear citing_numcasesdecade citing_numwords ///
    citing_nomcitevolyearstart citing_nomcitevolyearend citing_nomcitepagestart
citing_nomcitepageend citing_nomcitelawfrench citing_nomciterep

order citing_* ///
    cited_statutedate cited_statuteregnyear cited_statutechapter cited_statutename
cited_statutecitecontext

save "$path/statute_citations_combined_final.dta", replace

** clean data from incorrect statute citations, save dataset
drop if cited_statutedate == 0 // drop if regnal year is invalid (mainly due to OCR error)
drop if cited_statutechapter > cited_statutechapterstotal & cited_statutechapter != . // drop
if chapter is bigger than number of statutes in a given year
drop if cited_statutechapterstotal == .

save "$path/statute_citations_combined_final_cleaned.dta", replace

```

Appendix C: R code for the detection of network communities

```
### import graphs and packages
library(igraph)
setwd("/Users/M/Documents/Research/ER paper/3_Analysis/community detection")
commonlaw <- read.graph("common law no isolates.gml", format = "gml")
summary(commonlaw)
commonlawrandom <- read.graph("common law no isolates random.gml", format =
"gml")
summary(commonlawrandom)
uslaw <- read.graph("us no isolates.gml", format = "gml")
summary(uslaw)
commonlaw_undirected <- as.undirected(commonlaw, mode='collapse')

### prepare for export
id = get.vertex.attribute(commonlaw, "id")
nomcite = get.vertex.attribute(commonlaw, "nomcite")
date = get.vertex.attribute(commonlaw, "date")

idrandom = get.vertex.attribute(commonlawrandom, "id")
nomciterandom = get.vertex.attribute(commonlawrandom, "nomcite")
daterandom = get.vertex.attribute(commonlawrandom, "date")

idus = get.vertex.attribute(uslaw, "id")
nomciteus = get.vertex.attribute(uslaw, "nomcite")
dateus = get.vertex.attribute(uslaw, "date")

### authority and hub scores
authority = authority.score(commonlaw)$vector
top100authority = sort(authority, decreasing=TRUE)[1:100]

hub = hub.score(commonlaw)$vector
top100hub = sort(hub, decreasing=TRUE)[1:100]

# authorities and hubs
authoritieshubs = data.frame(id,nomcite,date,authority,hub)
getwd()
write.table(authoritieshubs,"authoritieshubs.csv",row.names=FALSE,col.names=TRUE,q
uote=FALSE,sep=",")
```

```

#### community detection
## simulated annealing (modularity optimization)
# spin glass - 2 spins
commonlaw_community_sg2 = spinglass.community(commonlaw, spins=2)

membership_sg2 = membership(commonlaw_community_sg2)
class(membership_sg2) = "numeric"
modularityscore_sg2 = modularity(commonlaw_community_sg2)

communityanalysis_sg2 = data.frame(id,nomcite,date,membership_sg2,
modularityscore_sg2)
getwd()
write.table(communityanalysis_sg2,"communityanalysis_sg2.csv",row.names=FALSE,col.names=TRUE,quote=FALSE,sep=",")

# spin glass - 3 spins
commonlaw_community_sg3 = spinglass.community(commonlaw, spins=3)

membership_sg3 = membership(commonlaw_community_sg3)
class(membership_sg3) = "numeric"
modularityscore_sg3 = modularity(commonlaw_community_sg3)

communityanalysis_sg3 = data.frame(id,nomcite,date,membership_sg3,
modularityscore_sg3)
getwd()
write.table(communityanalysis_sg3,"communityanalysis_sg3.csv",row.names=FALSE,col.names=TRUE,quote=FALSE,sep=",")

# spin glass - 4 spins
commonlaw_community_sg4 = spinglass.community(commonlaw, spins=4)

membership_sg4 = membership(commonlaw_community_sg4)
class(membership_sg4) = "numeric"
modularityscore_sg4 = modularity(commonlaw_community_sg4)

communityanalysis_sg4 = data.frame(id,nomcite,date,membership_sg4,
modularityscore_sg4)
getwd()
write.table(communityanalysis_sg4,"communityanalysis_sg4.csv",row.names=FALSE,col.names=TRUE,quote=FALSE,sep=",")

# spin glass - 2 spins (random model)

```

```

commonlaw_community_random_sg2 = spinglass.community(commonlawrandom,
spins=2)

membership_random_sg2 = membership(commonlaw_community_random_sg2)
class(membership_random_sg2) = "numeric"
modularityscore_random_sg2 = modularity(commonlaw_community_random_sg2)

communityanalysis_random_sg2 =
data.frame(idrandom,daterandom,membership_random_sg2,
modularityscore_random_sg2)
getwd()
write.table(communityanalysis_random_sg2,"communityanalysis_random_sg2.csv",row.
names=FALSE,col.names=TRUE,quote=FALSE,sep=",")

# spin glass - 2 spins (us)
uslaw_community_sg2 = spinglass.community(uslaw, spins=2)

usmembership_sg2 = membership(uslaw_community_sg2)
class(usmembership_sg2) = "numeric"
usmodularityscore_sg2 = modularity(uslaw_community_sg2)

uscommunityanalysis_sg2 = data.frame(idus,nomciteus,dateus,usmembership_sg2,
usmodularityscore_sg2)
getwd()
write.table(uscommunityanalysis_sg2,"uscommunityanalysis_sg2.csv",row.names=FALS
E,col.names=TRUE,quote=FALSE,sep=",")

# spin glass - 3 spins (us)
uslaw_community_sg3 = spinglass.community(uslaw, spins=3)

usmembership_sg3 = membership(uslaw_community_sg3)
class(usmembership_sg3) = "numeric"
usmodularityscore_sg3 = modularity(uslaw_community_sg3)

uscommunityanalysis_sg3 = data.frame(idus,nomciteus,dateus,usmembership_sg3,
usmodularityscore_sg3)
getwd()
write.table(uscommunityanalysis_sg3,"uscommunityanalysis_sg3.csv",row.names=FALS
E,col.names=TRUE,quote=FALSE,sep=",")

# spin glass - 4 spins (us)
uslaw_community_sg4 = spinglass.community(uslaw, spins=4)

usmembership_sg4 = membership(uslaw_community_sg4)
class(usmembership_sg4) = "numeric"
usmodularityscore_sg4 = modularity(uslaw_community_sg4)

```

```
uscommunityanalysis_sg4 = data.frame(idus,nomciteus,dateus,usmembership_sg4,  
usmodularityscore_sg4)  
getwd()  
write.table(uscommunityanalysis_sg4,"uscommunityanalysis_sg4.csv",row.names=FALSE,  
E,col.names=TRUE,quote=FALSE,sep=",")  
  
## limit communities from hierarchical analysis to n members and export  
#membership = cut_at(commonlaw_community_fg, no=2)
```

Appendix D: Stata code for the preparation of tables and figures

```
*** code to produce all the figures in the dissertation
clear
set more off
global path "/Users/M/Documents/Research/ER paper/4_Presentation/Figures"
global casescombinedinput "/Users/M/Documents/Research/ER
paper/2_Cleaning/case_attributes_combined.dta"
global volumesinput "/Users/M/Documents/Research/ER
paper/2_Cleaning/volume_attributes.dta"
global citesinput "/Users/M/Documents/Research/ER
paper/2_Cleaning/case_citations_combined_final_cleaned.dta"
global statutesinput "/Users/M/Documents/Research/ER
paper/2_Cleaning/statute_citations_combined_final_cleaned.dta"
global uscasesinput "/Users/M/Documents/Research/ER
paper/2_Cleaning/US/case_attributes.dta"
global uscitesinput "/Users/M/Documents/Research/ER
paper/2_Cleaning/US/case_citations.dta"
cd "$path/_temp"
*!rm *
cd "$path"

*****
*** number of cases
* equity versus common law
clear
use "$casescombinedinput"

* drop reports outside desired range
keep if inrange(date,1580,1865)

* merge volume information and create common law dummy
merge m:1 nomcite_vol using "$volumesinput"
gen common = 1 if inlist(court, "CP", "EX", "KB", "NP")
replace common = 0 if inlist(court, "CH", "Rolls", "VC")
drop if common == .

label define common 0 "equity law er series" 1 "common law er series"
label values common common

* calculate annual number of case reports by common law dummy
collapse (count) reports = uid [fweight= nomcite_num], by(date common)
```



```

label variable date "year"
label variable common "common law"
label variable reports "number of er case reports"

* plot number of case reports by year
twoway (line reports date) (lowess reports date, bwidth(0.3)), xlabel(1580 (40) 1860)
by(common) ///
    legend(label(1 "number of er case reports per year") label(2 "lowess smoothed"))
rows(2) region(col(white))

```

```

graph export "$path/case numbers per year.png", replace

```

```

* common law courts separately
clear
set more off
use "$casescombinedinput"
merge m:m nomcite_vol using "$volumesinput"
keep if inrange(date, 1580,1865)
keep if inlist(court,"CP","EX","KB")
replace court = "king's bench er series" if court == "KB"
replace court = "common pleas er series" if court == "CP"
replace court = "exchequer er series" if court == "EX"

```

```

collapse (count) cases = uid [fweight=nomcite_num], by(date court)
label variable date "year"
label variable cases "number of case reports"
save "$path/_temp/commonlawcourtcases.dta", replace

```

```

twoway (line cases date) (lowess cases date, bwidth(0.3)), xlabel(1580(40)1860)
ylabel(0(00)800) by(court, cols(1)) ///
    legend(label(1 "number of er case reports per year") label(2 "lowess smoothed"))
rows(2) region(col(white))

```

```

graph export "$path/common law courts case numbers per year.png", replace

```

```

* common law only
clear
set more off
use "$casescombinedinput"
merge m:m nomcite_vol using "$volumesinput"
keep if inrange(date, 1580,1865)
keep if inlist(court,"CP","EX","KB","NP")

preserve
collapse (count) cases = uid [fweight=nomcite_num], by(date)

```

```

label variable date "year"
label variable cases "number of case reports"
save "$path/_temp/commonlawcases.dta", replace
restore

```

```

preserve
collapse (count) cases = uid, by(date)
label variable date "year"
label variable cases "number of case reports"
save "$path/_temp/commonlawcasescombined.dta", replace
restore

```

```

*****

```

```

*** equity - common law split

```

```

clear
use "$citesinput"

```

```

* remove unwanted date ranges
drop if !inrange(citing_date, 1700, 1865)
drop if !inrange(cited_date, 1550, 1865)

```

```

* drop non-precedents (later analogies and reports of same case)
drop if cited_date >= citing_date

```

```

* remove case reports from unwanted courts
drop if inlist(citing_court, "Crown", "Ecc_Adm_PD", "HL", "PC")
drop if inlist(cited_court, "Crown", "Ecc_Adm_PD", "HL", "PC")

```

```

* create binary variable that distinguishes common law and equity
gen citing_common = 1 if inlist(citing_court, "CP", "EX", "KB", "NP")
replace citing_common = 0 if inlist(citing_court, "CH", "Rolls", "VC")

```

```

gen cited_common = 1 if inlist(cited_court, "CP", "EX", "KB", "NP")
replace cited_common = 0 if inlist(cited_court, "CH", "Rolls", "VC")

```

```

label define common 0 "equity law er series" 1 "common law er series"
label values citing_common cited_common common

```

```

* calculate citing equity court rates by decade
preserve
keep if citing_common == 0
collapse (count) equitycites=citing_uid, by(citing_decade cited_common)

```

```

reshape wide equitycites, i(citing_decade) j(cited_common)

ren equitycites0 equityequitycites
ren equitycites1 equitycommonlawcites
gen equitycitestotal = equityequitycites + equitycommonlawcites

gen equityequitycitespercent = equityequitycites/equitycitestotal
gen equitycommonlawcitespercent = equitycommonlawcites/equitycitestotal

ren citing_decade decade
keep decade equityequitycitespercent equitycommonlawcitespercent

save "$path/_temp/equitycites.dta", replace
restore

* calculate citing common law court rates by decade
preserve
keep if citing_common == 1
collapse (count) commonlawcites=citing_uid, by(citing_decade cited_common)
reshape wide commonlawcites, i(citing_decade) j(cited_common)

ren commonlawcites0 commonlawequitycites
ren commonlawcites1 commonlawcommonlawcites
gen commonlawcitestotal = commonlawequitycites + commonlawcommonlawcites

gen commonlawequityitespercent = commonlawequitycites/commonlawcitestotal
gen commonlawcommonlawcitespercent =
commonlawcommonlawcites/commonlawcitestotal

ren citing_decade decade
keep decade commonlawequityitespercent commonlawcommonlawcitespercent

save "$path/_temp/commonlawcites.dta", replace
restore

* random citing model predictions
clear
use "$casescombinedinput"
merge m:m nomcite_vol using "$volumesinput"
keep if inrange(date, 1580,1865)
drop if inlist(court,"Crown", "Ecc_Adm_PD", "HL", "PC")
gen common = 1 if inlist(court, "CP", "EX", "KB", "NP")
replace common = 0 if inlist(court, "CH", "Rolls", "VC")

collapse (count) cases = uid [fweight=nomcite_num], by(decade common)
reshape wide cases, i(decade) j(common)

```

```

ren cases0 equitycases
ren cases1 commonlawcases

replace equitycases = 0 if equitycases == .
replace commonlawcases = 0 if commonlawcases == .

gen equitycasestotal = .
    replace equitycasestotal = 0 if _n == 1
    replace equitycasestotal = equitycases[_n-1] + equitycasestotal[_n-1] if _n > 1
gen commonlawcasestotal = .
    replace commonlawcasestotal = 0 if _n == 1
    replace commonlawcasestotal = commonlawcases[_n-1] +
commonlawcasestotal[_n-1] if _n > 1
gen casestotal = equitycasestotal + commonlawcasestotal

gen randomequitypercent = equitycasestotal/casestotal
gen randomcommonpercent = commonlawcasestotal/casestotal

keep if decade >= 1700
keep decade randomequitypercent randomcommonpercent

save "$path/_temp/equityandcommonlawrandomcites.dta", replace

* merge equity, common law and random data
merge 1:1 decade using "$path/_temp/equitycites.dta"
drop _merge
merge 1:1 decade using "$path/_temp/commonlawcites.dta"
drop _merge

* plot graphs
twoway (line equityequitycitespercent decade, lcolor(gs10)) (line
equitycommonlawcitespercent decade, lcolor(gs2)) ///
    (line randomequitypercent decade, lcolor(gs10) lpattern(longdash)) (line
randomcommonpercent decade, lcolor(gs2) lpattern(longdash)) ///
    , legend(label(1 "citing equity law er series") label(2 "citing common law
er series")) ///
    label(3 "citing equity law predicted from model") label(4 "citing common
predicted from model") rows(4) region(col(white))) ///
    yscale(range(0 1)) title(equity law er series) name(equity)

twoway (line commonlawequityitespercent decade, lcolor(gs10)) (line
commonlawcommonlawcitespercent decade, lcolor(gs2)) ///
    (line randomequitypercent decade, lcolor(gs10) lpattern(longdash)) (line
randomcommonpercent decade, lcolor(gs2) lpattern(longdash)) ///

```

```

, legend(label(1 "citing equity law er series") label(2 "citing common law
er series") ///
label(3 "citing equity law predicted from model") label(4 "citing common
predicted from model") rows(4) region(col(white))) ///
yscale(range(0 1)) title(common law er series) name(common)

grc1leg equity common
graph export "$path/equity-common law split.png", replace

```

