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Abstract

We use machine-learning methods to study the features and origins of the ideas of Francis Bacon, a key figure who contributed to the intellectual roots of a cultural paradigm that spurred modern economic development. Bacon's works are the data in an estimation of a structural topic model, a state-of-the-art methodology for analysis of text corpora. The estimates uncover sixteen topics prominent in Bacon's opus. Two are key elements of the ideas usually associated with Bacon—inductive epistemology and fact-seeking. The utilitarian promise of science and the centralized organization of the scientific quest, embraced by Bacon's followers, were not emphasized by him. We provide the first quantitative evidence that the genesis of Bacon's epistemology lies in his experience in the common-law. Combining our findings with accepted arguments in the existing literature, we suggest that the effects of common-law culture can help explain the coincidence of political and economic development in England.

JEL-Codes: B310, Z100, C550, N730, K100, P100.

Keywords: Francis Bacon, culture, England, law, knowledge, scientific method.

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With regard to authority, it is the greatest weakness to attribute infinite credit to particular authors, and to refuse his own prerogative to time, the author of all authors, and, therefore, of all authority. For truth is rightly named the daughter of time, not of authority.

Francis Bacon, *Novum Organum*

1. Introduction

Perhaps the fundamental question of comparative economics is why some countries develop and why other countries fail to do so. In the economics literature on this question, the early development of England provides a paradigmatic example, perhaps the single most important data point (North and Weingast 1989, Acemoglu and Robinson 2012, Mokyr 2016). The most popular causal interpretation of England's unique early success emphasizes the effect of the institutions existing after the Glorious Revolution of 1688. But this interpretation has two weaknesses. First, supporting evidence is scant, especially quantitative evidence (Murrell 2017). Second, this interpretation offers no explanation of why England was unique at that time.

A different explanation of England's development might invoke an alternative approach to addressing the fundamental question of comparative economics—a distinctive culture. Mokyr (2016) offers such an alternative approach, pointing to the influence of a new "culture of growth". This culture stressed the possibilities of scientific advance and invention, encouraging their application to economic activities, thereby stimulating technological progress and economic growth. Yet despite its appeal, the emphasis on the culture of growth does not quite get to the heart of an explanation of England's rise. In particular, given that the culture of growth is really an 18th century Western European phenomenon, this cultural argument does not directly address the unique precocity of England. If the culture of growth is the key, why was England comparatively early in development? One possible answer suggests itself immediately within the very confines of Mokyr's argument. Mokyr (2016) identifies Francis Bacon (1561-1626), the preeminent English philosopher, statesman, scientist, jurist, and author, as providing a unique stimulus to the emergence of the culture of growth. Indeed, the central ingredient of the culture-of-growth was 'Baconianism', an amorphous set of philosophical and methodological principles advocated by Bacon's followers who adopted and built on Bacon's ideas.

Yet a focus on Bacon immediately leads one to ask: What exactly were his core ideas? And where did those ideas come from? For two important reasons, answering these questions would be a key first step in any effort to use a culture-of-growth explanation for England's early economic rise. First, Baconianism and the culture of growth were fully solidified only in the 18th century (Mokyr 2016, 2005). Thus, to the extent that Baconianism was instrumental in England's rise, it is Bacon's ideas, dating from the late 16th and early 17th century, that would have been particularly important at the onset of England's development, not the 18th century interpretations of Bacon. Second, an understanding of the genesis of Bacon's ideas sheds light on whether those ideas were original with him, or whether he was simply an influential mouthpiece for a culture that already existed. Identifying a pre-existing culture as a crucial input to Bacon's thought, and subsequently

into Baconianism, would lead to a very different interpretation of English history than concluding that Baconianism began to emerge *only* as a result of the contributions of the unique genius, Bacon, standing alone.

Methodologically, the focus on culture, and in particular the ideas of one person, raises the thorny question of how to bring to bear the favored tools of economics, quantitative empirics, to understand more about the characteristics and development of specific cultures within historical studies. In this paper, we show how new, machine-learning methods can provide the required methodology and thereby aid in understanding both the features and the origins of Bacon's ideas, a key component of 17th-century English culture. This distinguishes our contribution methodologically from that of the prevailing intellectual history on that period. But as we note in many places in the text below, we also differ from that literature in substantive conclusions about the nature and genesis of Bacon's thought.

We examine the features and the cultural origins of Bacon's works using topic modeling, a recently developed unsupervised machine-learning technique for analysis of large text corpora (Blei et al. 2003, Blei 2012, Roberts et al. 2014, 2016a). Topic models produce estimates of a small set of themes (the topics) that are present in an author's work. Applied to Bacon's corpus, the estimated topics identify the core set of his ideas and, by omission, allow identification of those elements of Baconianism that were not in fact emphasized by him. This immediately provides an answer to the first of the questions posed above, on the difference between Bacon's own ideas and Baconianism. Our estimated topic model clearly pinpoints two themes that the intellectual history literature invariably places at the center of Bacon's ideas: the emphasis on probing for facts and the epistemology of generalizing from facts. Importantly, we show that ideas about the utilitarian promise of science and the central direction of scientific efforts—often attributed to Bacon by his followers—are not prominent in Bacon's own work.

The topic model naturally produces estimates of the connections between the use of different topics, information that can help explain the genesis of Bacon's. This exercise provides strong evidence that important elements of Bacon's methodological ideas had their origins in his common-law jurisprudence. Our paper provides the only quantitative evidence to date that bears on this issue, providing insight into the broader culture that existed at the beginning of England's early economic development. The finding about the legal origins of Bacon's methodological ideas is also directly relevant to contentious debates in the existing intellectual history literature on Bacon. As we demonstrate in an extensive literature survey in Appendix A, only a very small subset of the multitude of Bacon scholars has attempted to explicitly investigate a connection between Bacon's scientific methodology and his legal background (Kocher 1957, Wheeler 1983, Simonds 1986, Cardwell 1990, Martin 1992: 164-171, Shapiro 2000: 107-112, Serjeantson 2014: 701-704). Moreover, the conclusions of these scholars have not been widely accepted in the literature. Additionally, even among this small set of scholars, there is disagreement about which aspect of Bacon's legal background was most influential. Yet we find strong quantitative support

in favor of the hypothesis that Bacon's ideas about scientific methodology emerged from his immersion in English common law.

Our analysis begins with the specification and estimation of a Structural Topic Model (STM; Roberts et al. 2014, 2016a), providing machine-learning-based, macroscopic, statistical evidence on the salient features of Bacon's work. STM is a recent innovation in topic modeling that integrates document-level data into the analysis. Given STM's general unfamiliarity to economists, Section 2 details the generative model that underpins STM. With their tremendous scope and breadth, Bacon's writings are particularly suitable for topic modeling.¹ In contrast to human analysts, topic models use a 'bag-of-words' conceptualization of texts, enabling the researcher to produce results that are devoid of preconceived notions about the content of texts. (The interpretation of the results is, of course, another matter.) By providing a direct path to an author's own words and allowing the central themes in a corpus to be 'discovered' by an unsupervised machine-learning algorithm, the conclusions from topic-model estimates are divorced from the history of scholarly interpretation. Nevertheless, we emphasize very strongly that we are not making the argument that these techniques are superior to existing textual-analysis methods. Instead, we view machine-learning as one more, hitherto unexplored, route to obtaining insight into the nature and sources of cultural ideas.

Section 3 documents the process of building the comprehensive, machine-readable corpus of Bacon's major writings, comprising 282 documents and nearly 900,000 words. Additionally, to apply STM, we associated with each document the values of variables characterizing the form of Bacon's work (e.g. an essay, a letter etc.) and its targeted audience (e.g. philosophers, politicians etc.).

As we discuss in Section 4, STM identifies sixteen topics that are central in Bacon's writings, topics that would not necessarily be obvious to a reader of many disparate documents. These topics provide novel interpretations of the ideas that spanned Bacon's works. By closely examining the specific words and the particular documents that STM associates with each topic, we give each topic an evocative name suggestive of its contents. This is the way in which our unsupervised machine-learning algorithm answers the question of which ideas Bacon emphasized (and implicitly which parts of Baconianism he did not).

In Section 5, we develop insights into the origins of the principal features of Bacon's work by examining the correlations across documents in the use of disparate topics and the commonalities between topics in the use of distinctive vocabulary. Our analysis demonstrates that Bacon's epistemological reasoning is strongly connected with his ideas about law and legal institutions. Because Bacon was first immersed in law and turned his scholarly attention to natural philosophy only later, this result provides evidence that the origins of Bacon's epistemological ideas lie in his common-law jurisprudence.

¹ Blaydes et al. (2018) emphasize that text-as-data approaches, such as topic modeling, are particularly valuable when examining a large number of texts simultaneously in order to investigate the broader themes in such texts.

Bacon has often been thought of as communicating his ideas strategically, especially taking into account political constraints. In Section 6, we make direct use of the defining element of STM, the integration into estimation of document-level information, to explore the effect of such constraints. We examine the way in which Bacon's emphases varied with the audience he was addressing. Bacon did not use his epistemology when addressing historians or communicating with the monarch. Perhaps, we have found one reason why Bacon's methodological ideas have usually been interpreted as applying more immediately to science than social science or governance, even though he emphasized the universal applicability of these ideas.