```

*****

```

```

*** intra - common law splits

```

```

clear

```

```

use "$citesinput"

```

```

* remove unwanted date ranges

```

```

drop if !inrange(citing_date, 1700, 1865)

```

```

drop if !inrange(cited_date, 1550, 1865)

```

```

* drop non-precedents (later analogies and reports of same case)

```

```

drop if cited_date >= citing_date

```

```

* remove case reports from unwanted courts

```

```

keep if inlist(citing_court,"KB", "CP", "EX")

```

```

keep if inlist(cited_court,"KB", "CP", "EX")

```

```

* create binary variable that distinguishes common law and equity

```

```

gen citing = 1 if citing_court == "KB"

```

```

replace citing = 2 if citing_court == "CP"

```

```

replace citing = 3 if citing_court == "EX"

```

```

gen cited = 1 if cited_court == "KB"

```

```

replace cited = 2 if cited_court == "CP"

```

```

replace cited = 3 if cited_court == "EX"

```

```

label define common 1 "king's bench er series" 2 "common pleas er series" 3 "exchequer
er series"

```

```

label values citing cited common

```

```

* calculate citing king's bench court rates by decade

```

```

preserve

```

```

keep if citing == 1

```

```

collapse (count) kbcites=citing_uid, by(citing_decade cited)
reshape wide kbcites, i(citing_decade) j(cited)

ren kbcites1 kkbkcites
ren kbcites2 kbpcites
ren kbcites3 kbexcites

replace kkbkcites = 0 if kkbkcites == .
replace kbpcites = 0 if kbpcites == .
replace kbexcites = 0 if kbexcites == .

gen kbcitestotal = kkbkcites + kbpcites + kbexcites

gen kkbkcitespercent = kkbkcites/kbcitestotal
gen kbpcitespercent = kbpcites/kbcitestotal
gen kbexcitespercent = kbexcites/kbcitestotal

ren citing_decade decade
keep decade kkbkcitespercent kbpcitespercent kbexcitespercent

save "$path/_temp/kbcites.dta", replace
restore

* calculate citing common pleas court rates by decade
preserve
keep if citing == 2
collapse (count) cpcites=citing_uid, by(citing_decade cited)
reshape wide cpcites, i(citing_decade) j(cited)

ren cpcites1 cpkbcites
ren cpcites2 cpcpcites
ren cpcites3 cpexcites

replace cpkbcites = 0 if cpkbcites == .
replace cpcpcites = 0 if cpcpcites == .
replace cpexcites = 0 if cpexcites == .

gen cpcitestotal = cpkbcites + cpcpcites + cpexcites

gen cpkbcitespercent = cpkbcites/cpcitestotal
gen cpcpcitespercent = cpcpcites/cpcitestotal
gen cpexcitespercent = cpexcites/cpcitestotal

ren citing_decade decade
keep decade cpkbcitespercent cpcpcitespercent cpexcitespercent

```

```

save "$path/_temp/cpcites.dta", replace
restore

* calculate citing exchequer court rates by decade
preserve
keep if citing == 3
collapse (count) excites=citing_uid, by(citing_decade cited)
reshape wide excites, i(citing_decade) j(cited)

ren excites1 exkbcites
ren excites2 excpcites
ren excites3 exexcites

replace exkbcites = 0 if exkbcites == .
replace excpcites = 0 if excpcites == .
replace exexcites = 0 if exexcites == .

gen excitestotal = exkbcites + excpcites + exexcites

gen exkbcitespercent = exkbcites/excitestotal
gen excpcitespercent = excpcites/excitestotal
gen exexcitespercent = exexcites/excitestotal

ren citing_decade decade
keep decade exkbcitespercent excpcitespercent exexcitespercent

save "$path/_temp/excites.dta", replace
restore

* random citing model predictions
clear
use "$casescombinedinput"
merge m:m nomcite_vol using "$volumesinput"
keep if inrange(date, 1580,1865)
keep if inlist(court,"KB", "CP", "EX")

gen common = 1 if court == "KB"
replace common = 2 if court == "CP"
replace common = 3 if court == "EX"

collapse (count) cases = uid [fweight=nomcite_num], by(decade common)
reshape wide cases, i(decade) j(common)

ren cases1 kbcases
ren cases2 cpcases
ren cases3 excases

```

```

replace kbcases = 0 if kbcases == .
replace cpcases = 0 if cpcases == .
replace excases = 0 if excases == .

gen kbcasestotal = .
    replace kbcasestotal = 0 if _n == 1
    replace kbcasestotal = kbcases[_n-1] + kbcasestotal[_n-1] if _n > 1
gen cpcasestotal = .
    replace cpcasestotal = 0 if _n == 1
    replace cpcasestotal = cpcases[_n-1] + cpcasestotal[_n-1] if _n > 1
gen excasestotal = .
    replace excasestotal = 0 if _n == 1
    replace excasestotal = excases[_n-1] + excasestotal[_n-1] if _n > 1

gen casestotal = kbcasestotal + cpcasestotal + excasestotal

gen randomkbpercent = kbcasestotal/casestotal
gen randomcppercent = cpcasestotal/casestotal
gen randomexpercent = excasestotal/casestotal

keep if decade >= 1700
keep decade randomkbpercent randomcppercent randomexpercent

save "$path/_temp/kbcpexrandomcites.dta", replace

* merge kb, cp, ex and random data
merge 1:1 decade using "$path/_temp/kbcites.dta"
drop _merge
merge 1:1 decade using "$path/_temp/cpcites.dta"
drop _merge
merge 1:1 decade using "$path/_temp/excites.dta"
drop _merge

* plot graphs
twayay (line kbkcitespercent decade, lcolor(gs2)) (line kbcpcitespercent decade,
lcolor(gs9)) (line kbexcitespercent decade, lcolor(gs14)) ///
    (line randomkbpercent decade, lcolor(gs2) lpattern(longdash)) (line
randomcppercent decade, lcolor(gs9) lpattern(longdash)) (line randomexpercent decade,
lcolor(gs14) lpattern(longdash)) ///
    , legend(label(1 "citing kb er series") label(2 "citing cp er series") label(3
"citing ex er series") ///
    label(4 "citing kb predicted from model") label(5 "citing cp predicted from
model") label(6 "citing ex predicted from model") rows(6) region(col(white))) ///
    yscale(range(0 1)) title(king's bench er series) name(kb)

```



```

twoway (line cpkbcitespercent decade, lcolor(gs2)) (line cpcpcitespercent decade,
lcolor(gs9)) (line cpexcitespercent decade, lcolor(gs14)) ///
      (line randomkbpercent decade, lcolor(gs2) lpattern(longdash)) (line
randomcppercent decade, lcolor(gs9) lpattern(longdash)) (line randomexpercent decade,
lcolor(gs14) lpattern(longdash)) ///
      , legend(label(1 "citing kb er series") label(2 "citing cp er series") label(3
"citing ex er series") ///
      label(4 "citing kb predicted from model") label(5 "citing cp predicted from
model") label(6 "citing ex predicted from model") rows(6) region(col(white))) ///
      yscale(range(0 1)) title(common pleas er series) name(cp)

```

```

twoway (line exkbcitespercent decade, lcolor(gs2)) (line excpcitespercent decade,
lcolor(gs9)) (line exexcitespercent decade, lcolor(gs14)) ///
      (line randomkbpercent decade, lcolor(gs2) lpattern(longdash)) (line
randomcppercent decade, lcolor(gs9) lpattern(longdash)) (line randomexpercent decade,
lcolor(gs14) lpattern(longdash)) ///
      , legend(label(1 "citing kb er series") label(2 "citing cp er series") label(3
"citing ex er series") ///
      label(4 "citing kb predicted from model") label(5 "citing cp predicted from
model") label(6 "citing ex predicted from model") rows(6) region(col(white))) ///
      yscale(range(0 1)) title(exchequer er series) name(ex)

```

```

grc1leg kb cp ex, rows(1)
graph export "$path/intra common law splits.png", replace

```

```

*****
*** common law's most cited cases
* open case citations file
clear
use "$citesinput"

* drop non-precedents and non-common law citations
keep if citing_date > cited_date
keep if citing_date > 1700
keep if inlist(citing_court,"CP","EX","KB","NP")
keep if inlist(cited_court,"CP","EX","KB","NP")

* create citations counts
preserve
collapse (count) cites = cited_uidcombined, by(cited_nomcitematched cited_date)
gsort - cites

```

```

* calculate top 10 and top 1 percentiles
egen top10 = pctl(cites), p(90)
egen top1 = pctl(cites), p(99)

* list most cited case reports
list cited_nomcitematched cited_date cites if cites > top1, table noobs

* create date histograms of most cited cases (top 10% and top 1%)
twoway (hist cited_date if cites > top10, width(5) start(1550) frequency fcolor(gs10)
lcolor(gs6)) ///
      (hist cited_date if cites > top1, width(5) start(1550) frequency fcolor(gs5)
lcolor(gs6)), ///
      legend(label(1 "top decile") label(2 "top percentile") region(col(white)))
name(top)

* save graph
graph export "$path/most cited histogram.png", replace

* create dindividual date histograms of 5 most cited cases
restore
keep if inlist(cited_nomcitematched, "1 wms saunders 319", "1 coke report 93", "1
burrow 38", "6 adolphus and ellis 469", "8 coke report 66")

global i = 1
graph drop _all
foreach c in "1 wms saunders 319" "1 coke report 93" "1 burrow 38" "6 adolphus and
ellis 469" "8 coke report 66" {
    preserve
    keep if cited_nomcitematched == "`c'"
    de, sh
    local area = 5 * `r(N)'
    twoway (hist citing_date, freq width(5) start(1700) title("`c'") yscale(range(0 25))
ylabel(0(5)25)) ///
          (kdensity citing_date, area(`area')), legend(off) name(hist_`$i)
    global i = $i + 1
    restore
}

graph combine hist_1 hist_2 hist_3 hist_4 hist_5, rows(2)
graph export "$path/most cited 5 histograms.png", replace

```

```

*****
*** time depreciation

```

```

clear
use "$citesinput"

* drop non-precedents and non-common law citations
keep if citing_date > cited_date
keep if citing_date > 1700
keep if inlist(citing_court,"CP","EX","KB","NP")
keep if inlist(cited_court,"CP","EX","KB","NP")

* calculate time difference distribution (all years)
preserve
gen timediff = citing_date - cited_date
label variable timediff "years between citing and cited case"
collapse (count) cites = citing_uid, by(timediff)
label variable cites "number of cites"
save "$path/_temp/commonlawcitestimedifferences.dta", replace

* fit exponential decay model
gen logcites = ln(cites)
reg logcites timediff
esttab using "$path/timedepreciationfit.rtf", se r2(%9.2f) replace

predict logciteshat
twoway (line logcites timediff) (line logciteshat timediff), ///
       legend(label(1 "actual log cites") label(2 "predicted log cites based on exponential
model fit")) rows(2) region(col(white))) xtitle(years between citing and cited case)
graph export "$path/timedepreciationfit.png", replace
restore

* calculate number of new cites per year
collapse (count) newcites = citing_uid, by(citing_date)
ren citing_date date
save "$path/_temp/commonlawnewcites.dta", replace

** calculate expected random cites
* merge with new cites and citations
clear
use "$path/_temp/commonlawcases.dta"
merge 1:1 date using "$path/_temp/commonlawnewcites.dta"
drop _merge

* calculate expected cites
forvalues y = 1701/1865 {
    gen timediff_`y' = `y' - date if date < `y'
    su newcites if date == `y'
}

```

```

    gen new_`y' = `r(mean)' if date < `y'
    egen total_`y' = sum(cases) if date < `y'
    gen p_`y' = cases / total_`y' if date < `y'
    gen Enew_`y' = p_`y' * new_`y' if date < `y'
}
save "$path/_temp/randommodel.dta", replace

* calculate expected time difference distribution (all years)
keep date timediff_ * Enew_ *
reshape long timediff Enew , i(date) j(year, string)
gen Enewrounded = round(Enew,-1)
drop year
collapse (sum) Enewrounded, by(timediff)

* graph time difference distribution
merge 1:1 timediff using "$path/_temp/commonlawcitestimedifferences.dta"
drop _merge
tway (hist timediff [fweight=cites], freq width(1)) (line Enewrounded timediff), ///
    legend(label(1 "actual distribution of time differences") label(2 "expected
distribution of time differences under random model") rows(2) region(col(white)))
xtitle(years between citing and cited case)
graph export "$path/time depreciation.png", replace

*****

*** degree distribution
** actual distribution
clear
use "$citesinput"

* drop non-precedents and non-common law citations
keep if citing_date > cited_date
keep if citing_date >= 1700
keep if inlist(citing_court,"CP","EX","KB","NP")
keep if inlist(cited_court,"CP","EX","KB","NP")

* calculate in-degree distribution
preserve
collapse (count) indegree = citing_uid, by(cited_uidcombined)
collapse (count) count = cited_uidcombined, by(indegree)
save "$path/_temp/commonlawcasesindegrees.dta", replace
restore

** attachment rates
* calculate attachment rates for different decades

```

```

forvalues y = 1710 (10) 1860 {

    * case indegrees for previous periods
    preserve
    keep if citing_date < `y'
    collapse (count) citesold = citing_uid, by(cited_uidcombined)
    save "$path/_temp/commonlawcasescitesold_`y'.dta", replace
    restore

    * case indegrees for current period
    preserve
    keep if citing_decade == `y'
    keep if cited_date < `y'
    collapse (count) citesnew = citing_uid, by(cited_uidcombined)
    merge 1:1 cited_uidcombined using
"$path/_temp/commonlawcasescitesold_`y'.dta"
    replace citesnew = 0 if citesnew == .
    replace citesold = 0 if citesold == .