Our methodology and our findings complement and supplement the existing literature in a number of ways. Apart from its specific implications for the interpretation of the rise of England, to which we return in the conclusion, our paper has broad relevance for the literature on comparative economic development. We contribute to the study of culture (e.g., Guiso et al. 2006, Alesina and Giuliano 2015), and particularly to the strand of research on culture that has focused on identifying culture's deep historical roots.² Our paper shows how machine-learning can be used to uncover broad cultural ideas and to estimate the connections between them, providing insights into their historical origins. In particular, we provide a new view within economics on why the common-law was important, focusing on its cultural influence rather than on the shaping of institutional arrangements (see, e.g., Djankov et al. 2003, Beck and Levine 2003, La Porta et al. 2008, Guerriero 2016). Additionally, by isolating the source of Bacon's ideas, we provide perspective on the question of how important the ideas and actions of influential individuals are in shaping fundamental societal and institutional change, relative to more deeply rooted forces (see e.g., Hughes 1986, Jones and Olken 2005, Besley et al. 2011, Brender and Drazen 2013).

Our contribution is also to the application of machine-learning in economics and in comparative economics in particular. Our paper is unique in economics in applying such methods to historical-cultural questions. It lies in a class of work that is beginning to appear in other social sciences—quantitative analyses of culture produced by examining the recorded ideas of important social actors (see, e.g., Blaydes et al. 2018, Lucas et al. 2015: Sec. 4; Roberts et al. 2014). Within economics, topic modeling has been employed only very recently.³ The Latent Dirichlet Allocation (LDA; Blei et al. 2003, Blei 2012) approach has been applied in understanding monetary policymaking (Fligstein et al. 2014, Hansen and McMahon 2016, Hansen et al. 2017), financial market performance (Larsen and Thorsrud 2015, Huang et al. 2016), and corporate behavior (Bandiera et al. 2016, Bellstam et al. 2016). We move beyond LDA, and use Structural Topic Modeling (Roberts et al. 2014, 2016a), integrating document-level data into our analysis.

Lastly, this paper is relevant to the voluminous intellectual history literature on Bacon and Baconianism. The interest of scholars in the features of Bacon's ideas, and their connectedness,

² On the importance of culture see, for example, Barro and McCleary (2003), Licht et al. (2007), Tabellini (2008), Kuran (2009), Algan and Cahuc (2010), Bowles and Gintis (2011), and Nunn (2012). For emphasis on deep historical roots, see Nunn (2008), Becker et al. (2016), and Guiso et al. (2016).

³ See Gentzkow et al. (2017) for an overview of recent research using computational text analysis that is relevant for economists.

has inspired a voluminous literature in the history of science, political philosophy, and intellectual history more broadly. Within this literature there are many contentious debates on the nature of Bacon's ideas and the source of those ideas. In the details of the paper, we comment on which debates our paper's evidence bears, which hypotheses our paper rejects, and which it accepts.

2. Structural Topic Modeling

With rising computer power and the increasing availability of machine-readable texts, new approaches to the quantitative analysis of culture have become increasingly feasible by examining the recorded ideas of important social actors (see, e.g., Blaydes et al. 2018, Lucas et al. 2015: Sec. 4; Roberts et al. 2014). Focusing on Bacon, this paper provides an example of such analysis for comparative economics, using a topic model (Blei et al. 2003). As the name suggests, the key output of a topic model is a set of 'topics', that is, the principal features of a corpus as identified by an unsupervised machine-learning algorithm. The estimated topics identify the emphases within a corpus that might not be readily apparent to a reader of many disparate documents (Blei 2012). Topic modeling is therefore ideally suited to identify ideas that are prominent in a particular corpus and reflect broader social culture.

The particular approach that we use is Structural Topic Modeling (STM), introduced by Roberts et al. (2014, 2016a). The key innovation of STM vis-à-vis earlier topic models is to use in the estimation process information on the documents themselves, rather than just the words in the documents. Thus, for example, an author's use of a cultural topic can be related to the type of audience that the author is addressing, leading to insights on which groups share a particular culture. In this spirit, recent work by comparative politics scholars has used STM, or related methods, to understand the timing and patterns of historic divergence between Christian and Islamic political thought (Blaydes et al. 2018), worldwide perceptions of the rise of China (Roberts et al. 2016a), communication strategies of Muslim clerics (Lucas et al. 2015: Sec. 4.1), and international views of the U.S. (Lucas et al. 2015: Sec. 4.2).

Falling under the umbrella of 'big data' analysis, topic models are machine-learning tools that use generative probabilistic models developed for quantitative investigation of large text corpora. Generative probability models require a researcher to postulate a model of a data-generating process and then use the corpus data to find the most likely values for the parameters within the model. Topic models such as STM view texts as 'bags of words' and exploit the co-occurrence of words across many documents with the aim of identifying groups of words that tend to co-occur (Tingley 2017). These groups of words are the topics, formally conceptualized as probability distributions over vocabulary. The name and interpretation associated with each topic are assigned by the researcher by examining the most important words for each topic and the particular texts featuring a topic most prominently. However, the topics are purely a product of model estimation. They are not produced to match words and documents to concrete issues specified in advance by the researcher as they would be in a supervised model.

The basic structure of the STM is as follows (Roberts et al. 2016a). There are D documents, indexed by d . The document generating process views a document, d , as beginning with a

collection of N_d empty positions, each of which is to be filled with a word. The process of filling a position first involves a choice of a topic from a fixed number available, indexed by $k \in \{1, \dots, K\}$.⁴ That process uses a K -dimensional vector of the parameters of a distribution that generates one of the topics $k \in \{1, \dots, K\}$ for each position in the document. This is the topic-prevalence vector, which lists the probabilities that each of the K topics will be assigned to an empty position. Then, given the chosen topic, k , there is the choice of a word from a corpus-level vocabulary, the elements of which are indexed by $v \in \{1, \dots, V\}$. This choice is determined by a topic-specific V -dimensional vector specifying the probabilities that each element of the vocabulary will be chosen to fill an empty position given that topic.⁵

Early versions of topic models viewed the topic-prevalence vector as drawn from the same distribution for all documents. In STM the topic-prevalence vector is a function of variables characterizing documents. Incorporation of the data on these variables improves the identification of topics and allows the researcher to estimate the relationship between document characteristics and topic prevalence (Roberts et al. 2014). For ease of reference, this document-level information is called the metadata, separating it conceptually from the core data input, the text in the corpus.

The key features of the data-generating process are the following (Roberts et al. 2014, 2016a, 2016b). The process of filling a word-position in a document begins with the generation of a document-specific topic-prevalence vector using the metadata. Let the metadata be given by a matrix \mathbf{X} , each row (denoted \mathbf{x}_d) listing the values of all metadata covariates for document d . Then, the topic-prevalence vector for document d ($\boldsymbol{\theta}_d$) is drawn from a logistic-normal distribution with parameters that are a function of the covariate values:

$$\boldsymbol{\theta}_d \sim \text{LogisticNormal}(\boldsymbol{\Gamma}\mathbf{x}_d', \boldsymbol{\Sigma}). \quad (1)$$

$\boldsymbol{\Gamma}$ is a matrix of coefficients relating covariate values to mean topic-prevalence. With $\boldsymbol{\Sigma}$ a general variance-covariance matrix, there is the possibility of correlations across documents in the topic-prevalence vector.

Now turn to the process of filling empty position $n \in \{1, \dots, N_d\}$ in document d . Given the topic-prevalence vector, one specific topic, denoted by z_{dn} , is associated with that position through the following process:

$$z_{dn} \sim \text{Multinomial}(\boldsymbol{\theta}_d), \quad (2)$$

where the k^{th} element of z_{dn} is unity and all other elements are zero when topic k is chosen.

To emphasize the innovative element of STM, the choice of a specific vocabulary word, v , is modeled as a function of two parameters, one indicating the baseline importance of that word across all documents, m_v , and one indicating the importance of the word given the topic k , κ_{kv} .

⁴ The 'bag-of-words' assumption implies that all positions in a document are interchangeable, meaning that the process determining the choice of topic for any empty position in a specific document is the same for all positions in that document.

⁵ In some applications of STM, these probabilities are allowed to vary in a systematic way across documents. In our application, we do not use this feature of STM.

Transforming the sum of these coefficients into probabilities for use in a multinomial distribution via a logistic transformation, one obtains:

$$\beta_{dkv} | z_{dn} \propto \exp(m_v + \kappa_{kv}), \quad (3)$$

where β_{dkv} is the probability of choosing vocabulary word v to fill a position in document d given topic k . Then a specific word, denoted w_{dn} , is chosen from the overall corpus vocabulary to fill position n in document d , using the following process:

$$w_{dn} \sim \text{Multinomial}(\beta_{dk1}, \dots, \beta_{dkV}). \quad (4)$$

The data to be used for estimation are the metadata matrix, \mathbf{X} , and all words in all documents, that is, w_{dn} , $n = 1, \dots, N_d$ and $d = 1, \dots, D$. Given these data, one estimates Γ , Θ_d , m_v , κ_{kv} , and β_{dkv} by maximizing the posterior likelihood that the observed data were generated by the above data-generating process. Computationally, the maximization problem is solved using an iterative approximation-based variational expectation-maximization algorithm available in R's `stm` package (Roberts et al. 2016a, 2016b). To address problems due to non-convexity, we rely on the spectral initialization approach advocated by Roberts et al. (2016b, 2016c).