    * calculate attachment average vs case indegree of previous periods
    egen citesoldaggregated = cut(citesold), at(1(1)17,20,23,30,100)
    drop citesold
    ren citesoldaggregated citesold
    collapse (mean) citesnew (sum) sumcitesnew=citesnew, by(citesold)

    save "$path/_temp/commonlawcasesattachments_`y'.dta", replace
    restore
}

* combine and average decade attachment rates
clear
use "$path/_temp/commonlawcasesattachments_1710.dta"
forvalues y = 1720 (10) 1860 {
    append using "$path/_temp/commonlawcasesattachments_`y'.dta"
}
* calculate
collapse (mean) citesnew [fweight=sumcitesnew], by(citesold)
save "$path/_temp/commonlawcasesattachmentrates.dta", replace

*** random model distribution
set seed 1234567
local nsimulation = 100

```

```

** degree distribution
forvalues n = 1/\`nsimulation' {

    * prepare output files
    clear
    set obs 1
    gen temp = .
    save "$path/_temp/randommodelcases.dta", replace
    save "$path/_temp/randommodelcites.dta", replace

    * provide annual case numbers and new citations
    clear
    use "$path/_temp/commonlawcasescombined.dta"
    merge 1:1 date using "$path/_temp/commonlawnewcites.dta"
    drop _merge
    sort date

    gen casestotal = .
    replace casestotal = 0 if _n == 1
    replace casestotal = cases[_n-1] + casestotal[_n-1] if _n > 1

    * generate case and cite files
    levelsof date
    foreach y of numlist `r(levels)' {

        * extract year-specific parameters
        preserve
        keep if date == `y'
        local newcites = newcites[1]
        local cases = cases[1]
        local casestotal = casestotal[1]

        * generate random cases
        clear
        set obs `cases'
        gen date = `y'
        append using "$path/_temp/randommodelcases.dta"
        save "$path/_temp/randommodelcases.dta", replace

        * generate random cites
        if `y' > 1700 {
            clear
            set obs `newcites'
            gen citing_rnd = runiform()
            gen cited_rnd = runiform()
            gen citing_uid = ceil(citing_rnd * `cases') + `casestotal'
        }
    }
}

```

```

        gen cited_uid = ceil(cited_rnd * `casestotal')
        append using "$path/_temp/randommodelcites.dta"
        save "$path/_temp/randommodelcites.dta", replace
    }
    restore
}

* clean up case attributes, generate case id
clear
use "$path/_temp/randommodelcases.dta"
dropmiss, force
dropmiss, obs force
sort date
gen uid = _n
save "$path/_temp/randommodelcases.dta", replace

* clean up case cites, merge dates
clear
use "$path/_temp/randommodelcites.dta"
dropmiss, force
dropmiss, obs force
drop citing_rnd cited_rnd

ren citing_uid uid
merge m:1 uid using "$path/_temp/randommodelcases.dta"
keep if _merge == 3
drop _merge
ren uid citing_uid
ren date citing_date

ren cited_uid uid
merge m:1 uid using "$path/_temp/randommodelcases.dta"
keep if _merge == 3
drop _merge
ren uid cited_uid
ren date cited_date
order citing_uid citing_date cited_uid cited_date
save "$path/_temp/randommodel case citations_`n'.dta.", replace

* calculate indegree distribution of random model
collapse (count) indegree = citing_uid, by(cited_uid)
collapse (count) randomcount = cited_uid, by(indegree)

save "$path/_temp/randommodelindegree_`n'.dta", replace
}

```

```

use "$path/_temp/randommodelindegree_1.dta"
forvalues n = 2/\`nsimulation' {
    append using "$path/_temp/randommodelindegree_`n'.dta"
}

collapse (mean) randomcount, by(indegree)
replace randomcount = round(randomcount,1)

* merge with actual indegree distribution and plot
merge 1:1 indegree using "$path/_temp/commonlawcasesindegrees.dta"
twoway (hist indegree [fweight = count], freq width(1)) (line randomcount indegree), ///
    legend(label(1 "actual distribution of received citations") label(2 "expected
number received citations under random model") rows(2) region(col(white)))
xtitle(received citations) name(indegree1)
twoway (hist indegree [fweight = count] if indegree <= 20, freq width(1)) (line
randomcount indegree if indegree <= 20), ///
    legend(off) xtitle(received citations) name(indegree2)
grc1leg indegree1 indegree2, ycommon
graph export "$path/degreedistributions.png", replace

```

```

** attachment rates
local nsimulation = 100
forvalues n = 1/\`nsimulation' {

    clear
    use "$path/_temp/randommodel case citations_`n'.dta"
    egen citing_decade = cut(citing_date), at(1710(10)1870)

    keep if citing_date > cited_date
    keep if citing_date >= 1700

    * calculate attachment rates for different decades

    forvalues y = 1710 (10) 1860 {

        * case indegrees for previous periods
        preserve
        keep if citing_date < `y'
        collapse (count) randomcitesold = citing_uid, by(cited_uid)
        save "$path/_temp/commonlawcasesrandomcitesold_`y'.dta", replace
        restore

        * case indegrees for current period
        preserve
        keep if citing_decade == `y'
    }
}

```



```

        keep if cited_date < `y'
        collapse (count) randomcitesnew = citing_uid, by(cited_uid)
        merge 1:1 cited_uid using
"$path/_temp/commonlawcasesrandomcitesold_`y'.dta"
        replace randomcitesnew = 0 if randomcitesnew == .
        replace randomcitesold = 0 if randomcitesold == .

        * calculate attachment average vs case indegree of previous periods
        egen randomcitesoldaggregated = cut(randomcitesold), at(1(1)10)
        drop randomcitesold
        ren randomcitesoldaggregated randomcitesold
        collapse (mean) randomcitesnew (sum)
randomsumcitesnew=randomcitesnew, by(randomcitesold)

        save "$path/_temp/commonlawcasesrandomattachments_`y'.dta", replace
        restore
    }

    * combine and average decade attachment rates
    clear
    use "$path/_temp/commonlawcasesrandomattachments_1710.dta"
    forvalues y = 1720 (10) 1860 {
        append using "$path/_temp/commonlawcasesrandomattachments_`y'.dta"
    }

save "$path/_temp/commonlawcasesrandomattachments_`n'.dta", replace
}

* combine different simulations
clear
use "$path/_temp/commonlawcasesrandomattachments_1.dta"
forvalues n = 2/^nsimulation' {
    append using "$path/_temp/commonlawcasesrandomattachments_`n'.dta"
}

* calculate attachment averages, merge, plot
collapse (mean) randomcitesnew [fweight=randomsumcitesnew], by(randomcitesold)
ren randomcitesold citesold
merge 1:1 citesold using "$path/_temp/commonlawcasesattachmentrates.dta"

twoway (line citesnew citesold) (line randomcitesnew citesold), ///
        xtitle(citations received before citing decade) ytitle(average number of new
citations) ///

```

```

        legend(label(1 "actual distribution of attachment rates") label(2 "expected
distribution of attachment rates under random model") rows(2) region(col(white)))
xtitle(number of previously received citations)

```

```

graph export "$path/attachmenrates.png", replace

```

```

*****
*** long-term persistence
** actual data
clear
graph drop _all
use "$citesinput"

* drop non-precedents and non-common law citations
keep if citing_date > cited_date
keep if citing_date >= 1700
keep if inlist(citing_court,"CP","EX","KB","NP")
keep if inlist(cited_court,"CP","EX","KB","NP")

* determine most recent citing year
collapse (max) citing_date, by(cited_uidcombined cited_date)
gen timediff = citing_date - cited_date
gen cited_decade = 10*floor(cited_date/10)

* time difference histograms for specific cited decades
gen uid = _n
collapse (count) citesperyear = uid, by(cited_decade timediff)
save "$path/_temp/survival cases all decades.dta", replace

* generate graphs
sort cited_decade timediff
tabstat citesperyear if cited_decade == 1580, st(sum) save
matrix tabs = r(StatTotal)
local numobs = tabs[1,1]
twoway (line citesperyear timediff) if cited_decade == 1580, ///
        name(g1580) xtitle("") ytitle(number of cites) title(1580's) subtitle(`numobs'
cases) legend(off)
tabstat cites if cited_decade == 1700, st(sum) save
matrix tabs = r(StatTotal)
local numobs = tabs[1,1]
twoway (line citesperyear timediff) if cited_decade == 1700, ///

```

```

name(g1700) xtitle(years since reported) ytitle(number of cites) title(1700's)
subtitle(`numobs' cases) legend(off)

* complete overview
keep if inrange(cited_decade,1580,1700)
twoway line citesperyear timediff, by(cited_decade, rows(5) legend(off)) xtitle(years
since reported) ytitle(number of cites)
graph export "$path/survival cases all decades.png", replace

** random model
forvalues y = 1/100 {
    clear
    use "/Users/M/Documents/Research/ER
paper/4_Presentation/Figures/_temp/randommodel case citations_`y'.dta"

    * drop non-precedents and non-common law citations
    keep if citing_date > cited_date
    keep if citing_date >= 1700

    * determine most recent citing year
    collapse (max) citing_date, by(cited_uid cited_date)
    gen timediff = citing_date - cited_date
    gen cited_decade = 10*floor(cited_date/10)

    * time difference histograms for specific cited decades
    gen uid = _n
    collapse (count) citesperyear = uid, by(cited_decade timediff)

    * save to temporary folder
    save "/Users/M/Documents/Research/ER
paper/4_Presentation/Figures/_temp/randommodel case citations_survival_`y'.dta",
replace
}
* combine random simulation
clear
use "/Users/M/Documents/Research/ER
paper/4_Presentation/Figures/_temp/randommodel case citations_survival_1.dta"
forvalues y = 2/100 {
    append using "/Users/M/Documents/Research/ER
paper/4_Presentation/Figures/_temp/randommodel case citations_survival_`y'.dta"
}
collapse (mean) citesperyear, by(cited_decade timediff)

* generate graphs
sort cited_decade timediff

```

```

tabstat cites if cited_decade == 1580, st(sum) save
matrix tabs = r(StatTotal)
local numobs = round(tabs[1,1],1)
tway (line citesperyear timediff) if cited_decade == 1580, ///
    name(rg1580) xtitle("") ytitle("") title("1580's (random model)")
subtitle(`numobs' cases) legend(off)
tabstat cites if cited_decade == 1700, st(sum) save
matrix tabs = r(StatTotal)
local numobs = round(tabs[1,1],1)
tway (line citesperyear timediff) if cited_decade == 1700, ///
    name(rg1700) xtitle(years since reported) ytitle("") title("1700's (random model)")
subtitle(`numobs' cases) legend(off)

```

```

** combine actual and random graphs
graph combine g1580 rg1580 g1700 rg1700, xcommon ycommon rows(2)
graph export "$path/survival cases 2 decades.png", replace

```

*** actual top authorities over whole time period

* open case citations file

clear

graph drop _all

use "\$citesinput"

* drop non-precedents and non-common law citations

keep if citing_date > cited_date

keep if citing_date >= 1700

keep if inlist(citing_court,"CP","EX","KB","NP")

keep if inlist(cited_court,"CP","EX","KB","NP")

* define matrix to collect results

matrix define year = [.]

matrix colnames year = year

mat define meanage_topcited = [.,.,.,.]

matrix colnames meanage_topcited = meantop10 meantop50 meantop100 meantop500

mat define medianage_topcited = [.,.,.,.]

matrix colnames medianage_topcited = medianp99 medianp95 medianp90 medianp80

mat define sdage_topcited = [.,.,.,.]

matrix colnames sdage_topcited = sdtop10 sdtop50 sdtop100 sdtop500

mat define madage_topcited = [.,.,.,.]

matrix colnames madage_topcited = madp99 madp95 madp90 madp80

```

forvalues y = 1700/1865 {
    preserve
    di "year: `y' *****"
    keep if citing_date <= `y'

    collapse (count) cites = cited_uid, by(cited_uidcombined cited_nomcitematched
cited_date)
    gsort - cites + cited_uidcombined

    egen p99 = pctlc(cites), p(99)
    egen p95 = pctlc(cites), p(95)
    egen p90 = pctlc(cites), p(90)
    egen p80 = pctlc(cites), p(80)

    gen timediff = `y' - cited_date

    su timediff if _n <= 10
    scalar meantop10 = `r(mean)'
    scalar sdtop10 = `r(sd)'
    su timediff if cites >= p99, detail
    scalar medianp99 = `r(p50)'
    egen madp99 = mad(timediff) if cites >= p99
    su madp99
    scalar madp99 = `r(mean)'

    su timediff if _n <= 50, detail
    scalar meantop50 = `r(mean)'
    scalar sdtop50 = `r(sd)'
    su timediff if cites >= p95, detail
    scalar medianp95 = `r(p50)'
    egen madp95 = mad(timediff) if cites >= p95
    su madp95
    scalar madp95 = `r(mean)'

    su timediff if _n <= 100, detail
    scalar meantop100 = `r(mean)'
    scalar sdtop100 = `r(sd)'
    su timediff if cites >= p90, detail
    scalar medianp90 = `r(p50)'
    egen madp90 = mad(timediff) if cites >= p90
    su madp90
    scalar madp90 = `r(mean)'

    su timediff if _n <= 500, detail

```

```

scalar meantop500 = `r(mean)'
scalar sdtop500 = `r(sd)'
su timediff if cites >= p80, detail
scalar medianp80 = `r(p50)'
egen madp80 = mad(timediff) if cites >= p80
su madp80
scalar madp80 = `r(mean)'

hist timediff if _n <= 100, percent width(5) xscale(reverse) name(h`y'top100)
nodraw ///
        title(`y', size(large) color(black) position(12) orientation(horizontal)
ring(0) margin(vlarge))

keep if _n <= 500
save "$path/_temp/meanagemedianage_topcited`y'.dta", replace

matrix define year = [year \ `y']
matrix define meanage_topcited = [meanage_topcited \
meantop10,meantop50,meantop100,meantop500]
matrix define medianage_topcited = [medianage_topcited \
medianp99,medianp95,medianp90,medianp80]
matrix define sdage_topcited = [sdage_topcited \ sdtop10, sdtop50, sdtop100,
sdtop500]
matrix define madage_topcited = [madage_topcited \ madp99, madp95, madp90,
madp80]
restore
}

clear
matrix define meanagemediansdmad =
[year,meanage_topcited,medianage_topcited,sdage_topcited,madage_topcited]
svmat meanagemediansdmad, names(col)
drop if year == .
save "$path/_temp/meanagemedianage_topcited_all.dta", replace

twoway (line meantop10 year, lcolor(gs10)) (line meantop50 year, lcolor(gs7)) (line
meantop100 year, lcolor(gs4)) (line meantop500 year, lcolor(black)), name(mean)
xlabel(1700(40)1865) title(mean) legend(region(col(white)))
twoway (line sdtop10 year, lcolor(gs10)) (line sdtop50 year, lcolor(gs7)) (line sdtop100
year, lcolor(gs4)) (line sdtop500 year, lcolor(black)), name(sd) xlabel(1700(40)1865)
title(sd) legend(region(col(white)))
twoway (line medianp99 year, lcolor(gs10)) (line medianp95 year, lcolor(gs7)) (line
medianp90 year, lcolor(gs4)) (line medianp80 year, lcolor(black)), name(median)
xlabel(1700(40)1865) title(median) legend(region(col(white)))

```

```
twoway (line madp99 year, lcolor(gs10)) (line madp95 year, lcolor(gs7)) (line madp90
year, lcolor(gs4)) (line madp80 year, lcolor(black)), name(mad) xlabel(1700(40)1865)
title(mad) legend(region(col(white)))
```

```
graph combine mean sd
graph export "$path/meanage_sdage_topcited.png", replace
```

```
graph combine median mad
graph export "$path/medianage_madage_toppercentiles.png", replace
```

```
graph combine h1740top100 h1790top100 h1810top100 h1860top100, xcommon
ycommon
graph export "$path/histograms_top100cited.png", replace
```

```
*** top authorities over whole time period (random model)
```

```
* open case citations file
```

```
clear
```

```
graph drop _all
```

```
forvalues n = 1/100 {
```

```
    use "/Users/M/Documents/Research/ER
```

```
paper/4_Presentation/Figures/_temp/randommodel case citations_`n'.dta"
```

```
    * drop non-precedents and non-common law citations
```

```
    keep if citing_date > cited_date
```

```
    keep if citing_date >= 1700
```

```
    * define matrix to collect results
```

```
    matrix define year = [.]
```

```
    matrix colnames year = year
```

```
    mat define meanage_topcited_random = [.,.,.,.]
```

```
    matrix colnames meanage_topcited_random = meantop10 meantop50
```

```
meantop100 meantop500
```

```
    mat define medianage_topcited_random = [.,.,.,.]
```

```
    matrix colnames medianage_topcited_random = medianp99 medianp95
```

```
medianp90 medianp80
```

```
    mat define sdage_topcited_random = [.,.,.,.]
```

```
    matrix colnames sdage_topcited_random = sdtop10 sdtop50 sdtop100 sdtop500
```