3. Data

3.1. The Corpus of Bacon's Works

The construction of the corpus began with a search for all Bacon's works that had been digitized accurately enough that most words could be machine read. Sources of documents were established repositories that specialize in making available machine-readable forms of old documents, such as Project Gutenberg (n.d.), Hathi Trust (n.d.), Internet Archive (n.d.), and, most importantly, The Text Creation Partnership for Early English Books Online (2014).

The larger works were broken up into smaller documents in a manual process that used natural breaks in the text. The result was a corpus of 282 text documents of varying length, containing 898,582 words in total, a mean of 3,186 words per document. Table 1 lists the works included in the corpus. In order to make the documents suitable for a statistical routine that assumed standard orthography and common language for all corpus words, these documents were then processed in a number of stages that are listed below. All operations were carried out using Python programs written by the authors.

The chaotic orthography of late 16th and early 17th century English was converted into standard modern orthography using a program that absorbed the database available with Morph Adorner (2013). This database contains translations between spelling variants and standardized spelling for words common in 16th and 17th century English. In the process of constructing our corpus many corrections and additions were made to this database, resulting in translations being available for over 361,000 spelling variants.

Given standardized spelling, word inflections were then removed by converting all words to their lexical roots, again using databases available in Morph Adorner. Corrections and additions

were made to these databases, resulting in the availability of translations between standard spellings and lexical roots for over 468,000 words.

The next steps required the use of a comprehensive list of standard English spellings, names, abbreviations, and acronyms. The construction of this list initially relied on databases from Moby Word Lists (2002). With additions made during the processing of the corpus, the resultant word list contained over 385,000 standard English words. If, at this stage, a word in the corpus matched a word in the English dictionary, then it was left in the corpus and omitted from all subsequent processing steps.

Because Bacon, like all his educated contemporaries, was fluent in Latin, a very large proportion of the words that did not produce a match were Latin words. But a peculiar variant of Latin was common at that time, the most distinctive peculiarity being the use of many, often idiosyncratic, accents on letters that do not appear in classical Latin. Therefore, accents were removed from all words that did not appear in the English dictionary, replacing accented letters with their nearest ASCII equivalent.

Those words remaining in the corpus that were not in the English word list were then matched against a word list of over 1 million Latin spellings (naturally including a large number of inflections of Latin root words). This Latin spelling list was obtained from Whitaker's Words (2006). Any word in the Latin spelling list, but not in the English word list, was stemmed using a version of the Schinke Latin stemming algorithm (Schinke et al. 1996) programmed in Python, with stemming being a standard process by which the variant forms of a word are translated into standard forms. In Latin this process gives the inflection-less form of a word.

Once the Latin words in the corpus were in their standard forms, they were translated into English. The Latin-English dictionary relied initially on the database available at Whitaker's Words (2006). Then, if a word in the corpus was simultaneously not in the English word list, within the Latin word list, and not in the Latin words in this initial Latin-English dictionary, a Python program searched for the word in the online Lewis and Short Latin Dictionary (Perseus n.d.). The Latin words and their online translations were then added to the original Latin-English dictionary. The resultant dictionary database contained over 59,000 Latin to English translations.

The resulting corpus was then imported into R using the `stm` package. To prepare the corpus for estimation, further text processing was implemented. Using R's `textProcessor` function, all words were converted to lower case and the Porter stemming algorithm was applied. Standard English stop words (natural language words which carry very little meaning, such as 'and', 'the', 'a', 'an'), numbers, and punctuation were removed. The resulting dataset consists of 282 text documents and 147,945 word tokens.

3.2. The Metadata

The last step in organizing the data was to assign values of the metadata covariates to each document in order to use a more complete model that facilitates directly examining the effect of metadata covariates on topical prevalence. Scholars of Bacon have argued that he purposefully

targeted different audiences with different ideas and tactically chose to disseminate different ideas in different forms (Peltonen 1992, 1996a: 10). This is consistent with recent quantitative evidence from political economists that powerful societal actors communicate their ideas strategically (see, e.g., Adena et al. 2015). We therefore coded two metavariables that capture two different characteristics of Bacon's varied opus. The first is Bacon's intended audience—historians, methodologists, lawyers, politicians, scientists, or philosophers. The second is the form of his finished work—case reports, apothegms, letters, essays, book-length tomes, or speeches. The coding of these metavariables was based on our own judgment using the large literature characterizing the context of Bacon's writings. The intended audience was coded after careful scrutiny of each document, simultaneously taking into account existing scholarship on Bacon's opus.⁶ The form of each text document was readily ascertained. Table 2 provides the document frequencies within each cell of the cross-classification of the two covariates.

In the estimations we describe below, we model topical prevalence (or importance) as a function of a linear combination of the dummy variables reflecting our two metadata covariates (see equation (1) above). Thus, the K topics that we identify with Bacon are the same across all documents but the prevalence of each topic (element of θ_d) varies with document type.

4. Estimating and Interpreting the Features of Bacon's Work

We now proceed to ask which topics are contained in Bacon's work. This is an absolutely fundamental research agenda, given Bacon's centrality in English cultural life. We are seeking to characterize the most prominent elements of the thought of a "cultural entrepreneur" whose ideas are believed to have spurred modern economic growth (Mokyr 2016). Importantly, we are doing this in a novel way, using unsupervised machine-learning methods. Thus, our estimates are not a product of any prior beliefs about Bacon that we might hold nor of the many interpretations of Bacon that have overlain his works in the four centuries since his death. Stated starkly, the topic model is *discovering* the central elements of Bacon's ideas, which in turn influenced the development of the culture of growth. Our analysis thereby contributes to the emerging body of social science research that draws on text-as-data and utilizes novel computational methods to study social thought, perceptions, and attitudes as key ingredients of culture (see, e.g., Roberts et al. 2016a: Sec. 3.1; Lucas et al. 2015: Sec. 4; Blaydes et al. 2018; Gutman et al. 2018: 283-284).

4.1. Choosing the Number of Topics to be Estimated

A key initial decision to be made in estimating a topic model is the choice of the (fixed) number of topics to be estimated. There exists no clear-cut or unified approach to this decision, with the literature advocating the use of both statistical measures and human judgment (Roberts et al. 2014: 1068-1070; 2016b). We therefore proceeded by estimating a series of STM models, by

⁶ Specifically, to code the intended audience, we examined each work, especially the prefaces, which often make clear the intended audience. Moreover, a large proportion of the documents are letters and speeches, where there is no doubt about who is the intended recipient or the actual listeners. In some cases, where the intended audience is not clear from the nature of the document itself, we relied on the existing secondary literature on Bacon, usually that accompanying publications of the documents themselves.

varying the number of topics. We considered all models containing from 5 to 25 topics.⁷ We first examined variations across the models in the held-out likelihood and the size of residuals to assess how goodness-of-fit varied with the number of topics (Wallach et al. 2009, Taddy 2012, Roberts et al. 2016b). We then examined the set of estimated models that fit the data particularly well and compared them using their scores on average semantic coherence and exclusivity. (Coherence measures the internal consistency of the topics and exclusivity captures the extent to which topics in the model can be differentiated from each other.) Our initial goal was to identify the set of models that were not strictly dominated by other models in terms of semantic coherence and exclusivity. Then, using our own judgment, we examined the cohesiveness and exclusivity of the topics in the set of non-dominated models, that is, those models located on the 'semantic coherence-exclusivity frontier' (Roberts et al. 2014). This process resulted in choosing 16 for the number of topics. We verified that all of our substantive findings were robust to small variations in the number of estimated topics.

4.2. Representation of Topics in the STM

Table 3 presents detailed results for the topics estimated by STM. Recall that a topic is formally a distribution over vocabulary. The words listed in Table 3—those that are most highly associated with each topic—come directly from the STM output, and therefore comprise word stems, which are often not English words themselves (e.g., 'statut'). Note that it is the statistical procedure that identifies the topics, together with the words and documents most highly associated with them. This is the sense in which one can truly say that STM estimates those ideas that are most prominent in Bacon's writings without using any pre-existing ideas on Bacon. (The names assigned to each topic in Table 3 are not produced by STM. They are our interpretations of the set of ideas that underlie each topic, interpretations justified in subsection 4.3.)

When observing some of the mundane words in Table 3, it might be worth recalling that the STM estimates are driven by correlations across documents in the occurrence of words even though, in isolation, some words provide little direct information about the fundamental ideas underlying a topic. (For example, 'thing' is quite highly associated with 9 of the 16 topics).⁸ Indeed that is the aspect of STM that cannot be easily matched by human readers. An author's employment of one topic might be characterized by the subtle use of particular combinations of mundane words in ways that a reader would find very hard to detect.

We present two lists of the 30 most important words for each topic, with the two lists reflecting different criteria of what is most important. The highest probability ('Highest prob') words are those that are most common for a given topic, but are also non-exclusive, in the sense that they may be associated with any number of topics and might be the highest probability words in more than one topic (as is the case, for example, with 'king', 'law', 'man', 'will' in our corpus).