```
    mat define madage_topcited_random = [.,.,.,.]
```

```
    matrix colnames madage_topcited_random = madp99 madp95 madp90 madp80
```

```

forvalues y = 1701/1865 {
    preserve
    di "year: `y' *****"
    keep if citing_date <= `y'

    collapse (count) cites = citing_uid, by(cited_uid cited_date)
    gsort - cites + cited_uid

    egen p99 = pctl(cites), p(99)
    egen p95 = pctl(cites), p(95)
    egen p90 = pctl(cites), p(90)
    egen p80 = pctl(cites), p(80)

    gen timediff = `y' - cited_date

    su timediff if _n <= 10
    scalar meantop10 = `r(mean)'
    scalar sdtop10 = `r(sd)'
    su timediff if cites >= p99, detail
    scalar medianp99 = `r(p50)'
    egen madp99 = mad(timediff) if cites >= p99
    su madp99
    scalar madp99 = `r(mean)'

    su timediff if _n <= 50, detail
    scalar meantop50 = `r(mean)'
    scalar sdtop50 = `r(sd)'
    su timediff if cites >= p95, detail
    scalar medianp95 = `r(p50)'
    egen madp95 = mad(timediff) if cites >= p95
    su madp95
    scalar madp95 = `r(mean)'

    su timediff if _n <= 100, detail
    scalar meantop100 = `r(mean)'
    scalar sdtop100 = `r(sd)'
    su timediff if cites >= p90, detail
    scalar medianp90 = `r(p50)'
    egen madp90 = mad(timediff) if cites >= p90
    su madp90
    scalar madp90 = `r(mean)'

    su timediff if _n <= 500, detail
    scalar meantop500 = `r(mean)'
    scalar sdtop500 = `r(sd)'
    su timediff if cites >= p80, detail

```



```

scalar medianp80 = `r(p50)'
egen madp80 = mad(timediff) if cites >= p80
su madp80
scalar madp80 = `r(mean)'

matrix define year = [year \ `y']
matrix define meanage_topcited_random = [meanage_topcited_random \
meantop10,meantop50,meantop100,meantop500]
matrix define medianage_topcited_random =
[medianage_topcited_random \ medianp99,medianp95,medianp90,medianp80]
matrix define sdage_topcited_random = [sdage_topcited_random \
sdtop10, sdtop50, sdtop100, sdtop500]
matrix define madage_topcited_random = [madage_topcited_random \
madp99, madp95, madp90, madp80]
restore
}

clear
matrix define meanagemediansdmad_random =
[year,meanage_topcited_random,medianage_topcited_random,sdage_topcited_random,m
adage_topcited_random]
svmat meanagemediansdmad_random, names(col)
drop if year == .
save "$path/_temp/meanagemediansdmad_random_`n'.dta", replace
}

* calculate expected value of mc simulations
clear
use "$path/_temp/meanagemediansdmad_random_1.dta"
forvalues n = 2/100 {
    append using "$path/_temp/meanagemediansdmad_random_`n'.dta"
}

collapse (mean) meantop10 meantop50 meantop100 meantop500 medianp99 medianp95
medianp90 medianp80 sdtop10 sdtop50 sdtop100 sdtop500 madp99 madp95 madp90
madp80, by(year)

* remove labels
ds3
foreach v in `r(varlist)' {
    label variable `v' ""
}

* plot
twoway (line meantop10 year, lcolor(gs10)) (line meantop50 year, lcolor(gs7)) (line
meantop100 year, lcolor(gs4)) (line meantop500 year, lcolor(black)), name(mean)

```

```

xlabel(1700(40)1865) title(mean) legend(region(col(white) label(1 "top 1%") label(2 "top
5%") label(3 "top 10%") label(4 "top 20%")))
twoway (line sdtop10 year, lcolor(gs10)) (line sdtop50 year, lcolor(gs7)) (line sdtop100
year, lcolor(gs4)) (line sdtop500 year, lcolor(black)), name(sd) xlabel(1700(40)1865)
title(sd) legend(region(col(white)))
twoway (line medianp99 year, lcolor(gs10)) (line medianp95 year, lcolor(gs7)) (line
medianp90 year, lcolor(gs4)) (line medianp80 year, lcolor(black)), name(median)
xlabel(1700(40)1865) title(median) legend(region(col(white)))
twoway (line madp99 year, lcolor(gs10)) (line madp95 year, lcolor(gs7)) (line madp90
year, lcolor(gs4)) (line madp80 year, lcolor(black)), name(mad) xlabel(1700(40)1865)
title(mad) legend(region(col(white)))

grc1leg combine mean sd, name(meansd) xcommon ycommon
grc1leg combine median mad, name(meansd) xcommon ycommon

graph combine meansd medianmad, rows(2)
graph export "$path/meanage_sdage_medianage_madage_toppercentiles_random.png",
replace

```

*** top 100 authorities in specific time periods

```
clear
```

```
graph drop _all
```

```
use "$citesinput"
```

* drop non-precedents and non-common law citations

```
keep if citing_date > cited_date
```

```
keep if citing_date >= 1700
```

```
keep if inlist(citing_court,"CP","EX","KB","NP")
```

```
keep if inlist(cited_court,"CP","EX","KB","NP")
```

```
forvalues y = 1740(30)1830 {
```

```
    preserve
```

```
    local yend = `y' + 30
```

```
    keep if inrange(citing_date, `y', `yend')
```

```
    collapse (count) cites = cited_uid, by(cited_uidcombined cited_nomcitematched
```

```
cited_date)
```

```
    gsort - cites + cited_uidcombined
```

```
    keep if _n <= 100
```

```
    hist cited_date, freq width(5) name(h`y' `yend') nodraw ///
```

```
        xtitle(year of cited case) title(`y' - `yend', size(large) color(black))
```

```
position(12) orientation(horizontal) ring(0) margin(vlarge))
```

```
    restore
```

```
}
```

```
graph combine h1740_1770 h1770_1800 h1800_1830 h1830_1860, xcommon ycommon
graph export "$path/histograms_top100cited_timeperiod.png", replace
```

```
*****
```

```
*** generate example time profile for year 1780
```

```
clear
graph drop _all
use "$citesinput"
```

```
* drop non-precedents and non-common law citations
```

```
keep if citing_date > cited_date
keep if citing_date >= 1700
keep if inlist(citing_court,"CP","EX","KB","NP")
keep if inlist(cited_court,"CP","EX","KB","NP")
```

```
* calculate relative cites for example year
```

```
keep if citing_date == 1780
collapse (count) cites = cited_uidcombined, by(cited_date)
egen cites_total = total(cites)
gen citesrel = cites/cites_total
```

```
* aggregate over semidecades
```

```
gen cited_semidecade = 5 * floor(cited_date/5)
bysort cited_semidecade: egen citesrel_semidecade = total(citesrel)
bysort cited_semidecade: replace citesrel_semidecade = . if _n != 1
```

```
* plot graph and save
```

```
line citesrel cited_date, xtitle(year) ytitle(fraction of citations per year) lcolor(gs2)
name(year)
line citesrel_semidecade cited_semidecade, xtitle(year) ytitle(fraction of citations per
semidecade) lcolor(gs6) name(semidecade)
graph combine year semidecade, rows(2)
graph export "$path/time profile.png", replace
```

```
*** generate comparison between model prediction and actual observations for year 1790
```

```
clear
graph drop _all
set more off
```

```
use "/Users/M/Documents/Research/ER paper/3_Analysis/model estimation/ready to estimate delta new.dta"
```

```
keep if year == 1780  
drop if dT == 1
```

```
** actual data
```

```
preserve  
keep if target == 1  
collapse (count) cites=uid, by(target_possible)  
egen cites_total = total(cites)  
gen citesrel = cites/cites_total  
line citesrel target_possible, title(actual data) xtitle("") ytitle("") name(actual)
```

```
gen cited_semidecade = 5 * floor(target_possible/5)  
bysort cited_semidecade: egen citesrel_semidecade = total(citesrel)  
bysort cited_semidecade: replace citesrel_semidecade = . if _n != 1  
line citesrel_semidecade cited_semidecade, title(actual data) xtitle("") ytitle("")  
name(actualsemidecade)  
restore
```

```
** representative courtroom model
```

```
asclogit target knew_In dT, case(uid) alternatives(target_possible) noconstant  
predict predicted
```

```
collapse (mean) predicted, by(target_possible)  
line predicted target_possible, title(representative courtroom model) xtitle(year) ytitle("")  
cmissing(n) name(courtroom)
```

```
gen cited_semidecade = 5 * floor(target_possible/5)  
bysort cited_semidecade: egen citesrel_semidecade = total(predicted)  
bysort cited_semidecade: replace citesrel_semidecade = . if _n != 1  
line citesrel_semidecade cited_semidecade, title(representative courtroom model)  
xtitle("") ytitle("") name(courtroomsemidecade)
```

```
** random citing model
```

```
clear  
use "$casescombinedinput"  
merge m:m nomcite_vol using "$volumesinput"  
keep if inrange(date, 1580, 1865)  
keep if inlist(court, "KB", "CP", "EX", "NP")
```

```
collapse (count) cases = uid [fweight=nomcite_num], by(date)
```

```

keep if date < 1780
egen casestotal1800 = total(cases)
gen citesrel = cases/casestotal1800

line citesrel date, title(random citing model) xtitle("") ytitle(fraction of citations per year)
name(random)

gen cited_semidecade = 5 * floor(date/5)
bysort cited_semidecade: egen citesrel_semidecade = total(citesrel)
bysort cited_semidecade: replace citesrel_semidecade = . if _n != 1
line citesrel_semidecade cited_semidecade, title(random citing model) xtitle(year)
ytitle("") name(randomsemidecade)

** combine graphs
graph combine actual random courtroom , ycommon imargin(b=1 t=1) rows(3) name(g1)
graph combine actualsemidecade randomsemidecade courtroomsemidecade, ycommon
imargin(b=1 t=1) rows(3) name(g2)
graph combine g1 g2
graph export "$path/time profile model predictions vs actual.png", replace

*****
*** time profiles
** random citing model
clear
use "$casescombinedinput"
merge m:m nomcite_vol using "$volumesinput"
keep if inrange(date, 1580,1865)
keep if inlist(court,"KB", "CP", "EX", "NP")

* generate semidecades variable
gen semidecade = 5 * floor(date/5)

* calculate number of cases per year and number of total cases preceding year
collapse (count) casessemidcade = uid [fweight=nomcite_num], by(semidecade decade)

gen casestotal = .
    replace casestotal = 0 if _n == 1
    replace casestotal = casessemidcade[_n-1] + casestotal[_n-1] if _n > 1

bysort decade: egen casesdecade = total(casessemidcade)

```

```

** citing_decade to cited_semidecade
* calculate probabilities in random citing model
preserve
forvalues y = 1700(10)1860 {
    su casestotal if semidecade == `y'
    gen citing_casestotal = `r(mean)'
    gen citing_randompercent`y' = casessemidcade/citing_casestotal if semidecade <
`y'
    drop citing_casestotal
}

* clean, reshape and save to file
drop decade casessemidcade casestotal casesdecade
ren semidecade cited_semidecade
dropmiss citing*, obs force
reshape long citing_randompercent, i(cited_semidecade) j(citing_decade)
order citing_decade cited_semidecade
save "$path/_temp/timeprofilerandomcites citingdecade to citedsemidecade.dta", replace
restore

** cited_decade to citing_semidecade
* calculate probabilities in random citing model
forvalues y = 1700(5)1865 {
    su casestotal if semidecade == `y'
    gen citing_casestotal = `r(mean)'
    gen citing_randompercenttemp`y' = casessemidcade/citing_casestotal if
semidecade < `y'
    bysort decade: egen citing_randompercent`y' =
total(citing_randompercenttemp`y'), missing
    drop citing_casestotal citing_randompercenttemp`y'
}

* clean, reshape and save to file
keep if semidecade/10 == int(semidecade/10)
drop semidecade casessemidcade casestotal casesdecade
ren decade cited_decade
dropmiss citing*, obs force
reshape long citing_randompercent, i(cited_decade) j(citing_semidecade)
order citing_semidecade cited_decade
save "$path/_temp/timeprofilerandomcites citingsemidecade to citeddecade.dta", replace

** actual observations
* open case citations file
clear

```

```

use "$citesinput"

* drop non-precedents and non-common law citations
keep if citing_date > cited_date
keep if citing_date >= 1700
keep if inlist(citing_court,"CP","EX","KB","NP")
keep if inlist(cited_court,"CP","EX","KB","NP")

* generate semidecades variable
gen citing_semidecade = 5 * floor(citing_date/5)
gen cited_semidecade = 5 * floor(cited_date/5)

* generate citation counts per cited semidecade by citing decade
preserve
collapse (count) cites = citing_uid, by(citing_decade cited_semidecade)
by citing_decade: egen citing_decadetotal = total(cites)
gen citesrel = cites/citing_decadetotal

merge 1:1 citing_decade cited_semidecade using "/Users/M/Documents/Research/ER
paper/4_Presentation/Figures/_temp/timeprofilerandomcites citingdecade to
citedsemidecade.dta"
drop if _merge == 1
dropmiss citesrel citing_randompercent, obs force
sort citing_decade cited_semidecade

twoway (line citesrel cited_semidecade, xtitle("") xlabel(1650(100)1850, grid)
ytitle(fraction of citations) yscale(range(0 0.18)) ylabel(0(0.05)0.18) lcolor(gs6)) ///
(line citing_randompercent cited_semidecade, xtitle("") xlabel(1650(100)1850)
yscale(range(0 0.18)) ylabel(0(0.05)0.18) lcolor(gs10) lpattern(shortdash)), ///
by(citing_decade, note("")) legend(off) rows(3) compact
graph export "$path/time profiles cited semidecade by citing decade.png", replace
restore

* generate citation counts per citing semidecade by cited decade
collapse (count) cites = citing_uid, by(citing_semidecade cited_decade)
by citing_semidecade: egen citing_semidecadetotal = total(cites)
gen citesrel = cites/citing_semidecadetotal

merge 1:1 cited_decade citing_semidecade using "/Users/M/Documents/Research/ER
paper/4_Presentation/Figures/_temp/timeprofilerandomcites citingsemidecade to
citeddecade.dta"
drop if _merge == 1
dropmiss citesrel citing_randompercent, obs force
sort cited_decade citing_semidecade

```

```

twoway (line citesrel citing_semidecade, xtitle("") xlabel(1750(50)1850, grid)
ytitle(fraction of citations) color(gs10)) ///
      (line citing_randompercent citing_semidecade, xtitle("") xlabel(1750(50)1850)
lcolor(gs10) lpattern(shortdash)), by(cited_decade, note("")) legend(off) rows(3) compact)
graph export "$path/time profiles citing_semidecade by cited_decade.png", replace

```

```

*** create matrix graph and correlation table for year persistence
clear
use "$citesinput"

```

```

* drop non-precedents and non-common law citations
keep if citing_date > cited_date
keep if citing_date >= 1700
keep if inlist(citing_court,"CP","EX","KB","NP")
keep if inlist(cited_court,"CP","EX","KB","NP")

```

```

* generate semidecade variable
gen cited_semidecade = 5 * floor(cited_date/5)

```

```

* generate citation counts per cited semidecade by citing decade
collapse (count) cites = citing_uid, by(citing_decade cited_semidecade)
by citing_decade: egen citing_decadetotal = total(cites)
gen citesrel = cites/citing_decadetotal

```

```

* reshape
drop cites citing_decadetotal
reshape wide citesrel, i(cited_semidecade) j(citing_decade)
forvalues y = 1700(10)1860 {
    label variable citesrel`y' "`y'"
}

```