⁷ In a robustness check, reported in Section 4.2, we considered additional models featuring an even greater number of topics.

⁸ The word 'thing' (or 'particular') was often used as indicating the more modern 'fact' during Bacon's time. It was only during the 17th century that the modern usage of 'fact' became much more common (Shapiro 2000). In Bacon's works, the most common use of 'fact' was in a legal proceeding indicating the deed of which someone was accused.

In contrast, 'FREX' words for a given topic reflect a weighted combination of two criteria: association with that topic with a high probability and a greater likelihood of being associated with that topic than with other topics.⁹

4.3. Characterizing the Topics

The usual procedure in characterizing the topics by assigning names is to examine the specific words that are most important within each topic (reflecting estimates of the β_{dkv} in (3) above) and the ideas in the documents for which a topic is most important (reflecting estimates of the θ_d in (1) above). For each estimated topic, we examined closely the twenty documents that featured a given topic most prominently. The assignment of names to the estimated topics is a crucial step in the analysis because our ultimate conclusions about the features and the cultural origins of Bacon's thought are based on which particular topics are reflected in Bacon's corpus, which topics are correlated across documents, which topics entail overlapping vocabulary, and how Bacon's usage of different topics varies with both intended audience and document form.

Readers will note below that we are able to easily identify the underlying ideas for all 16 topics and assign non-controversial names for each. This is evidence for the internal validity of our results. As Mimno et al. (2011) remark, practical applications of topic modeling often result in some topics that seem nonsensical. This leads to the common procedure of presenting example topics and hiding dubious ones. In contrast, we present all estimated topics and provide evocative names that clearly capture the content for each of the topics.

Table 3 begins with two topics that were part of the core set of ideas that Bacon's later followers came to refer to as the "Baconian program" (Mokyr 2005, 2010, 2016). Labeling the first of these topics Epistemology needs little justification, the words most highly associated with it being so unified in theme—'philosophy', 'knowledge', 'method', 'system', 'logic', 'inquiry', 'discovery', 'experiment', etc. This topic is most strongly associated with Bacon's two great works of methodology, *Novum Organum* and *The Advancement of Learning*. There can be no doubt about a topic whose most highly associated documents are sections of the *Novum Organum* that urge that "Our only hope, then, is in genuine induction...But a really useful induction for the discovery and demonstration of the arts and sciences, should separate nature by proper rejections and exclusions, and then conclude for the affirmative, after collecting a sufficient number of negatives....[Some] may raise this question rather than objection, whether we talk of perfecting natural philosophy alone according to our method, or the other sciences also, such as logic, ethics, politics. We certainly intend to comprehend them all. And as common logic, which regulates matters by syllogisms, is applied not only to natural, but also to every other science, so our inductive method likewise comprehends them all" (Bacon 2014, Sections XIV CV CXXVII).

⁹ We do however restrict FREX words to those used with some frequency in order not to focus on, say, one word that just happens to be used in one document, and once only. Specifically, our choice of FREX words is characterized by a frequency to exclusivity ratio of 0.25 (see Roberts et al. 2016b).

The documents associated with the second of the scientific method topics are a mixed bag. There are two of Bacon's most enigmatic works, *New Atlantis* and the *Apothegms* (nine pieces of text in all). There are three charges presented by Bacon the Attorney General. There are several of his essays. Reading through these works and looking for what connects them, one concludes that their common elements comprise questions being asked and answers being provided. In the charges, Bacon the prosecutor asks why a person is guilty and answers with evidence. A large number of the *Apothegms*, a collection of widely disparate, cryptic aphorisms or amusements with obscure broader implications, pose a scene where one person asks and another answers, for example, "Mr. Popham (afterwards Lord chief Justice Popham) when he was Speaker; And the House of Commons had sat long and done, in effect nothing; coming one day to Queen Elizabeth, she said to him; Now Mr. Speaker; what hath passed in the Commons House? He answered, if it please your majesty, seven weeks."¹⁰ In the associated sections of the *New Atlantis* there are many similar inquisitions and responses, the Governor of Bensalem telling his visitors that "because he that knoweth least is fittest to ask questions, it is more reason, for the entertainment of the time, that ye ask me questions, than that I ask you." Notably for the five sections of *New Atlantis* that are included as separate items in our corpus, the three that are highly associated with this topic do not contain the descriptions of the infrastructure of science on Bensalem. This topic is clearly not about organization of science, the subject often associated with *New Atlantis* (Sargent 1996).

There are two general words that appear under this topic and not under any other—"ask" and "answer". Both of these words are used with a high probability within this topic, but also are highly specific to this topic (as indicated by FREX). This is consistent with the common thread that we find in the disparate documents most associated with this topic, and we therefore designate it as Probing for Facts.¹¹ Thus, STM identifies a key aspect of Bacon's scientific method that has been highlighted by multiple scholars (see e.g., Peltonen 1996a: 17; Mahlerbe 1996, Mokyr 2005: 289, 304): "an umbrella ideology for people to collect data" Mokyr (2016: 92).¹² Notably however, STM has found this topic in a different set of documents and expressed in a different way than is usual in the conventional textual-analysis literature.

Whereas the first two topics dealt with Bacon's avocation, the scientific method, the work for which he is most renowned, the next five center on his vocation, the law, for which he is less famous. The topic Land Law reflects Bacon's work for the Crown especially as Lord Chancellor, the chief judge of the Chancery court, which had a large role in land cases arising out the law of trusts and inheritance. Thus, one sees standard words such as 'legacy' and 'estate', but also words highly characteristic of English property relations; 'feoff', for example, is a word-stem connected

¹⁰ To enhance readability, we have edited the direct historical quotes that we provide by updating to modern spelling and punctuation.

¹¹ Our use of the word 'facts' might be somewhat anachronistic because the modern use of that word only gradually developed during the 17th century. However, as Shapiro (2000) relates, the modern usage had its origin in the law and Bacon was one of the authors who began to use it in the modern sense in many areas of human activity.

¹² Note, however, that this topic is slightly different from the aspect of Bacon's ideas emphasized in Shapiro (2000). She focuses on fact verification, while this topic centers on fact seeking as the process of asking the questions aimed at eliciting possible facts. The aspects of legal fact verification emphasized by Shapiro are not prominent in the documents highly associated with the topic.

with land transfer. The document most associated with this topic is Bacon's disquisition on the Statute of Uses, a 1535 law on the inheritance of land. Many of the legal *Maxims* are also strongly associated with this topic because Bacon used examples from land law to elucidate the more general principles embodied in his maxims.

King, Court & Law reflects the experience of the law that was more personal to Bacon, arising in connection with official appointments: 'solicitor', 'attorney', 'chancellor' are all associated with this topic. 'Essex' was a patron of Bacon but Bacon was also later engaged in legal proceedings against his former patron. All of the documents most strongly associated with this topic are letters, but all are on law. For example, a letter to the King reports on Bacon's visit to a sickly Lord Chancellor but also comments on the "Sickness, of your Chancery Court, though, (by the Grace of God) that Cure will be much easier, than the other".

Law & Nation focuses on what constituted the nation and its citizens, and the legal status of its institutions. In the early 17th century, England had acquired a Scottish King, who was head of two separate nations. As Attorney General, Bacon pleaded the government's cause in the great legal case in which questions of citizenship arose, that of the Postnati, or Calvin's case. Thus, the stem 'allegi' appears in only this topic as Bacon debates the legal nature of the origins of allegiance. Bacon persuaded the judges to extend the protections of the common law (within England) to all those born in Scotland after 1603. The four documents with which this topic is most highly associated all concern this issue.

The Religious Law topic captures legal issues connected with religious controversies and with the status of organizations closely connected with religious bodies. Religious words are numerically dominant in the word lists, but law is one of the highest probability words. In the documents most associated with this topic the religious words are almost invariably used in connection with the discussion of legal issues. Documents highly associated with this topic include those where Bacon suggests compiling, systematizing, and amending the English laws, especially canon law. Second highest in these documents is Bacon's discourse on Sutton's case, a landmark in the law concerning the status of organizations dependent on charities, a legal subject inevitably associated with religion in a country where education and medical care were usually provided by charitable religious entities. In another document strongly associated with this topic, Bacon suggests updating the laws relevant to the Church of England, a long-neglected subject.

The Legal Theory topic is the one in which Bacon discusses ideas that are broader than those on one single legal issue. Many of the documents associated with this topic are from his *Maxims*, in which he tried to condense the principles of English laws into pithy statements. For example, the seventeenth maxim (the third most strongly associated with this topic) is that "The faith and duty of a judge are not subject to question, but it is otherwise of his knowledge either of law or fact", which contains an obvious resonance with Bacon's notions that factual and scientific claims should always be contestable. Also strongly associated with this topic is an essay on the uses of the law, a pedagogical discussion of the purposes of the law, drawing links between the law's objectives and the most important English legal institutions. Consistently, the words associated

with this topic cover a broad range of the institutions of the English legal system, words such as 'assize', 'sergeant', 'leet' [court], 'petty' [sessions court], 'jury', 'escheat', 'attaint', etc.

The next three topics reflect Bacon the political animal and the historian, two deeply interwoven activities (see e.g., Peltonen 1996b). Judging by words and documents, they are not closely connected to either law or scientific method. Religion & Diplomacy centers on foreign affairs, at a time when these were always intertwined with religion. Thus, two of the documents most associated with this topic concern deliberation on the advisability of wars to propagate religion, in which Bacon advises "That Wars Defensive for Religion...are most just; Though Offensive Wars, for Religion, are seldom to be approved". The arguments used are not mainly legal, but rather moral and strategic. Consistently, the distinctive FREX words center on military, foreign, and religious terms.

Bacon wrote in *The Advancement of Learning* that "we are much beholden to Machiavelli and others, that write what men do, and not what they ought to do". This is the spirit that he imbues in the topic we label Political Strategy. It is about specific aspects of civic engagement, which Bacon explored from a philosophical standpoint (Peltonen 1996a: 7), commenting on the games that politicians play, the use of dissimulation and cunning, the role of virtue and malum, and the advice of Cicero, Tacitus, and Machiavelli, all of whom greatly influenced Bacon's views about civic life (Benjamin 1965, Peltonen 1996b: 295-296). These words and names are among those associated with this topic. The documents highly associated with this topic are Bacon's essays, a set of works that provide more general ruminations rather than focusing on specific events or decisions. Thus one of the essays highly associated with this topic analyzes "three degrees of this hiding and veiling of a man's self: secrecy, when a man leaveth himself without observation what he is; dissimulation, when a man lets fall signs and arguments, that he is not, that he is; and simulation, when a man industriously and expressly feigns and pretends to be, that he is not."

Bacon was a historian (Tinkler 1996), a fact that is reflected in the topic we call Dynastic Politics. The documents most associated with this topic are Bacon's discussions of the reigns of the three great Tudor monarchs. Most important was the history of the reign of Henry VII, which naturally was concerned with the dynastic rivalries that led to a century of ongoing war—hence FREX words such as 'York' and 'Plantagenet'—and that continued into Henry's reign with challenges by pretenders to the throne—hence 'Perkin'. Many references to nobility indicate similar concerns. But, these are not mere histories: it seems that Bacon's writing always had an ulterior purpose. Thus his history of the reign of Henry VII was dedicated to the young Prince Charles that he might learn about his ancestor "...a Wise Man, and an Excellent King...I have not flattered him, but took him to life as well as I could, sitting so far off, and having no better light...it is not amisse for You also to see one of these Ancient Pieces". If history is any judge, Charles did not read very carefully.

Our name for the next topic, Classical Thought, needs little justification. Over one half of the FREX words are transparent references to Greek or Roman places, gods, people, or mythological creatures. Notably, law is absent within this topic, although Bacon wrote much about

government and law in Greek and Roman times. The documents most highly associated with this topic are sections of *The Wisdom of the Ancients*. These are a collection of short ancient tales but, as often was the case, Bacon saw more than myth in them for "these Fables contain certain hidden and involved meanings".

Five topics remain, all related to Bacon's writings on the philosophical study of nature and the physical universe. The names of these topics all are self-evidently justifiable from both the highest probability and FREX words for each topic. We use Physics, Energy; Physics, Air and Sound; Botany; Life & Death; and Pharmacology.

4.4. What Is and What Is Not Emphasized by Bacon?

The analysis above has given us a machine-learning, macroscopic, statistical answer to the fundamental question: What themes are emphasized in Bacon's work? (Peltonen 1996a, Vickers 1992). More broadly, the answer provides a window into an understanding of the main ideas that underpinned early 17th-century English culture, at least as absorbed or generated by Bacon.

One crucial insight provided by our results is best framed by contrasting our findings with some standard lessons from the existing intellectual history literature. Within the literature on Bacon's influence on later ideas, one finds emphasis on four distinctive contributions that Bacon has been said to make to Baconianism and, thus, the culture of growth. First, there is the set of ideas on the inductive logic of interpreting the world given the ascertained facts (see e.g., Peltonen 1996a, Rossi 1996). Second there is the emphasis on an intensive effort to find out about, and catalogue, the world (see e.g., Malherbe 1996: 79, 83). Third, some view Bacon as inspiring the later (18th-century) emphasis on the production of useful knowledge (e.g., Rossi 1968, Gaukroger 2001: 14, Losee 2001: 61, Mokyr 2005, 2010). Fourth, others have viewed Bacon as emphasizing the necessity of large-scale, centralized organizational arrangements for scientific investigation (see, e.g., Jonas 1984, Sargent 1996, Gaukroger 2001, Harkness 2007).

We find only two of these four sets of ideas in STM's estimated topics. Epistemology matches the first and Probing for Facts the second. These two topics together reveal the spirit of the Baconian emphasis on the appropriate research procedures and the scientific method (see e.g., Jonas 1984, Sagasti 2000, Malherbe 1996). However, there is no emphasis in Bacon on either the utilitarian value of useful knowledge or on the centralized organization of the scientific quest. It follows that an emphasis on utilitarian value of science and the centralized organization of the scientific quest must have been a product of later interpretations of the followers of Bacon, rather than a product of Bacon's own emphases.¹³ Appendix B demonstrates that these results are fully robust to estimating STMs at much higher levels of granularity.

¹³ As Mokyr remarks (2016: 64): "The exact content of the writings of cultural entrepreneurs sometimes mattered less than the message that future generations chose to distill from it." Or as Snider (1991: 120) argues, 'Baconianism' should be understood as "a dialectical process of production and reception contracted between an author and his readers". The lack of emphasis in Bacon on utilitarianism that is revealed by our estimates is fully consistent with Rossi's (1996: 35-36) and Hill's (1997: 84) argument that Bacon's own interest in science was driven primarily by his quest for truth per se, and was thus distinctly non-utilitarian. Similarly,

We have therefore discovered a fundamental way in which the ideas emphasized by Bacon are very different from those usually associated with Baconianism. This has important implications because Bacon's ideas were so prominent in his own society that they provide a window into the emphases in 17th century English culture. In contrast, Baconianism was both later—the 18th century—and more widespread—across Western Europe. Given that the seeds of England's development were in the 17th century, much earlier than elsewhere, our results suggest that it is the first two elements of Baconianism listed above that were crucial, not the second two. Inductive empiricism was crucial, but perhaps not the broader elements of the culture of growth.

Turning to a broader overview of the topics, the STM estimates illustrate the tremendous breadth of Bacon's opus, a subject much emphasized by modern scholars (Peltonen 1992). Importantly, the set of topics unmistakably reveal that Bacon was, above all, a lawyer and in particular a jurisprudential scholar. Figure 1 illustrates the relative importance of the various topics in the corpus and demonstrates that legal topics are among those most prevalent in the corpus. Of course, the sheer proportion of the corpus attributed to legal topics is in part a reflection of the underlying composition of our corpus. However, recall that the STM estimation algorithm identifies topics based on the co-occurrence of words in disparate documents and conditional on metadata. This means that identification of topics by the STM should not be affected solely by the balance of different types of documents in the corpus, assuming that a full range of the author's works appears in the empirical corpus. Thus, the fact that law is featured prominently in no less than five substantively different STM-estimated topics (King, Court, & Law; Land Law; Religious Law; Legal Theory; Law & Nation) is evidence that legal reasoning is indeed a very important feature of the set of ideas underpinning Bacon's work. Law, in addition, contributes significantly to the documents associated with Probing for Facts, and is present in Religion & Diplomacy. Furthermore, as discussed above, four out of the five STM-estimated legal topics (Legal Theory; Religious Law; Law & Nation; Land Law) are featured prominently in documents where Bacon engages in jurisprudence and scholarship as opposed to writing about comparatively more mundane legal matters in the context of his professional practice of law.

The finding that legal topics are many and prominent in Bacon's opus is a significant one for scholars of Bacon because Bacon's contributions as a legal practitioner and a legal scholar have been relatively neglected in the literature, despite clear evidence in the historical record that these pursuits were important elements of his intellectual efforts.¹⁴ At the same time, for scholars of comparative development, it is a noteworthy result that the father of the modern scientific method emphasized law and jurisprudence since it raises the question of the potential connection between

the absence of a distinct emphasis in Bacon on the centralized organization of the scientific quest, implied by our estimates, is fully consistent with Zagorin's (1998: 170) characterization of the *New Atlantis*.

¹⁴ Coquillette (2004: 313) argues that Bacon "has never been given the proper credit" for his "juristic writing, long overlooked". Shapiro (1980: 333) comments that "...the role of Bacon in law reform has been...obscured by the dearth of scholarly writings on the legal aspects of Bacon's thought". Earlier, Holdsworth (1927: 10) noted that "Of all Bacon's claims to greatness, his claims as a lawyer are the least of all known". De Montmorency (1905: 263) remarked that "...the world of thought is apt to forget that Francis Bacon, the Master of Laws, was a lawyer".

the two, suggesting the possibility of an influence of legal reasoning on the development of scientific methodology.