```

* matrix graph and correlation matrix for selected decades
graph matrix citesrel1700 citesrel1720 citesrel1740 citesrel1760 citesrel1780 citesrel1800
citesrel1820 citesrel1840 citesrel1860, ///
      half msymbol(p) maxes(ylab(0.05 0.10) xlab(0.05 0.10) xscale(range(0 0.15))
yscale(range(0 0.15)))
graph export "$path/matrixgraphs_citingsemidecade.png", replace
cd "$path"
mkcorr citesrel1700 citesrel1720 citesrel1740 citesrel1760 citesrel1770 citesrel1780
citesrel1800 citesrel1820 citesrel1840 citesrel1860, lab
log(matrixcorrelations_citingsemidecade.txt) replace

```



```

*** time plot of parameter estimates from conditional logit model
clear
graph drop _all
use "/Users/M/Documents/Research/ER paper/3_Analysis/model
estimation/results_constrained 120 years indegreeadded.dta"
replace delta = -1*delta
serrbar delta deltase year, scale(1.96) xlabel(1700(20)1870) legend(off) addplot(lowess
delta year, bwidth(0.2) lcolor(red) xlabel(1700(20)1870))
graph export "$path/citation model estimates constrained 120 years.png", replace

clear
use "/Users/M/Documents/Research/ER paper/3_Analysis/model
estimation/results_unconstrained 120 years indegreeadded.dta"
graph drop _all
replace delta = -1*delta
serrbar delta deltase year, scale(1.96) xlabel(1700(20)1870) legend(off) addplot(lowess
delta year, bwidth(0.2) lcolor(red) xlabel(1700(20)1870)) name(delta)
serrbar alpha alphase year, scale(1.96) xlabel(1700(20)1870) legend(off) addplot(lowess
alpha year, bwidth(0.2) lcolor(red) xlabel(1700(20)1870)) name(alpha)
graph combine delta alpha, rows(2)
graph export "$path/citation model estimates unconstrained 120 years.png", replace

clear
graph drop _all
use "/Users/M/Documents/Research/ER paper/3_Analysis/model estimation/results lrtest
120 years indegreeadded.dta"
twoway (line chi2 year) , xlabel(1700(20)1870) legend(off)
graph export "$path/citation model lrtest constrained 120 years.png", replace

*****
*** temporal composition of communities
*** prepare gephi & r input
* actual nodes
clear
use "$casescombinedinput"
merge m:m nomcite_vol using "$volumesinput"
keep if inrange(date, 1580,1865)
keep if inlist(court,"KB", "CP", "EX", "NP")
ren uid id
keep id nomcite date
sort id

```

outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi nodes.csv", comma replace

* actual cites

clear

use "\$citesinput"

keep if citing_date > cited_date

keep if citing_date >= 1700

keep if inlist(citing_court,"CP","EX","KB","NP")

keep if inlist(cited_court,"CP","EX","KB","NP")

ren citing_uidcombined source

ren cited_uidcombined target

gen type = "directed"

keep source target type

sort source

outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi cites.csv", comma replace

* eliminate isolated actual nodes

clear

insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/common law communityanalysis start.csv"

bysort modularityclass: egen modularityclasssize = count(id)

drop if modularityclasssize < 10

keep id nomcite date

outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi nodes no isolates.csv", comma replace

save "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi nodes no isolates.dta", replace

* eliminate cites to/from isolated actual nodes

clear

insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi cites.csv"

ren source id

merge m:1 id using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi nodes no isolates.dta"

ren id source

keep if _merge == 3

drop _merge

ren target id

merge m:1 id using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi nodes no isolates.dta"

ren id target

keep if _merge == 3

drop _merge

```

keep source target type
rm "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi
nodes no isolates.dta"
outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/gephi cites no isolates.csv", comma replace

* random nodes
clear
use "/Users/M/Documents/Research/ER
paper/4_Presentation/Figures/_temp/randommodel case citations_100.dta"
keep if citing_date > cited_date
keep if citing_date >= 1700
keep citing_uid citing_date
ren citing_uid id
ren citing_date date
save "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi
nodes random temp.dta", replace

clear
use "/Users/M/Documents/Research/ER
paper/4_Presentation/Figures/_temp/randommodel case citations_100.dta"
keep if citing_date > cited_date
keep if citing_date >= 1700
keep cited_uid cited_date
ren cited_uid id
ren cited_date date
append using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/gephi nodes random temp.dta"
rm "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi
nodes random temp.dta"
duplicates drop id, force
outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/gephi nodes random.csv", comma replace

* random cites
clear
use "/Users/M/Documents/Research/ER
paper/4_Presentation/Figures/_temp/randommodel case citations_100.dta"
keep if citing_date > cited_date
keep if citing_date >= 1700
ren citing_uid source
ren cited_uid target
gen type = "directed"
keep source target type
sort source

```

outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi cites random.csv", comma replace

* eliminate isolated random nodes

clear

insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/common law communityanalysis start random.csv"

bysort modularityclass: egen modularityclasssize = count(id)

drop if modularityclasssize < 10

keep id date

outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi nodes no isolates random.csv", comma replace

save "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi nodes no isolates random.dta", replace

* eliminate cites to/from isolated random nodes

clear

insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi cites random.csv"

ren source id

merge m:1 id using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi nodes no isolates random.dta"

ren id source

keep if _merge == 3

drop _merge

ren target id

merge m:1 id using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi nodes no isolates random.dta"

ren id target

keep if _merge == 3

drop _merge

keep source target type

rm "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi nodes no isolates random.dta"

outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/gephi cites no isolates random.csv", comma replace

*** characterize detected communities

** spinglass2

clear

insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/communityanalysis_sg2.csv"

* label communities

```

ren membership spinglass2
recode spinglass2 (1=2) (2=1)
label define spinglass2 1 "community 1" 2 "community 2"
label values spinglass2 spinglass2

* save to file
save "$path/_temp/communitydetection_spinglass2.dta", replace

* calculate fractions
collapse (percent) percent = id, by(date spinglass2)

bysort date: egen datepercent = total(percent)
bysort date spinglass2: egen datespinglass2percent = total(percent)
gen datefraction = datespinglass2percent/datepercent

gen semidecade = 5*floor(date/5)
bysort semidecade: egen semidecadepercent = total(percent)
bysort semidecade spinglass2: egen semidecadespinglass2percent = total(percent)
gen semidecadefraction = semidecadespinglass2percent/semidecadepercent
bysort semidecade spinglass2: replace semidecadefraction = . if _n != 1

* plot
twoway (line semidecadefraction semidecade if spinglass2 == 1, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs8)) (lowess semidecadefraction semidecade if spinglass2 == 1,
bwidth(0.3) lcolor(red)) ///
(line semidecadefraction semidecade if spinglass2 == 2, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs4)) (lowess semidecadefraction semidecade if spinglass2 == 2,
bwidth(0.3) lcolor(red)), legend(off) title("2 spinglass communities") name(sg2)

** spinglass3
clear
insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/communityanalysis_sg3.csv"

* label communities
ren membership spinglass3
label define spinglass3 1 "community 1" 2 "community 2" 3 "community 3"
label values spinglass3 spinglass3

* save to file
save "$path/_temp/communitydetection_spinglass3.dta", replace

* calculate fractions
collapse (percent) percent = id, by(date spinglass3)

```

```

bysort date: egen datepercent = total(percent)
bysort date spinglass3: egen datespinglass3percent = total(percent)
gen datefraction = datespinglass3percent/datepercent

gen semidecade = 5*floor(date/5)
bysort semidecade: egen semidecadepercent = total(percent)
bysort semidecade spinglass3: egen semidecadespinglass3percent = total(percent)
gen semidecadefraction = semidecadespinglass3percent/semidecadepercent
bysort semidecade spinglass3: replace semidecadefraction = . if _n != 1

* plot
twoway (line semidecadefraction semidecade if spinglass3 == 1, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs8)) (lowess semidecadefraction semidecade if spinglass3 == 1,
bwidth(0.3) lcolor(red)) ///
      (line semidecadefraction semidecade if spinglass3 == 2, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs4)) (lowess semidecadefraction semidecade if spinglass3 == 2,
bwidth(0.3) lcolor(red)) ///
      (line semidecadefraction semidecade if spinglass3 == 3, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs4)) (lowess semidecadefraction semidecade if spinglass3 == 3,
bwidth(0.3) lcolor(red)), legend(off) title("3 spinglass communities") name(sg3)

** spinglass4
clear
insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/communityanalysis_sg4.csv"

* label communities
ren membership spinglass4
label define spinglass4 1 "community 1" 2 "community 2" 3 "community 3" 4
"community 4"
label values spinglass4 spinglass4

* save to file
save "$path/_temp/communitydetection_spinglass4.dta", replace

* calculate fractions
collapse (percent) percent = id, by(date spinglass4)

bysort date: egen datepercent = total(percent)
bysort date spinglass4: egen datespinglass4percent = total(percent)
gen datefraction = datespinglass4percent/datepercent

gen semidecade = 5*floor(date/5)
bysort semidecade: egen semidecadepercent = total(percent)
bysort semidecade spinglass4: egen semidecadespinglass4percent = total(percent)

```

```

gen semidecadefraction = semidecadespinglass4percent/semidecadepercent
bysort semidecade spinglass4: replace semidecadefraction = . if _n != 1

* plot
tway (line semidecadefraction semidecade if spinglass4 == 1, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs10)) (lowess semidecadefraction semidecade if spinglass4 == 1,
bwidth(0.3) lcolor(red)) ///
    (line semidecadefraction semidecade if spinglass4 == 2, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs8)) (lowess semidecadefraction semidecade if spinglass4 == 2,
bwidth(0.3) lcolor(red)) ///
    (line semidecadefraction semidecade if spinglass4 == 3, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs6)) (lowess semidecadefraction semidecade if spinglass4 == 3,
bwidth(0.3) lcolor(red)) ///
    (line semidecadefraction semidecade if spinglass4 == 4, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs4)) (lowess semidecadefraction semidecade if spinglass4 == 4,
bwidth(0.3) lcolor(red)), legend(off) title("4 spinglass communities") name(sg4)

*** louvain
** louvain2
* import data
clear
insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/communityanalysis_louvain2.csv"

* label communities
ren modularityclass louvain2
replace louvain2 = louvain2 + 1
label define louvain2 1 "community 1" 2 "community 2"
label values louvain2 louvain2

* save to file
save "$path/_temp/communitydetection_louvain2.dta", replace

* calculate fractions
collapse (percent) percent = id, by(date louvain2)

bysort date: egen datepercent = total(percent)
bysort date louvain2: egen datelouvain2percent = total(percent)
gen datefraction = datelouvain2percent/datepercent

gen semidecade = 5*floor(date/5)
bysort semidecade: egen semidecadepercent = total(percent)
bysort semidecade louvain2: egen semidecadelouvain2percent = total(percent)
gen semidecadefraction = semidecadelouvain2percent/semidecadepercent

```

```

bysort semidecade louvain2: replace semidecdefraction = . if _n != 1

* plot
twoway (line semidecdefraction semidecade if louvain2 == 1, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs8)) (lowess semidecdefraction semidecade if louvain2 == 1,
bwidth(0.3) lcolor(red)) ///
(line semidecdefraction semidecade if louvain2 == 2, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs4)) (lowess semidecdefraction semidecade if louvain2 == 2,
bwidth(0.3) lcolor(red)), legend(off) title("2 louvain communities") name(louvain2)

* louvain3
* import data
clear
insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/communityanalysis_louvain3.csv"

* label communities
ren modularityclass louvain3
replace louvain3 = louvain3 + 1
label define louvain3 1 "community 1" 2 "community 2" 3 "community 3"
label values louvain3 louvain3

* save to file
save "$path/_temp/communitydetection_louvain3.dta", replace

* calculate fractions
collapse (percent) percent = id, by(date louvain3)

bysort date: egen datepercent = total(percent)
bysort date louvain3: egen datelouvain3percent = total(percent)
gen datefraction = datelouvain3percent/datepercent

gen semidecade = 5*floor(date/5)
bysort semidecade: egen semidecadepercent = total(percent)
bysort semidecade louvain3: egen semidecadelouvain3percent = total(percent)
gen semidecdefraction = semidecadelouvain3percent/semidecadepercent
bysort semidecade louvain3: replace semidecdefraction = . if _n != 1

* plot
twoway (line semidecdefraction semidecade if louvain3 == 1, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs12)) (lowess semidecdefraction semidecade if louvain3 == 1,
bwidth(0.3) lcolor(red)) ///
(line semidecdefraction semidecade if louvain3 == 2, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs8)) (lowess semidecdefraction semidecade if louvain3 == 2,
bwidth(0.3) lcolor(red)) ///

```



```

(line semidecafraction semidecade if louvain3 == 3, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs4)) (lowess semidecafraction semidecade if louvain3 == 3,
bwidth(0.3) lcolor(red)), legend(off) title("3 louvain communities") name(louvain3)

```

```

** louvain4
* import data
clear
insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/communityanalysis_louvain4.csv"

```

```

* label communities
ren modularityclass louvain4
replace louvain4 = louvain4 + 1
label define louvain4 1 "community 1" 2 "community 2" 3 "community 3" 4
"community 4"
label values louvain4 louvain4

```

```

* save to file
save "$path/_temp/communitydetection_louvain4.dta", replace

```

```

* calculate fractions
collapse (percent) percent = id, by(date louvain4)

```

```

bysort date: egen datepercent = total(percent)
bysort date louvain4: egen datelouvain4percent = total(percent)
gen datefraction = datelouvain4percent/datepercent

```

```

gen semidecade = 5*floor(date/5)
bysort semidecade: egen semidecadepercent = total(percent)
bysort semidecade louvain4: egen semidecadelouvain4percent = total(percent)
gen semidecafraction = semidecadelouvain4percent/semidecadepercent
bysort semidecade louvain4: replace semidecafraction = . if _n != 1

```

```

* plot
tway (line semidecafraction semidecade if louvain4 == 1, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs16)) (lowess semidecafraction semidecade if louvain4 == 1,
bwidth(0.3) lcolor(red)) ///
(line semidecafraction semidecade if louvain4 == 2, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs12)) (lowess semidecafraction semidecade if louvain4 == 2,
bwidth(0.3) lcolor(red)) ///
(line semidecafraction semidecade if louvain4 == 3, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs8)) (lowess semidecafraction semidecade if louvain4 == 3,
bwidth(0.3) lcolor(red)) ///

```

```
(line semidecafraction semidecade if louvain4 == 4, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs4)) (lowess semidecafraction semidecade if louvain4 == 4,
bwidth(0.3) lcolor(red)), legend(off) title("4 louvain communities") name(louvain4)
```

```
*** merge data and produce graphs
```

```
** merge
```

```
clear
```

```
use "$path/_temp/communitydetection_spinglass2.dta"
```

```
keep nomcite date spinglass2
```

```
merge 1:1 nomcite using "$path/_temp/communitydetection_spinglass3.dta",
keepusing(spinglass3)
```

```
drop _merge
```

```
merge 1:1 nomcite using "$path/_temp/communitydetection_spinglass4.dta",
keepusing(spinglass4)
```

```
drop _merge
```

```
merge 1:1 nomcite using "$path/_temp/communitydetection_louvain2.dta",
keepusing(louvain2)
```

```
drop _merge
```

```
merge 1:1 nomcite using "$path/_temp/communitydetection_louvain3.dta",
keepusing(louvain3)
```

```
drop _merge
```

```
merge 1:1 nomcite using "$path/_temp/communitydetection_louvain4.dta",
keepusing(louvain4)
```