5. Evidence on the Origins of Bacon's Ideas

The importance of legal ideas among the estimated topics raises the question of the potential link between Bacon's legal background and his inductive empiricism. Given Bacon's central role in the development of the culture of growth (Mokyr 2016), quantitative evidence on the existence (or lack thereof) of a link between Bacon's experience in the law and his scientific methodology would cast light on the origins of the cultural ideas associated with England's rise. Moreover, given the distinctiveness of England's legal system and the widespread knowledge of law in England during Bacon's times, one would have an explanation of why Baconianism came earlier to England and diffused more quickly there than elsewhere.

We use STM to inquire into the connection between Bacon's ideas that emanated from his experience in the law and his scientific method based on the following reasoning. Given that Bacon was first and foremost educated in law (Holdsworth 1924: 139) and "played all the major legal roles" (Coquillette 1992: 2) during his professional engagement, statistical evidence of a connection between Bacon's legal topics and his methodological topics would support the hypothesis that Bacon's methodological ideas were rooted in his legal background. In contrast, a connection between Bacon's non-legal topics and his methodological topics would be consistent with the argument that the former were influenced by the latter. Similarly, a lack of a connection between Bacon's methodological topics and other topics would be consistent with the view that Bacon's scientific methodology was largely *sui generis* with him, in the sense of not being influenced by other themes in his work.

We examine two different aspects of the connection between Bacon's legal and non-legal topics and his methodological ideas: one based on document-level correlations among topics and one based on the overlap of vocabulary use across topic pairs.

5.1. Topic Correlations

An important advantage of STM over LDA is that the generative model underlying STM explicitly incorporates the possibility that topic usage is correlated across documents.¹⁵ We use this aspect of STM to examine the interconnectedness at the document level of the various sets of ideas in Bacon's opus, developing insights into their origin. Figure 2 provides a visualization of the links between topics, where those links capture how the importance of two topics positively covaries across documents (reflecting the estimate of $\theta_d'\theta_d$, which in turn reflects the metadata in Γ and the estimates of \mathbf{x}_d and Σ).¹⁶

¹⁵ Topic correlation is allowed also in the correlated topic model of Blei and Lafferty (2007).

¹⁶ See Roberts et al. (2016b: 23) for discussion of topic correlation. The links that appear in our diagram are those for which the correlation is positive. Note that if all data were random the generative model implies that the correlation between topics would be -0.0667. There are 120 topic correlations, implying that Figure 2 captures the 6% of correlations that are the strongest positive ones.

A key empirical fact about Bacon's opus, evident from Figure 2, is that Epistemology is directly correlated only with Physics, Energy and, importantly, with Religious Law, where Bacon focuses on the legal aspects of religious controversies and organizations (as opposed to religion per se; see Section 4.1). The link between Epistemology and Religious Law is slightly stronger than that between Epistemology and Physics, Energy. (The estimated correlation coefficient equals 0.0417 for Epistemology and Religious Law and 0.0189 for Epistemology and Physics, Energy.) Via Religious Law, Epistemology is further indirectly linked with another legal topic, Law & Nation. These document-level topic correlations show that Bacon combined epistemological reasoning with discussion of both natural philosophy and the law. Given Bacon's early training in law and a later interest in scholarship about natural philosophy¹⁷, this is one piece of evidence consistent with the hypothesis that a core aspect of Bacon's methodological ideas emerged from his immersion in the epistemology of the common law.¹⁸ William Harvey's disparagement of Bacon—that he wrote philosophy like a Lord Chancellor (Clark 1898: 299)—was perhaps a more acute observation than Harvey had intended.

Bacon was certainly also familiar with continental legal thought and spent part of his professional career in non-common-law courts (see, e.g., Holdsworth 1938). Thus, had Bacon viewed the rules of civil-law inquisitorial procedure as providing the paramount methodological paradigm applicable to scientific methodology (see, e.g., Simonds 1986: 499, Cardwell 1990: 270, 274, 276; Serjeantson 2014: 701-702), we would have expected to detect a link between Bacon's

¹⁷ For the topics Religious Law and Epistemology we examined the available historical records to date each of the top twenty documents that feature a given topic most prominently. Consistent with the claim that Bacon's immersion in law preceded his work in natural philosophy and scientific methodology more generally, we found that the documents featuring the Religious Law topic prominently are on average more than six years older than the documents featuring the Epistemology topic prominently.

¹⁸ We use the term 'epistemology' in the general sense of the process by which beliefs about the world come to be established and viewed as justified beliefs. Adding connotations to this term that implied 21st-century precision would be inappropriate for the inchoate ideas on epistemology that existed in Bacon's time.

Referring to the 'epistemology of the common law' raises the question what comprised that epistemology. Since there exists in the literature no well-accepted answer to this question, since constructing an answer would require in itself a separate paper, and since any highly specific answer would invite unproductive controversy, we only provide a list of its core features, which is sufficient for the macroscopic view that this paper provides. Two elements of the method of the common-law are most relevant for our paper, the epistemology of finding/creating the law (or laws) and the process of deciding on facts in specific cases.

Finding the law depended on an implicit assumption that the underlying implicit law or even, perhaps, the optimal laws, were to be discovered in an ongoing decentralized process that depended on the deciding of real disputes, not through abstract speculations. This process involved observations of custom and an overview of past analogous cases, with analysis by trained professionals. Custom was important because it was thought to produce rules that were most useful. Rulings in past cases provided historical wisdom (see Grajzl and Murrell 2016). Expert professionals were essential because they had been through a long process of training their mind in the processes of legal reasoning and absorbing a large stock of knowledge on the procedures and precedents of law. That knowledge was made available by the legal profession in the form of records of past arguments and judgments, the collection of which became more systematic over time. Conclusions about the underlying law were drawn from the common elements of both custom and many cases, using precedent, analogy, and rudimentary induction. This process was ongoing, with middle-level legal rules discovered as time passed, often stated in the form of aphorisms or maxims.

The process of deciding on facts will be familiar to most readers because the common-law model was the conduct of jury trials (see, e.g., Damaška 1986). The impartial juror gradually became central in the process. The courts relied on witness testimony and developed criteria for judging the credibility and competence of witnesses. Multiple witnesses increased the reliability of fact-finding. The expertise of witnesses was considered. The publicity of proceedings enhanced the credibility of the process. The model was one where the criterion of success was the implementation of a process that was best suited to pursue the likely answer to a highly specific question, rather than one where success was judged on whether truth had been discovered. Process rather than product was the mark of a satisfactory decision-making based on facts.

legal topics and Probing for Facts, that is, the part of Bacon's methodological thought in which he stresses the need to collect and investigate facts. Yet we see no such connection in Figure 2; indeed, Probing for Facts is not correlated with any other STM-discovered topic. We interpret this as evidence that law's effect on Bacon's scientific methodology did not arise from his civil jurisprudence. Rather since Epistemology concerns making generalizations from facts (a characteristic of common-law reasoning) and because it is Epistemology that is correlated with a legal topic, our results indicate strongly that the roots of Bacon's methodological ideas sprang primarily from his immersion in English common law (see Wheeler 1983, Martin 1992).

Finally, aside from the already noted link between Bacon's epistemological ideas and one aspect of his science (Physics, Energy), no other non-legal topic—including Classical Thought—is connected to any of the two methodological topics (see Figure 2). At the very least, our empirical evidence is therefore consistent with the interpretation that Bacon's exposure to non-legal ideas—including classical philosophy (see, e.g., Peltonen 2004, Zagorin 1998: 68)—was comparatively less critical for the development of his methodological thought than was his immersion in law.

5.2. Word Usage Across Topic Pairs

To further explore the connection between Bacon's jurisprudential thought and his scientific methodology, we now examine whether selected pairs of topics use similar vocabularies.¹⁹ The degree of overlap in vocabulary use is indicative of the degree to which the contrasted topics share a common semantic foundation. Note that the analysis of word usage across topic pairs exploits different patterns in the data than do the topic correlations. An overlap in vocabulary is possible even when the topics being compared are featured prominently in quite disparate documents. In contrast, using correlations to establish a link between two topics required that the topics be featured prominently in overlapping sets of documents. In this sense, the examination of overlapping word usage adds to and complements the previous analysis of connections between topics that was based on positive correlations. The analysis of overlapping word usage may be able to detect connections between topics that could not be as easily detected via the analysis of document-level topic correlations (and vice versa).

Given the positive document-level correlation between Bacon's use of legal topics and aspects of his methodology, we produce a series of examinations of the overlap in the usage of words between topic pairs that each compare one legal topic with one methodological topic, particularly focusing on words relating to either inductive reasoning or fact-finding. Because of Bacon's education and his early professional immersion in law, evidence of an overlap in such word usage between the two types of topics would be another piece of evidence in favor of the hypothesis that Bacon's legal reasoning exerted an influence on his non-legal methodological ideas. Furthermore, following a difference-in-differences type of reasoning, we examine whether the extent of overlap

¹⁹ Interestingly, Bacon himself endorsed the investigation of specific words that recur in the depiction of different domains (in his case, natural processes) as means to understanding the world (see Jardine 1974: 106-107).

in inductive or fact-finding vocabulary between a legal topic and a methodological topic is weaker than the extent of overlap in the usage of such vocabulary between a science topic and a methodological topic. If this is not the case, then this is evidence pointing to the legal origins of Bacon's methodological ideas, rather than origins outside the legal domain.