```
drop _merge
```

```
gen n = _n
```

```
** histograms
```

```
hist date, freq width(5) by(spinglass2, title(spinglass communities) note(""))
name(histsg2)
```

```
hist date, freq width(5) by(louvain2, title(louvain communities) note(""))
name(histlouvain2)
```

```
graph combine histsg2 histlouvain2, rows(2) ycommon
```

```
graph export "$path/communitydetection2histograms.png", replace
```

```
** fractions
```

```
graph combine sg2 louvain2, rows(1) ycommon
```

```

graph export "$path/communitydetection2fractions.png", replace

** robustness
hist date, freq width(5) by(spinglass3)
hist date, freq width(5) by(louvain3)

hist date, freq width(5) by(spinglass4)
hist date, freq width(5) by(louvain4)

graph combine sg2 sg3 sg4 louvain2 louvain3 louvain4, rows(2) ycommon
graph export "$path/communitydetectiontemporalcomposition.png", replace

*** random citing model
** spinglass2 (random)
clear
insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/communityanalysis_random_sg2.csv"

* label communities
ren idrandom id
ren daterandom date
ren membership spinglass2
label define spinglass2 1 "community 1" 2 "community 2"
label values spinglass2 spinglass2

* histogram
hist date, freq width(5) by(spinglass2, title(spinglass communities) note(""))
name(histsg2random)

* calculate fractions
collapse (percent) percent = id, by(date spinglass2)

bysort date: egen datepercent = total(percent)
bysort date spinglass2: egen datespinglass2percent = total(percent)
gen datefraction = datespinglass2percent/datepercent

gen semidecade = 5*floor(date/5)
bysort semidecade: egen semidecadepercent = total(percent)
bysort semidecade spinglass2: egen semidecadespinglass2percent = total(percent)
gen semidecadefraction = semidecadespinglass2percent/semidecadepercent
bysort semidecade spinglass2: replace semidecadefraction = . if _n != 1

* plot

```

```

twoway (line semidecafraction semidecade if spinglass2 == 1, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs8)) (lowess semidecafraction semidecade if spinglass2 == 1,
bwidth(0.3) lcolor(red)) ///
      (line semidecafraction semidecade if spinglass2 == 2, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs4)) (lowess semidecafraction semidecade if spinglass2 == 2,
bwidth(0.3) lcolor(red)), legend(off) title("2 spinglass communities") name(sg2random)

** louvain2 (random)
* import data
clear
insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/communityanalysis_louvain2_random.csv"

* label communities
ren modularityclass louvain2
replace louvain2 = louvain2 + 1
recode louvain2 (1=2) (2=1)
label define louvain2 1 "community 1" 2 "community 2"
label values louvain2 louvain2

* histogram
hist date, freq width(5) by(louvain2, title(louvain communities) note(""))
name(histlouvain2random)

* calculate fractions
collapse (percent) percent = id, by(date louvain2)

bysort date: egen datepercent = total(percent)
bysort date louvain2: egen datelouvain2percent = total(percent)
gen datefraction = datelouvain2percent/datepercent

gen semidecade = 5*floor(date/5)
bysort semidecade: egen semidecadepercent = total(percent)
bysort semidecade louvain2: egen semidecadelouvain2percent = total(percent)
gen semidecafraction = semidecadelouvain2percent/semidecadepercent
bysort semidecade louvain2: replace semidecafraction = . if _n != 1

* plot
twoway (line semidecafraction semidecade if louvain2 == 1, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs8)) (lowess semidecafraction semidecade if louvain2 == 1,
bwidth(0.3) lcolor(red)) ///
      (line semidecafraction semidecade if louvain2 == 2, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs4)) (lowess semidecafraction semidecade if louvain2 == 2,
bwidth(0.3) lcolor(red)), legend(off) title("2 louvain communities")
name(louvain2random)

```

```

** histograms
graph combine histsg2random histlouvain2random, rows(2) ycommon
graph export "$path/communitydetection2histogramsrandom.png", replace

```

```

** fractions
graph combine sg2random louvain2random, rows(1) ycommon
graph export "$path/communitydetection2fractionsrandom.png", replace

```

```

*****
*** quality of case reports
** quality and authority
clear
use "$citesinput"
keep if citing_date > cited_date
keep if citing_date >= 1700
keep if inlist(citing_court,"CP","EX","KB","NP")
keep if inlist(cited_court,"CP","EX","KB","NP")

collapse (count) cites = citing_uidcombined, by(cited_uidcombined cited_numwords)
keep if cites <= 40
keep if cited_numwords <= 15000
tway (scatter cites cited_numwords, msize(vtiny) jitter(1.5)) (lowess cites
cited_numwords, lcolor(red) lwidth(medium)), xtitle(number of words in case report)
ytitle(number of citations) legend(off)
graph export "$path/casereportqualitycites.png", replace

* quality over time
clear
use "$casescombinedinput"
merge m:m nomcite_vol using "$volumesinput"
keep if inrange(date, 1580,1865)
keep if inlist(court,"KB", "CP", "EX", "NP")

bysort date: egen num_wordsave = mean(num_words)

keep if num_words <= 15000

tway (scatter num_words date, msize(vtiny)) ///
      (line num_wordsave date, lcolor(red) lwidth(medium) cmissing(n)) ///

```

```
, xtitle(date) ytitle(number of words in case report) legend(off)
graph export "$path/casereportqualitydates.png", replace
```

```
*****
*****
*** prepare us law data
** case attributes
clear
insheet using "/Users/M/Documents/Research/ER paper/0_Data/US/judicial.csv"
rename caseid uid
rename year date
gen decade = 10*floor(date/10)
rename usid uscite
order uid uscite date decade parties
keep if date >= 1780
save "/Users/M/Documents/Research/ER paper/2_Cleaning/US/case_attributes.dta",
replace

** case citations
clear
insheet using "/Users/M/Documents/Research/ER paper/0_Data/US/allcites.txt",
delimiter(" ")

* citing
ren v1 uid
merge m:1 uid using "/Users/M/Documents/Research/ER
paper/2_Cleaning/US/case_attributes.dta", keepusing(date decade uscite parties)
keep if _merge == 3
drop _merge
ren uid citing_uid
ren uscite citing_uscite
ren date citing_date
ren decade citing_decade
ren parties citing_parties

* cited
```

```

ren v2 uid
merge m:1 uid using "/Users/M/Documents/Research/ER
paper/2_Cleaning/US/case_attributes.dta", keepusing(date decade uscite parties)
keep if _merge == 3
drop _merge
ren uid cited_uid
ren uscite cited_uscite
ren date cited_date
ren decade cited_decade
ren parties cited_parties

order citing* cited*
keep if citing_date >= 1780
keep if cited_date >= 1780
save "/Users/M/Documents/Research/ER paper/2_Cleaning/US/case_citations.dta",
replace

*** number of cases
clear
use "$uscasesinput"

collapse (count) uscases = uid, by(date)
label variable date "year"
label variable uscases "number of case reports"
merge 1:1 date using "$path/_temp/commonlawcases.dta"

sort date
twoway (line uscases date) (line cases date, lpattern(dash)), legend(label(1 "us judicial
opinions") label(2 "er common law case reports") rows(2) region(col(white)))
graph export "$path/us case numbers per year.png", replace

*** time depreciation
clear
use "$uscitesinput"
keep if citing_date > cited_date

* calculate cites per time difference
gen timediff = citing_date - cited_date
label variable timediff "years between citing and cited case"
collapse (count) uscites = citing_uid, by(timediff)
label variable uscites "number of cites"
save "$path/_temp/uscommonlawcitestimedifferences.dta", replace

```

```

merge 1:1 timediff using "$path/_temp/commonlawcitestimedifferences.dta"

* fit exponential decay model
gen logcites = ln(cites)
reg logcites timediff
predict logciteshat

gen uslogcites = ln(uscites)
reg uslogcites timediff
predict uslogciteshat
esttab using "$path/ustimedepreciationfit.rtf", se r2(%9.2f) replace

* plot and export graph
twoway (line uslogcites timediff, lcolor(edkblue)) (line uslogciteshat timediff,
lcolor(red)) ///
      (line logcites timediff, lcolor(edkblue) lpattern(dash)) (line logciteshat timediff,
lcolor(red) lpattern(dash)), ///
      legend(label(1 "actual us log cites") label(2 "us log cites exponential model
prediction")) ///
      label(3 "actual er log cites") label(4 "er log cites exponential model prediction")
///
      rows(2) region(col(white))) xtitle(years between citing and cited case)
graph export "$path/ustimedepreciationfit.png", replace

*** degree distribution and attachment rates
clear
use "$uscitesinput"
keep if citing_date > cited_date

** in-degree distribution
* calculate
collapse (count) indegree = citing_uid, by(cited_uid)
collapse (count) uscount = cited_uid, by(indegree)
save "$path/_temp/uscommonlawcasesindegrees.dta", replace
merge 1:1 indegree using "$path/_temp/commonlawcasesindegrees.dta"

* plot
twoway (hist indegree [fweight = uscount], freq width(1)) (line count indegree [fweight =
count]), ///
      legend(label(1 "us distribution of received citations") label(2 "er common law
distribution of received citations") rows(2) region(col(white))) xtitle(received citations)
name(indegree1)
twoway (hist indegree [fweight = uscount] if indegree <= 20, freq width(1)) (line count
indegree [fweight = count] if indegree <= 20), ///

```



```

    legend(off) xtitle(received citations) name(indegree2)
    grc1leg indegree1 indegree2, ycommon
    graph export "$path/usdegreedistributions.png", replace

** attachment rates
clear
use "$uscitesinput"
keep if citing_date > cited_date

* calculate attachment rates for different decades
forvalues y = 1820 (10) 2000 {

    * case indegrees for previous periods
    preserve
    keep if citing_date < `y'
    collapse (count) citesold = citing_uid, by(cited_uid)
    save "$path/_temp/uscommonlawcasescitesold_`y'.dta", replace
    restore

    * case indegrees for current period
    preserve
    keep if citing_decade == `y'
    keep if cited_date < `y'
    collapse (count) citesnew = citing_uid, by(cited_uid)
    merge 1:1 cited_uid using "$path/_temp/uscommonlawcasescitesold_`y'.dta"
    replace citesnew = 0 if citesnew == .
    replace citesold = 0 if citesold == .

    * calculate attachment average vs case indegree of previous periods
    egen citesoldaggregated = cut(citesold), at(1(1)17,20,23,30,100)
    drop citesold
    ren citesoldaggregated citesold
    collapse (mean) citesnew (sum) sumcitesnew=citesnew, by(citesold)

    save "$path/_temp/uscommonlawcasesattachments_`y'.dta", replace
    restore
}

* combine and average decade attachment rates
clear
use "$path/_temp/uscommonlawcasesattachments_1790.dta"
forvalues y = 1790 (10) 2000 {
    append using "$path/_temp/uscommonlawcasesattachments_`y'.dta"
}

```

```

* calculate
collapse (mean) uscitesnew = citesnew [fweight=sumcitesnew], by(citesold)
save "$path/_temp/uscommonlawcasesattachmentrates.dta", replace
merge 1:1 citesold using "$path/_temp/commonlawcasesattachmentrates.dta"

* plot
twayay (line uscitesnew citesold) (line citesnew citesold), ///
        xtitle(citations received before citing decade) ytitle(average number of new
citations) ///
        legend(label(1 "us distribution of attachment rates") label(2 "er common law
distribution of attachment rates") rows(2) region(col(white))) xtitle(years between citing
and cited case)
graph export "$path/usattachmentrates.png", replace

*** long-term-persistence
clear
use "$uscitesinput"
keep if citing_date > cited_date

* determine most recent citing year
collapse (max) citing_date, by(cited_uid cited_date)
gen timediff = citing_date - cited_date
gen cited_decade = 10*floor(cited_date/10)

* time difference histograms for specific cited decades
gen uid = _n
collapse (count) uscitesperyear = uid, by(cited_decade timediff)
merge 1:1 timediff cited_decade using "$path/_temp/survival cases all decades.dta"
drop _merge

* generate graphs
sort cited_decade timediff
tabstat uscitesperyear if cited_decade == 1800, st(sum) save
matrix tabs = r(StatTotal)
local numobs = tabs[1,1]
twayay (line uscitesperyear timediff if cited_decade == 1800), ///
        name(usg1800) xtitle("years since reported") ytitle(number of cites) title(1800's)
subtitle(`numobs' cases) legend(off)
tabstat uscitesperyear if cited_decade == 1840, st(sum) save
matrix tabs = r(StatTotal)
local numobs = tabs[1,1]
twayay (line uscitesperyear timediff if cited_decade == 1840), ///
        name(usg1840) xtitle("years since reported") ytitle(number of cites) title(1840's)
subtitle(`numobs' cases) legend(off)

```

```

graph combine usg1800 usg1840, cols(2) xcommon ycommon
graph export "$path/ussurvival cases 2 decades.png", replace

* complete overview
keep if inrange(cited_decade,1800,1900)
twoway line uscitesperyear timediff, by(cited_decade, rows(4) legend(off)) xtitle(years
since reported) ytitle(number of cites)
graph export "$path/ussurvival cases all decades.png", replace

*** actual top authorities over whole time period
* open case citations file
clear
graph drop _all
use "$uscitesinput"

* drop non-precedents and non-common law citations
keep if citing_date > cited_date

* define matrix to collect results
matrix define year = [.]
matrix colnames year = year
mat define meanage_topcited = [.,.,.,.]
matrix colnames meanage_topcited = meantop10 meantop50 meantop100 meantop500
mat define medianage_topcited = [.,.,.,.]
matrix colnames medianage_topcited = medianp99 medianp95 medianp90 medianp80
mat define sdage_topcited = [.,.,.,.]
matrix colnames sdage_topcited = sdtop10 sdtop50 sdtop100 sdtop500
mat define madage_topcited = [.,.,.,.]
matrix colnames madage_topcited = madp99 madp95 madp90 madp80

forvalues y = 1820/2000 {
    preserve
    di "year: `y' *****"
    keep if citing_date <= `y'

    collapse (count) cites = citing_uid, by(cited_uid cited_parties cited_date)
    gsort - cites + cited_uid

    egen p99 = pctl(cites), p(99)
    egen p95 = pctl(cites), p(95)
    egen p90 = pctl(cites), p(90)
    egen p80 = pctl(cites), p(80)

```

```

gen timediff = `y' - cited_date

su timediff if _n <= 10
scalar meantop10 = `r(mean)'
scalar sdtop10 = `r(sd)'
su timediff if cites >= p99, detail
scalar medianp99 = `r(p50)'
egen madp99 = mad(timediff) if cites >= p99
su madp99
scalar madp99 = `r(mean)'

su timediff if _n <= 50, detail
scalar meantop50 = `r(mean)'
scalar sdtop50 = `r(sd)'
su timediff if cites >= p95, detail
scalar medianp95 = `r(p50)'
egen madp95 = mad(timediff) if cites >= p95
su madp95
scalar madp95 = `r(mean)'

su timediff if _n <= 100, detail
scalar meantop100 = `r(mean)'
scalar sdtop100 = `r(sd)'
su timediff if cites >= p90, detail
scalar medianp90 = `r(p50)'
egen madp90 = mad(timediff) if cites >= p90
su madp90
scalar madp90 = `r(mean)'

su timediff if _n <= 500, detail
scalar meantop500 = `r(mean)'
scalar sdtop500 = `r(sd)'
su timediff if cites >= p80, detail
scalar medianp80 = `r(p50)'
egen madp80 = mad(timediff) if cites >= p80
su madp80
scalar madp80 = `r(mean)'

hist timediff if _n <= 100, percent width(5) xscale(reverse) name(ush`y'top100)
nodraw ///
        title(`y', size(large) color(black) position(12) orientation(horizontal)
ring(0) margin(vlarge))

keep if _n <= 500
save "$path/_temp/usmeanagemedianage_topcited`y'.dta", replace

```

```

matrix define year = [year \ `y']
matrix define meanage_topcited = [meanage_topcited \
meantop10,meantop50,meantop100,meantop500]
matrix define medianage_topcited = [medianage_topcited \
medianp99,medianp95,medianp90,medianp80]
matrix define sdage_topcited = [sdage_topcited \ sdtop10, sdtop50, sdtop100,
sdtop500]
matrix define madage_topcited = [madage_topcited \ madp99, madp95, madp90,
madp80]
restore
}

```

```

clear
matrix define meanagemediansdmad =
[year,meanage_topcited,medianage_topcited,sdage_topcited,madage_topcited]
svmat meanagemediansdmad, names(col)
drop if year == .
ren * us*
ren usyear year
save "$path/_temp/usmeanagemedianage_topcited_all.dta", replace
merge 1:1 year using "$path/_temp/meanagemedianage_topcited_all.dta"
drop _merge
sort year

```

```

twoway (line meantop10 year, lcolor(gs10) lpattern(dash)) (line meantop50 year,
lcolor(gs7) lpattern(dash)) (line meantop100 year, lcolor(gs4) lpattern(dash)) (line
meantop500 year, lcolor(black) lpattern(dash)) ///
      (line usmeantop10 year, lcolor(gs10)) (line usmeantop50 year, lcolor(gs7))
(line usmeantop100 year, lcolor(gs4)) (line usmeantop500 year, lcolor(black)) ///
      , name(usmean) xlabel(1700(40)2000) ytitle(years) title(mean)
legend(region(col(white)) rows(2) ///
      label(1 "england top 10") label(2 "england top 50") label(3 "england top
100") label(4 "england top 500") label(5 "us top 10") label(6 "us top 50") label(7 "us top
100") label(8 " us top 500"))
twoway (line sdtop10 year, lcolor(gs10) lpattern(dash)) (line sdtop50 year, lcolor(gs7)
lpattern(dash)) (line sdtop100 year, lcolor(gs4) lpattern(dash)) (line sdtop500 year,
lcolor(black) lpattern(dash)) ///
      (line ussdtop10 year, lcolor(gs10)) (line ussdtop50 year, lcolor(gs7)) (line
ussdtop100 year, lcolor(gs4)) (line ussdtop500 year, lcolor(black)) ///
      , name(ussd) xlabel(1700(40)2000) title(sd) legend(off)
twoway (line medianp99 year, lcolor(gs10) lpattern(dash)) (line medianp95 year,
lcolor(gs7) lpattern(dash)) (line medianp90 year, lcolor(gs4) lpattern(dash)) (line
medianp80 year, lcolor(black) lpattern(dash)) ///
      (line usmedianp99 year, lcolor(gs10)) (line usmedianp95 year, lcolor(gs7))
(line usmedianp90 year, lcolor(gs4)) (line usmedianp80 year, lcolor(black)) ///

```

```

, name(usmedian) xlabel(1700(40)2000) ytitle(years) title(median)
legend(region(col(white)) rows(2) ///
label(1 "england top 1%") label(2 "england top 5%") label(3 "england top
10%") label(4 "england top 20%") label(5 "us top 1%") label(6 "us top 5%") label(7 "us
top 10%") label(8 " us top 20%"))
twoway (line madp99 year, lcolor(gs10) lpattern(dash)) (line madp95 year, lcolor(gs7)
lpattern(dash)) (line madp90 year, lcolor(gs4) lpattern(dash)) (line madp80 year,
lcolor(black) lpattern(dash)) ///
(line usmadp99 year, lcolor(gs10)) (line usmadp95 year, lcolor(gs7)) (line
usmadp90 year, lcolor(gs4)) (line usmadp80 year, lcolor(black)) ///
, name(usmad) xlabel(1700(40)2000) title(mad) legend(off)

```

```

grc1leg usmean ussd
graph export "$path/usmeanage_sdage_topcited.png", replace

```

```

grc1leg usmedian usmad
graph export "$path/usmedianage_madage_toppercentiles.png", replace

```

```

graph combine ush1880top100 ush1920top100 ush1960top100 ush1990top100,
xcommon ycommon
graph export "$path/ushistograms_top100cited.png", replace

```

*** top 100 authorities in specific time periods

```

clear
graph drop _all
use "$uscitesinput"

```

```

* drop non-precedents and non-common law citations
keep if citing_date > cited_date

```

```

forvalues y = 1830(40)1950 {
    preserve
    local yend = `y' + 30
    di "`y'`yend'"
    keep if inrange(citing_date, `y', `yend')
    collapse (count) cites = citing_uid, by(cited_uid cited_parties cited_date)
    gsort - cites + cited_uid
    keep if _n <= 100
    hist cited_date, freq width(5) name(ush`y'`yend') nodraw ///
        xtitle(year of cited case) title(`y' - `yend', size(large) color(black))
    position(12) orientation(horizontal) ring(0) margin(vlarge)
    restore
}

```

```
graph combine ush1830_1860 ush1870_1900 ush1910_1940 ush1950_1980, xcommon
ycommon
graph export "$path/ushistograms_top100cited_timeperiod.png", replace
```

```
*****
*** time profiles
** random citing model
clear
use "$scasesinput"

* generate semidecades variable
gen semidecade = 5 * floor(date/5)

* calculate number of cases per year and number of total cases preceding year
collapse (count) casessemidecade = uid, by(semidecade decade)

gen casestotal = .
    replace casestotal = 0 if _n == 1
    replace casestotal = casessemidecade[_n-1] + casestotal[_n-1] if _n > 1

bysort decade: egen casesdecade = total(casessemidecade)

** citing_decade to cited_semidecade
* calculate probabilities in random citing model
preserve
forvalues y = 1780(10)1995 {
    su casestotal if semidecade == `y'
    gen citing_casestotal = `r(mean)''
    gen citing_randompercent`y' = casessemidecade/citing_casestotal if semidecade <
`y'
    drop citing_casestotal
}

* clean, reshape and save to file
drop decade casessemidecade casestotal casesdecade
ren semidecade cited_semidecade
dropmiss citing*, obs force
reshape long citing_randompercent, i(cited_semidecade) j(citing_decade)
order citing_decade cited_semidecade
save "$path/_temp/ustimeprofilerandomcites citingdecade to citedsemidecade.dta",
replace
restore
```

```

** cited_decade to citing_semidecade
* calculate probabilities in random citing model
forvalues y = 1780(5)1995 {
    su casestotal if semidecade == `y'
    gen citing_casestotal = `r(mean)'
    gen citing_randompercenttemp`y' = casessemidecade/citing_casestotal if
semidecade < `y'
    bysort decade: egen citing_randompercent`y' =
total(citing_randompercenttemp`y'), missing
    drop citing_casestotal citing_randompercenttemp`y'
}

* clean, reshape and save to file
keep if semidecade/10 == int(semidecade/10)
drop semidecade casessemidecade casestotal casesdecade
ren decade cited_decade
dropmiss citing*, obs force
reshape long citing_randompercent, i(cited_decade) j(citing_semidecade)
order citing_semidecade cited_decade
save "$path/_temp/ustimeprofilerandomcites citingsemidecade to citeddecade.dta",
replace

** actual observations
* open case citations file
clear
use "$uscitesinput"
keep if citing_date > cited_date

* generate semidecades variable
gen citing_semidecade = 5 * floor(citing_date/5)
gen cited_semidecade = 5 * floor(cited_date/5)

* generate citation counts per cited semidecade by citing decade
preserve
collapse (count) cites = citing_uid, by(citing_decade cited_semidecade)
by citing_decade: egen citing_decadetotal = total(cites)
gen citesrel = cites/citing_decadetotal

merge 1:1 citing_decade cited_semidecade using "/Users/M/Documents/Research/ER
paper/4_Presentation/Figures/_temp/ustimeprofilerandomcites citingdecade to
citedsemidecade.dta"
drop if _merge == 1
dropmiss citesrel citing_randompercent, obs force

```



```

sort citing_decade cited_semidecade

drop if citing_decade == 1790 | citing_decade == 1800

twoway (line citesrel cited_semidecade, xtitle("") xlabel(1850(50)1950, grid)
ytitle(fraction of citations) lcolor(gs6)) ///
      (line citing_randompercent cited_semidecade, xtitle("") xlabel(1850(50)1950)
lcolor(gs10) lpattern(shortdash)) ///
      , by(citing_decade, note("")) legend(off) rows(3) compact)
graph export "$path/ustime profiles cited semidecade by citing decade.png", replace
restore

```

```

*** time plot of parameter estimates from conditional logit model
clear
graph drop _all
use "/Users/M/Documents/Research/ER paper/3_Analysis/model estimation/additional
estimations/US/results_constrained 120 years indegree added.dta"
replace delta = -1*delta
serrbar delta deltase year, scale(1.96) xlabel(1840(20)2000) legend(off) addplot(lowess
delta year, bwidth(0.2) lcolor(red) xlabel(1840(20)2000))
graph export "$path/us citation model estimates constrained 120 years.png", replace

```

```

*** temporal composition of communities
*** prepare gephi & r input
* actual nodes
clear
use "$uscasesinput"
ren uid id
keep id date
gen nomcite = id
tostring nomcite, replace
sort id
outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/US/gephi nodes.csv", comma replace

* actual cites
clear
use "$uscitesinput"
keep if citing_date > cited_date

```

```

ren citing_uid source
ren cited_uid target
gen type = "directed"
keep source target type
sort source
outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/US/gephi cites.csv", comma replace

* eliminate isolated actual nodes
clear
insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/US/us communityanalysis start.csv"
bysort modularityclass: egen modularityclasssize = count(id)
drop if modularityclasssize < 10
keep id nomcite date
outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/US/gephi nodes no isolates.csv", comma replace
save "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/US/gephi nodes no isolates.dta", replace

* eliminate cites to/from isolated actual nodes
clear
insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/US/gephi cites.csv"
ren source id
merge m:1 id using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/US/gephi nodes no isolates.dta"
ren id source
keep if _merge == 3
drop _merge
ren target id
merge m:1 id using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/US/gephi nodes no isolates.dta"
ren id target
keep if _merge == 3
drop _merge
keep source target type
rm "/Users/M/Documents/Research/ER paper/3_Analysis/community detection/US/gephi
nodes no isolates.dta"
outsheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/US/gephi cites no isolates.csv", comma replace

*** characterize detected communities
** spinglass2

```

```

clear
insheet using "/Users/M/Documents/Research/ER paper/3_Analysis/community
detection/US/uscommunityanalysis_sg2.csv"
ren dateus date

* label communities
ren usmembership spinglass2
recode spinglass2 (1=2) (2=1)
label define spinglass2 1 "community 1" 2 "community 2"
label values spinglass2 spinglass2

* plot temporal compositions
hist date, freq width(5) by(spinglass2, title(spinglass communities) note(""))
name(ushistsg2)
graph export "$path/us communitydetectionhistogram.png", replace

* save to file
save "$path/_temp/uscommunitydetection_spinglass2.dta", replace

* calculate fractions
collapse (percent) percent = id, by(date spinglass2)

bysort date: egen datepercent = total(percent)
bysort date spinglass2: egen datespinglass2percent = total(percent)
gen datefraction = datespinglass2percent/datepercent

gen semidecade = 5*floor(date/5)
bysort semidecade: egen semidecadepercent = total(percent)
bysort semidecade spinglass2: egen semidecadespinglass2percent = total(percent)
gen semidecadefraction = semidecadespinglass2percent/semidecadepercent
bysort semidecade spinglass2: replace semidecadefraction = . if _n != 1

* plot fractions
twoway (line semidecadefraction semidecade if spinglass2 == 1, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs8)) (lowess semidecadefraction semidecade if spinglass2 == 1,
bwidth(0.3) lcolor(red)) ///
(line semidecadefraction semidecade if spinglass2 == 2, ytitle(fraction)
ylabel(0(0.2)1) lcolor(gs4)) (lowess semidecadefraction semidecade if spinglass2 == 2,
bwidth(0.3) lcolor(red)), legend(off) title("2 spinglass communities") name(ussg2)
graph export "$path/us communitydetectionfraction.png", replace

```

```

*****
*****
*** number of statutes
clear
use "$statutesinput"
keep if citing_date > cited_statutedate
keep if citing_date >= 1700
keep if inlist(citing_court,"CP","EX","KB","NP")

collapse (mean) statutes = cited_statutechapterstotal, by(cited_statutedate)
label variable cited_statutedate "year"
label variable statutes "number of statutes"
save "/Users/M/Documents/Research/ER paper/2_Cleaning/_statutes
added/statutenumbers.dta", replace

clear
set obs 631
gen temp1 = 1235
gen temp2 = _n - 1
gen cited_statutedate = temp1 + temp2
keep cited_statutedate
merge 1:1 cited_statutedate using "/Users/M/Documents/Research/ER
paper/2_Cleaning/_statutes added/statutenumbers.dta",
drop _merge
replace statutes = 0 if statutes == .
save "/Users/M/Documents/Research/ER paper/2_Cleaning/_statutes
added/statutenumbers.dta", replace

sort cited_statutedate
twoway (line statutes cited_statutedate, xlabel(1300(100)1800)) (lowess statutes
cited_statutedate, bwidth(0.1)), legend(off)
graph export "$path/statute numbers per year.png", replace

*** time depreciation
clear
use "$statutesinput"
keep if citing_date > cited_statutedate
keep if citing_date >= 1700
keep if inlist(citing_court,"CP","EX","KB","NP")

```

```

* calculate cites per time difference
gen timediff = citing_date - cited_statutedate
label variable timediff "years between citing case and cited statute"
collapse (count) statutecites = citing_uid, by(timediff)
label variable statutecites "number of cites"
save "$path/_temp/statutecitestimedifferences.dta", replace

* fit exponential decay model
gen statutelogcites = ln(statutecites)
reg statutelogcites timediff
predict statutelogciteshat
esttab using "$path/statutetimedepreciationfit.rtf", se r2(%9.2f) replace

* plot and export graph
twoway (line statutelogcites timediff, lcolor(edkblue)) (line statutelogciteshat timediff,
lcolor(red)), ///
      legend(label(1 "actual statute cites") label(2 "predicted statute cites")) ///
      rows(2) region(col(white))) xtitle(years between citing case and cited statute)
graph export "$path/statutetimedepreciationfit.png", replace

*** degree distribution
clear
use "$statutesinput"
keep if citing_date > cited_statutedate
keep if citing_date >= 1700
keep if inlist(citing_court,"CP", "EX", "KB", "NP")

* calculate
collapse (count) indegree = citing_uid, by(cited_statuteregnyear cited_statutechapter )
drop if cited_statutechapter == .
collapse (count) statutecount = cited_statutechapter, by(indegree)
save "$path/_temp/statuteindegrees.dta", replace

* plot
twoway (hist indegree [fweight = statutecount], freq width(1)), xtitle(received citations)
name(indegree1)
twoway (hist indegree [fweight = statutecount] if indegree <= 50, freq width(1)) ,
xtitle(received citations) name(indegree2)
graph combine indegree1 indegree2, ycommon
graph export "$path/statutedegreedistributions.png", replace

```