To implement the test, in Figures 3-6, we present a series of plots of the top 80 FREX words within chosen topic pairs.²⁰ In order to keep the number of figures to a minimum, for each of law and science, we choose one topic that is directly connected to Epistemology in the topic correlation diagram (Figure 2) and one topic that is not connected. We use Religious Law and Legal Theory for law and Physics, Energy, and Botany for science. In each of the plots, the size of any displayed word is proportional to the word's use within the combined topics. The position of a word along the horizontal axis measures the difference in the probabilities that associate a word with each topic normalized by the maximum difference in such probabilities that occurs in the set of 80 words (Roberts et al. 2016b, fn. 20).²¹ The position of each word along the horizontal axis is thus indicative of how common a word is in one topic versus the other topic (given that the words are among the 80 used most frequently by the combination of topics). Words located at, or close to, the vertical dashed line are the ones that are shared equally by both topics and are therefore very important in the analysis. They provide the vocabulary that the two topics have in common.

Analyzing Figure 3, we focus on words characteristic of methodology such as 'reason', 'true', 'find', 'cause', 'therefore', 'yet', 'understand', and 'matter', all indicative of discussion that refers to justifying arguments and examining relationships between facts.²² These are words that are central to inductive reasoning. Both Physics, Energy and Religious Law share these concepts equally with Epistemology. They are also at least as important in the combination of Epistemology with Religious Law as in the combination of Epistemology with Physics, Energy. Thus, at a minimum, the connection of Epistemology to Physics, Energy is no stronger than the connection of Epistemology to Religious Law, an observation that endorses the conclusion reached when examining topic correlations. Exactly the same argument could be made using Figure 4, which examines the words that Epistemology shares with Legal Theory and Botany, respectively.

Given that Bacon was first and foremost a jurist, and not a scientist, one must conclude that Bacon carried ideas absorbed from legal processes into the epistemology of science. This is very clearly captured by statements in two documents highly associated with two of our topics. The

²⁰ To relate these plots to our formal model in Section 2, had we chosen to use the 80 highest probability words (instead of FREX words), when relating topics k and j , we would have chosen the 80 words corresponding to the 80 v , for which estimates of the following was greatest: $\sum_d N_d(\beta_{dkv} + \beta_{djv})$. Use of FREX implies using estimates of parameters that we have not included in our formal model description.

²¹ The vertical configuration of the words is random.

²² To make judgments on word usage in Bacon's time, we used the Oxford English Dictionary (OED). For example the OED defines one use of 'yet' as "conjunctive adv. or conj. introducing an additional fact or circumstance which is adverse to, or the contrary of what would naturally be expected from, that just mentioned". This is a frequent usage in the law reports of that time, for example, "[T]he court answered, that all the justices of peace in England did so, and therefore, though they have not authority to do it in strictness of law, yet *communis error facit jus*" (1 Lord Raymond 42; English Reports 91: 925). The OED gives the following usage "1596, Spenser *Prothalamion* 117: As he would speake, but that he lackt a tong yeat did by signes his glad affection show." Our Python programs have 'yet' as the modern spelling of 'yeat'.

document that is fourth most associated with Land Law is the *Reading on the Statute of Uses*, which was prepared in 1599 for an audience of lawyers. It states that "The nature of a use is best discerned by considering what it is not, and then what it is, for it is the nature of all humane Science, and knowledge to proceed most safely by Negative and exclusive." This is Bacon's approach to induction that focuses on ruling out instances by negative example. It is virtually repeated for scientists in the *Novum Organum* in 1620, in a section that is the fifth most highly associated with our Epistemology topic: "...it is the peculiar and perpetual error of the human understanding to be more moved and excited by affirmatives than negatives, whereas it ought duly and regularly to be impartial; nay, in establishing any true axiom the negative instance is the most powerful."

Our STM-based evidence thus indicates that the most celebrated element of Bacon's thought—inductive reasoning—had its genesis in the law. As Appendix A shows, this conclusion is not prominent, and sometimes explicitly rejected, in the vast interpretative literature on Bacon. This is a finding of central interest to scholars of comparative development. It suggests that crucial elements of the very culture that was associated with England's economic rise (Mokyr 2016) arose neither as a result of historical accident nor was exclusively a product of a one-of-a-kind genius, but rather grew from already established inductive principles embedded in the English common-law tradition.

Figures 5 and 6 carry out the same exercise for another much-celebrated Baconian contribution, Probing for Facts. Commonalities between the pairs of topics in word usage are few. The distinctiveness of shared words is less. 'Ask' and 'answer', the two words emblematic of Probing for Facts, appear in similar places on both figures, among words not shared to any significant degree with the legal or scientific topics. Hence, the word-usage diagrams imply that Probing for Facts is, in contrast to Epistemology, much more *sui generis*, in the sense of being unrelated to other topics. This conclusion is consistent with the evidence based on the examination of positive topic correlations discussed in Section 5.1. Again, STM-based evidence does not confirm the hypothesis that Bacon's background in the law influenced his scientific method via an emphasis on fact-seeking and fact-verification (Shapiro 2000: 109, Martin 1992: 165, Wheeler 1983: 113; Simonds 1986: 499, Serjeantson 2014: 701-702).

6. Evidence on Strategic Communication of Bacon's Ideas

The importance of constraints on the communication strategy of powerful social actors and groups has recently become a topic of direct interest to political economists (see, e.g., Coşgel et al. 2012, Rubin 2014, Adena et al. 2015). Bacon has often been thought of as communicating his ideas strategically, taking into account political constraints and the receptiveness of different constituencies (Peltonen 1992, Zagorin 1998: 180). We now examine if Bacon's emphasis on specific topics varied with the audience he was addressing and the form he used to communicate his ideas. By producing evidence on how Bacon the "cultural entrepreneur" (Mokyr 2016) chose to disseminate his different ideas, we enhance the understanding of how Bacon's own strategic choices might have led to those ideas diffusing more strongly in some domains (e.g. science) than in others (e.g. history or politics). Given Bacon's major role in the development of English culture

and given the rising interest in economics in the role of societal leaders (Jones and Olken 2005, Besley et al. 2011, Brender and Drazen 2013), a closer understanding of Bacon's communication strategy provides insight into the evolution of English culture in a way that is directly relevant to issues that are currently debated in the literature on comparative economic development. Even more broadly, we show the power of STM as an analytical tool to address questions about the nature of the dissemination of ideas using only the writings of the social actor under consideration, an approach that would have uses in many areas of comparative cultural history.

To analyze the impact of intended audience and writing form, we proceed as follows. After obtaining the parameter estimates for our 16-topic STM, we estimate the relationship between the proportion of each document devoted to a topic (reflecting estimates of the θ_d in (1) above) and the values of a particular covariate for all documents, thereby obtaining estimates of the pertinent column of Γ in (1) above (Roberts et al. 2016b: 17-18). We then plot either mean estimated topic proportions for different document-level covariate values (Figures 7, 8, 11, 13, 15) or mean differences in estimated topic proportions for two different values of a document-level covariate (Figures 9, 10, 12, 14).

We first examine the role of the intended audience. Our STM-based evidence indicates that Bacon's use of the two central methodological topics that were much emphasized by his followers, Probing for Facts and Epistemology, indeed varied with whom he was addressing. Bacon's emphasis on questioning the world to establish facts (Probing for Facts) was addressed primarily to philosophers (Figure 7). This evidence is consistent with Bacon's aim of challenging the standard Aristotelian philosophical paradigm of his day, which he viewed as jumping much too quickly to general principles and not focused enough on deriving intermediate generalizations from existing facts. Similarly, Bacon emphasized his Epistemology most of all when addressing methodologists (Figure 8), thus directing his work toward those social actors who would find it most useful and thus most likely to disseminate further.

Consistent with the general proposition that he communicated his ideas strategically, Bacon did not emphasize the core elements of his ideas on scientific methodology when addressing other audiences. When Bacon addressed historians (Figure 9), for example, he instead focused on the history of England's dynasties (Dynamic Politics) and classical stories (Classical Thought). Bacon's methodological ideas similarly took a back seat in his communications with politicians (Figure 10). When he addressed politicians, Bacon instead emphasized religion, in connection with both law and diplomacy.²³

Interestingly, Bacon also did not choose politicians as his primary audience when communicating insights about political tactics and the games politicians play (Political Strategy), but rather intended those insights mainly as contributions to philosophical debates (Figure 11). Bacon's analysis of politics seems to have been more congruent with that of a modern-day rational-choice political-economy theorist than a practicing politician. He did, however, communicate

²³ In our coding of the metadata, monarchs are politicians.

extensively to politicians about official legal matters of the crown (King, Law & Court; Figure 10), but he did so in private letters, as opposed to published works (Figure 12). These findings are consistent with the prevailing view of Bacon as a shrewd political actor, adept at strategically maneuvering across the political landscape and relentless at pursuing his personal political goals (Peltonen 1996b, Drinker Bowen 1993, Powell 1996).