```

*****
*** long-term-persistence
clear
use "$statutesinput"
keep if citing_date > cited_statutedate
keep if citing_date >= 1700
keep if inlist(citing_court,"CP", "EX", "KB", "NP")

* determine most recent citing year
collapse (max) citing_date, by(cited_statutedate cited_statutechapter)
gen timediff = citing_date - cited_statutedate
gen cited_statutedecade = 10*floor(cited_statutedate/10)

* time difference histograms for specific cited decades
gen uid = _n
collapse (count) statutecitesperyear = uid, by(cited_statutedecade timediff)

* generate graphs
sort cited_statutedecade timediff
tabstat statutecitesperyear if cited_statutedecade == 1580, st(sum) save
matrix tabs = r(StatTotal)
local numobs = tabs[1,1]
tway (line statutecitesperyear timediff if cited_statutedecade == 1580), ///
      name(statuteg1580) xtitle("years since enacted") ytitle(number of cites)
title(1580's) subtitle(`numobs' statutes) legend(off)
tabstat statutecitesperyear if cited_statutedecade == 1700, st(sum) save
matrix tabs = r(StatTotal)
local numobs = tabs[1,1]
tway (line statutecitesperyear timediff if cited_statutedecade == 1700), ///
      name(statuteg1700) xtitle("years since enacted") ytitle(number of statutes)
title(1700's) subtitle(`numobs' statutes) legend(off)
graph combine statuteg1580 statuteg1700, cols(2) xcommon ycommon
graph export "$path/statutesurvival 2 decades.png", replace

*****
*** actual top authorities over whole time period
* open case citations file
clear
graph drop _all
use "$statutesinput"
keep if citing_date > cited_statutedate

```

```

keep if citing_date >= 1700
keep if inlist(citing_court,"CP","EX","KB","NP")

* define matrix to collect results
matrix define year = [.]
matrix colnames year = year
mat define meanage_topcited = [.,.,.,.]
matrix colnames meanage_topcited = meantop10 meantop50 meantop100 meantop500
mat define medianage_topcited = [.,.,.,.]
matrix colnames medianage_topcited = medianp99 medianp95 medianp90 medianp80
mat define sdage_topcited = [.,.,.,.]
matrix colnames sdage_topcited = sdtop10 sdtop50 sdtop100 sdtop500
mat define madage_topcited = [.,.,.,.]
matrix colnames madage_topcited = madp99 madp95 madp90 madp80

forvalues y = 1701/1865 {
    preserve
    di "year: `y' *****"
    keep if citing_date <= `y'

    collapse (count) cites = citing_uid, by(cited_statutedate cited_statutechapter)
    gsort - cites + cited_statutechapter
    drop if cited_statutechapter == .

    egen p99 = pctlc(cites), p(99)
    egen p95 = pctlc(cites), p(95)
    egen p90 = pctlc(cites), p(90)
    egen p80 = pctlc(cites), p(80)

    gen timediff = `y' - cited_statutedate

    su timediff if _n <= 10
    scalar meantop10 = `r(mean)'
    scalar sdtop10 = `r(sd)'
    su timediff if cites >= p99, detail
    scalar medianp99 = `r(p50)'
    egen madp99 = mad(timediff) if cites >= p99
    su madp99
    scalar madp99 = `r(mean)'

    su timediff if _n <= 50, detail
    scalar meantop50 = `r(mean)'
    scalar sdtop50 = `r(sd)'
    su timediff if cites >= p95, detail
    scalar medianp95 = `r(p50)'

```

```

egen madp95 = mad(timediff) if cites >= p95
su madp95
scalar madp95 = `r(mean)'

su timediff if _n <= 100, detail
scalar meantop100 = `r(mean)'
scalar sdtop100 = `r(sd)'
su timediff if cites >= p90, detail
scalar medianp90 = `r(p50)'
egen madp90 = mad(timediff) if cites >= p90
su madp90
scalar madp90 = `r(mean)'

su timediff if _n <= 500, detail
scalar meantop500 = `r(mean)'
scalar sdtop500 = `r(sd)'
su timediff if cites >= p80, detail
scalar medianp80 = `r(p50)'
egen madp80 = mad(timediff) if cites >= p80
su madp80
scalar madp80 = `r(mean)'

hist timediff if _n <= 100, percent width(10) xscale(reverse)
name(statuteh`y'top100) nodraw ///
      title(`y', size(large) color(black) position(12) orientation(horizontal)
ring(0) margin(vlarge))

keep if _n <= 500
save "$path/_temp/statutemeanagemedianage_topcited`y'.dta", replace

matrix define year = [year \ `y']
matrix define meanage_topcited = [meanage_topcited \
meantop10,meantop50,meantop100,meantop500]
matrix define medianage_topcited = [medianage_topcited \
medianp99,medianp95,medianp90,medianp80]
matrix define sdage_topcited = [sdage_topcited \ sdtop10, sdtop50, sdtop100,
sdtop500]
matrix define madage_topcited = [madage_topcited \ madp99, madp95, madp90,
madp80]
restore
}

clear
matrix define meanagemediansdmd =
[year,meanage_topcited,medianage_topcited,sdage_topcited,madage_topcited]
svmat meanagemediansdmd, names(col)

```



```

drop if year == .
ren * statute*
ren statuteyear year
save "$path/_temp/statutemeanagemedianage_topcited_all.dta", replace
merge 1:1 year using "$path/_temp/meanagemedianage_topcited_all.dta"
drop _merge
sort year

twoway (line meantop10 year, lcolor(gs10) lpattern(dash)) (line meantop50 year,
lcolor(gs7) lpattern(dash)) (line meantop100 year, lcolor(gs4) lpattern(dash)) ///
      (line statutemeanop10 year, lcolor(gs10)) (line statutemeanop50 year,
lcolor(gs7)) (line statutemeanop100 year, lcolor(gs4)) ///
      , name(statutemean) xlabel(1700(40)1865) title(mean)
legend(region(col(white)) rows(2) ///
      label(1 "case top 10") label(2 "case top 50") label(3 "case top 100")
label(4 "statute top 10") label(5 "statute top 50") label(6 "statute top 100"))
twoway (line sdtop10 year, lcolor(gs10) lpattern(dash)) (line sdtop50 year, lcolor(gs7)
lpattern(dash)) (line sdtop100 year, lcolor(gs4) lpattern(dash)) ///
      (line statutesdtop10 year, lcolor(gs10)) (line statutesdtop50 year,
lcolor(gs7)) (line statutesdtop100 year, lcolor(gs4)) ///
      , name(statutesd) xlabel(1700(40)1865) title(sd) legend(off)
twoway (line medianp99 year, lcolor(gs10) lpattern(dash)) (line medianp95 year,
lcolor(gs7) lpattern(dash)) (line medianp90 year, lcolor(gs4) lpattern(dash)) ///
      (line statutemedianp99 year, lcolor(gs10)) (line statutemedianp95 year,
lcolor(gs7)) (line statutemedianp90 year, lcolor(gs4)) ///
      , name(statutemedian) xlabel(1700(40)1865) title(median)
legend(region(col(white)) rows(2) ///
      label(1 "case top 1%") label(2 "case 5%") label(3 "case 10%") label(4
"statute top 1%") label(5 "statute top 5%") label(6 "statute top 10%"))
twoway (line madp99 year, lcolor(gs10) lpattern(dash)) (line madp95 year, lcolor(gs7)
lpattern(dash)) (line madp90 year, lcolor(gs4) lpattern(dash)) (line madp80 year,
lcolor(black) lpattern(dash)) ///
      (line statutemadp99 year, lcolor(gs10)) (line statutemadp95 year,
lcolor(gs7)) (line statutemadp90 year, lcolor(gs4)) (line statutemadp80 year,
lcolor(black)) ///
      , name(statutemad) xlabel(1700(40)1865) title(mad) legend(off)

grc1leg statutemean statutesd
graph export "$path/statutemeanage_sdage_topcited.png", replace

grc1leg statutemedian statutemad
graph export "$path/statutemedianage_madage_toppercentiles.png", replace

graph combine statuteh1740top100 statuteh1790top100 statuteh1810top100
statuteh1860top100, xcommon ycommon

```

```
graph export "$path/statutehistograms_top100cited.png", replace
```

```
*** top 100 authorities in specific time periods
```

```
clear
```

```
graph drop _all
```

```
use "$statutesinput"
```

```
keep if citing_date > cited_statutedate
```

```
keep if citing_date >= 1700
```

```
keep if inlist(citing_court,"CP","EX","KB","NP")
```

```
forvalues y = 1740(30)1830 {
```

```
    preserve
```

```
    local yend = `y' + 30
```

```
    di "`y'`yend'"
```

```
    keep if inrange(citing_date, `y', `yend')
```

```
    collapse (count) cites = citing_uid, by(cited_statutedate cited_statutechapter)
```

```
    gsort - cites + cited_statutechapter
```

```
    drop if cited_statutechapter == .
```

```
    keep if _n <= 100
```

```
    hist cited_statutedate, freq width(10) name(statuteh`y'`yend')
```

```
xlabel(1200(200)1865) nodraw ///
```

```
    xtitle(year of cited statute) title(`y' - `yend', size(large) color(black)
```

```
position(12) orientation(horizontal) ring(0) margin(vlarge))
```

```
    restore
```

```
}
```

```
graph combine statuteh1740_1770 statuteh1770_1800 statuteh1800_1830
```

```
statuteh1830_1860, ycommon
```

```
graph export "$path/statutehistograms_top100cited_timeperiod.png", replace
```

```
*****
```

```
*** time profiles
```

```
** random citing model
```

```
clear
```

```
graph drop _all
```

```
use "/Users/M/Documents/Research/ER paper/2_Cleaning/_statutes
```

```
added/statutenumbers.dta"
```

```
keep if inrange(cited_statutedate,1580,1865)
```

```
ren cited_statutedate date
```

```

* generate semidecades variable
gen semidecade = 5 * floor(date/5)
gen decade = 10 * floor(date/10)
* calculate number of statutes per year and number of total statutes preceding year
bysort semidecade: egen statessesemidecade = sum(statutes)
duplicates drop statessesemidecade, force
drop date statutes

gen statuestotal = .
    replace statuestotal = 0 if _n == 1
    replace statuestotal = statessesemidecade[_n-1] + statuestotal[_n-1] if _n > 1

bysort decade: egen statutesdecade = total(statessesemidecade)

** citing_decade to cited_semidecade
* calculate probabilities in random citing model
preserve
forvalues y = 1700(10)1865 {
    su statuestotal if semidecade == `y'
    if `r(N)' != 0 {
        gen citing_statuestotal = `r(mean)'
        gen citing_randompercent`y' = statessesemidecade/citing_statuestotal if
semidecade < `y'
        drop citing_statuestotal
    }
    else {
        gen citing_randompercent`y' = 0
    }
}

* clean, reshape and save to file
drop decade statessesemidecade statuestotal statutesdecade
ren semidecade cited_semidecade
dropmiss citing*, obs force
reshape long citing_randompercent, i(cited_semidecade) j(citing_decade)
order citing_decade cited_semidecade
save "$path/_temp/statutetimeprofilerandomcites citingdecade to citedsemidecade.dta",
replace
restore

** cited_decade to citing_semidecade
* calculate probabilities in random citing model
forvalues y = 1580(5)1865 {
    su statuestotal if semidecade == `y'
    if `r(N)' != 0 {

```

```

        gen citing_statutestotal = `r(mean)'
        gen citing_randompercenttemp`y' =
statutessemidecade/citing_statutestotal if semidecade < `y'
        bysort decade: egen citing_randompercent`y' =
total(citing_randompercenttemp`y'), missing
        drop citing_statutestotal citing_randompercenttemp`y'
    }
    else {
        gen citing_randompercenttemp`y' = 0
    }
}

* clean, reshape and save to file
keep if semidecade/10 == int(semidecade/10)
drop semidecade statutessemidecade statutestotal statutesdecade
ren decade cited_decade
dropmiss citing*, obs force
reshape long citing_randompercent, i(cited_decade) j(citing_semidecade)
order citing_semidecade cited_decade
save "$path/_temp/statutetimeprofilerandomcites citingsemidecade to citeddecade.dta",
replace

** actual observations
* open case citations file
clear
use "$statutesinput"
keep if citing_date > cited_statutedate
keep if citing_date >= 1700
keep if inlist(citing_court,"CP","EX","KB","NP")

* generate semidecades variable
gen citing_semidecade = 5 * floor(citing_date/5)
gen cited_semidecade = 5 * floor(cited_statutedate/5)

* generate citation counts per cited semidecade by citing decade
collapse (count) cites = citing_uid, by(citing_decade cited_semidecade)
by citing_decade: egen citing_decadetotal = total(cites)
gen citesrel = cites/citing_decadetotal

merge 1:1 citing_decade cited_semidecade using "/Users/M/Documents/Research/ER
paper/4_Presentation/Figures/_temp/statutetimeprofilerandomcites citingdecade to
citedsemidecade.dta"
drop if _merge == 1
dropmiss citesrel citing_randompercent, obs force
sort citing_decade cited_semidecade

```

```

twoway (line citesrel cited_semidecade, xtitle("") xlabel(1650(100)1850, grid)
ytitle(fraction of citations) lcolor(gs6)) ///
      (line citing_randompercent cited_semidecade, xtitle("") xlabel(1650(100)1850)
lcolor(gs10) lpattern(shortdash)) ///
      , by(citing_decade, note("")) legend(off) rows(3) compact)
graph export "$path/statute time profiles cited semidecade by citing decade.png", replace

```

```

*** time plot of parameter estimates from conditional logit model
clear
graph drop _all
use "/Users/M/Documents/Research/ER paper/3_Analysis/model estimation/additional
estimations/statutes/results_constrained.dta"
replace delta = -1*delta
serrbar delta deltase year, scale(1.96) xlabel(1700(20)1870) legend(off) addplot(lowess
delta year, bwidth(0.2) lcolor(red) xlabel(1700(20)1870))
graph export "$path/statute citation model estimates constrained 120 years.png", replace

```

```

*** case-statute use
* prepare data
clear
use "$citesinput"
append using "$statutesinput"
drop if citing_date <= cited_date & cited_date != .
drop if citing_date <= cited_statutedate & cited_statutedate != .
drop if citing_date < 1700
drop if citing_date > 1865
drop if cited_statutedate < 1580
drop if cited_statutedate > 1865 & cited_statutedate != .
drop if !inlist(citing_court,"CP","EX","KB","NP")
drop if !inlist(cited_court,"CP","EX","KB","NP","")

* calculate case and statute citations per case
bysort citing_uidcombined: egen casecites = count(cited_uid)
bysort citing_uidcombined: egen statuteecites = count(cited_statutedate)
gen totalcites = casecites + statuteecites
gen casescites_rel = casecites / totalcites
gen statuteecites_rel = statuteecites / totalcites
duplicates drop citing_uidcombined, force

```

```

* calculate annual mean
bysort citing_date: egen statutecitesmean = mean(statutecites_rel)

* plot graphs
hist statutecites_rel, percent width(0.2) xlabel(0(0.2)1, grid) xtitle(fraction of statute
citations in citing case) note("") by(citing_decade, note(""))
graph export "$path/statute fraction case citations.png", replace

duplicates drop citing_date, force
twoway (line statutecitesmean citing_date) (lowess statutecitesmean citing_date),
xlabel(1700(20)1870) ylabel(0(0.2)1) legend(off)
graph export "$path/statute mean case citations.png", replace

```

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