Were the core methodological elements of Bacon's thought relatively favored in some writing forms more than in others? Figure 13 shows that Bacon preferred apothegms to other writing forms when articulating his convictions about Probing for Facts. Consistent with Kocher (1957), Figure 14 further shows that Bacon also relied more on apothegms when he expressed some of his legal ideas (Legal Theory; Land Law). Bacon, however, does not use apothegms to convey his Epistemology.²⁴ Indeed, as Figure 15 illustrates, Bacon strove to develop his epistemological ideas primarily in book-length volumes and, to some extent, essays. This finding resonates with Peltonen's (1996a: 10) interpretation that in order to reach new audiences Bacon deliberately chose to disseminate his groundbreaking views about the genesis of knowledge in a broadly-available printed form, despite the fact that such publication had at the time been viewed as "degrading" for a member of the aristocracy.

In sum, evidence on the effects of both intended audience and writing form demonstrates that Bacon communicated his ideas strategically, with corresponding repercussions for their social reception. Bacon, the sometimes very modern-sounding political scientist, did not use his political theories when communicating with politicians. Bacon, the evangelist of the modern scientific method, did not use that method when addressing historians or communicating with the monarch. Perhaps Bacon himself was responsible for the fact that his own methodological contributions were more usually associated with science than with social science or governance, even though he emphasized the universal applicability of his epistemology.

7. Conclusion

We conclude by going beyond our detailed results to make a conjecture about a much broader implication of our findings. We place those findings within the broader sweep of the economics literature that focuses on what English experience can tell us about the complicated puzzle of how modern societies emerge. A key observation in that literature is that when England became the first country to evidence modern economic development, its political institutions were far superior to those of any other country (North and Weingast 1989, Acemoglu and Robinson 2012). This is consistent with the appealing conclusion that it is the formal institutions that led to the economic development. Our findings raise the possibility that the coincidence of better political institutions and economic development is not necessarily causal, but could be the product of deeper phenomena rooted in English common-law culture.

²⁴ We distinguish here between Bacon's apothegms, short pithy disconnected statements, and his use of aphorisms in the longer works *Novum Organum* and *The Advancement of Learning*. In those works, the aphorisms are connected with each other, and constitute sequential steps in arguments, rather than disconnected statements.

The common law rose to a degree of sophistication and effectiveness over many centuries, reaching an unparalleled degree of centrality in English life in the 17th century (Holdsworth 1927). Thus, a long line of research in history, political science, and law has argued that the influence of common-law thinking was a key ingredient in the development of political institutions in England during the 17th century (Nenner 1977, Cromartie 2006). This influence arose, at least in part, because the politico-legal ideas emanating from the experience with the common-law had diffused into the broader English culture, an education in law being prevalent among the upper reaches of English society at that time (Stone 1964, Hill 1997). In Nenner's (1977: x) words: "By the seventeenth century, England had developed a political culture completely comfortable with sophisticated legal concepts...[A] legal disposition of mind...was being increasingly brought to bear upon political and constitutional problems. It conditioned men's thought and language and ultimately their actions." The existing literature, therefore, gives us a direct link from the common-law culture of the early 17th century to the political institutions of the early 18th century.

The piece of evidence that our paper adds is in showing how key elements of Bacon's ideas were a reflection of aspects of the common-law culture in which he was immersed. With Bacon's ideas so resonant with elements of the broader culture of the time, it is not surprising that elements of Baconianism diffused earlier in England than elsewhere. Combined with Mokyr's (2005, 2006, 2010, 2016) compelling case for the subsequent influence of Baconianism on technological progress, our findings provide evidence in support of a direct link from common-law culture in 17th century England to the early economic development of the 18th century.

Therefore, the observed association between sophisticated political institutions and early economic development in 18th century England need not necessarily reflect a causal effect of the former on the latter. Instead, both better political institutions and sustained economic growth could have emerged as a consequence of England's many years of experience with the common-law and the culture that this experience generated. The influence of that culture can help explain both the institutional and the economic development. Perhaps, what made England uniquely early in these two aspects of development was that a common-law culture had developed over many centuries and suffused English society. After all, Bacon himself, while enormously important in communicating the vast potential of the ideas within that culture, viewed truth as "the daughter of time, not of authority".

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Table 1: Works Included in the Corpus

Name or type of work	No. of text documents (chunks)
<i>New Atlantis</i>	5
<i>Novum Organum</i>	17
<i>The Advancement of Learning</i>	12
<i>The Use of the Law</i>	5
<i>A Collection of Apothegms, New and Old</i>	6
<i>History Natural and Experimental of Life and Death</i>	9
<i>Sylva Sylvarum</i>	10
<i>The History of The Reign of King Henry the Seventh</i>	6
<i>The Natural and Experimental History of Winds</i>	7
<i>The Wisdom of the Ancients</i>	5
<i>The Elements of the Common Laws of England</i>	28
Other writings (various essays, letters, speeches, case reports)	172
Total	282

Notes: Some names edited for rendering in modern English.

Table 2: Frequency of Documents by Writing Form and Audience

Audience	Writing Form							Total
	Apothegm	Case report	Essay	Letter	Speech	Tome		
Historians	0	0	2	0	0	12		14
Lawyers	25	1	12	22	10	4		74
Methodologists	1	0	3	1	0	34		39
Philosophers	6	0	42	2	0	0		50
Politicians	2	1	16	36	3	0		58
Scientists	0	0	20	0	1	26		47
Total	34	2	95	61	14	76		282

Table 3: Topics and Top Words for the Estimated 16-Topic STM

Note that the 'words' listed below are those used by STM after reducing all original text words to their stemmed form. Thus, for example, 'theolog' could reflect an original usage of theology, theologies, theologian, theologians, theologise, theologised, theologises, theologising, etc, etc.

1. Epistemology

Highest Prob: natur, man, will, thing, philosophi, may, histori, knowledg, scienc, part, use, one, experi, can, mind, great, upon, shall, make, therefor, yet, first, matter, particular, understand, caus, much, invent, observ, true

FREX: philosophi, method, defici, logic, system, scienc, axiom, histori, metaphys, idol, discoveri, everyth, aristotl, invent, inquiri, theori, abstract, mathemat, rhetor, notion, mankind, deduc, knowledg, induct, fallaci, theolog, inventor, principl, poesi, contempl

2. Probing for Facts

Highest Prob: say, will, man, one, shall, upon, come, great, answer, lord, make, take, give, king, may, think, day, tell, know, ask, hous, can, sir, see, time, like, use, much, mani, friend

FREX: overburi, impoison, somerset, ask, weston, diogen, galleri, bensalem, tell, poison, answer, pompey, nichola, vespasian, dinner, aristippus, gentleman, injunct, sir, front, chamber, yes, forgiv, tower, philip, friend, chair, ladi, feast, boat

3. Land Law

Highest Prob: use, law, shall, statut, make, feoff, upon, case, will, word, take, land, yet, therefor, may, sez, estat, heir, first, can, act, reason, say, good, one, time, life, give, right, grant

FREX: feoff, cesti, feme, lesse, remaind, disseise, statut, aver, sez, clausula, rend, duress, usuri, claus, leas, purchas, advowson, remitt, commonlaw, fee, proviso, tail, parol, demis, atturn, void, dissent, deed, bargain, enrol

4. King, Court & Law

Highest Prob: majesti, will, shall, may, good, lord, upon, time, lordship, king, make, think, self, man, can, know, great, say, take, matter, letter, give, much, well, thing, god, now, mean, one, first

FREX: lordship, plantat, majesti, humbl, undertak, letter, squir, essex, solicitor, attorney, gracious, lord, project, pleas, queen, secretari, coke, chancellor, servic, busi, con, honest, advertis, pray, manuel, antonio, wish, care, protest, beseech

5. Law & Nation

Highest Prob: law, king, shall, may, england, will, natur, majesti, one, subject, case, say, make, time, first, kingdom, man, therefor, can, scotland, person, upon, court, question, sever, point, whether, parliament, take, yet

FREX: scotland, england, duel, allegi, born, union, parliament, kingdom, britain, challeng, alien, conquest, gascoign, subject, question, vote, nation, offenc, royal, law, normandi, post, preced, crown, submiss, prerog, duchi, infer, court, style

6. Religious Law

Highest Prob: god, man, time, learn, law, may, great, make, church, will, shall, upon, good, work, one, say, yet, thing, see, majesti, well, give, first, natur, matter, part, can, use, mani, person

FREX: learn, church, christ, preach, preacher, atheism, benefic, scriptur, dedic, controversi, baptism, liturgi, hospit, endow, alexand, god, theme, holi, reveal, prayer, ecclesiast, bishop, institut, ministri, minist, callisthen, censur, pastor, polici, compil

7. Legal Theory

Highest Prob: land, man, shall, king, good, felon, may, make, upon, court, treason, call, take, justic, heir, parti, give, one, can, peac, will, law, offic, constabl, everi, yet, life, lord, grant, person

FREX: felon, constabl, sheriff, counti, debt, executor, forfeit, escheat, juri, tenur, legaci, attaint, treason, petti, assiz, shire, felon, leet, attaint, gaol, owner, chattel, chap, indict, viii, clerk, writ, clergi, outlawri, praemunir

Table 3 continued

8. Religion & Diplomacy

Highest Prob: great, upon, war, will, man, state, make, spain, time, say, shall, yet, may, peopl, part, one, king, take, come, now, england, mani, law, much, like, natur, nation, true, never, princ

FREX: spain, invas, spaniard, speaker, libel, cathol, war, spanish, enterpris, pollio, christendom, türk, sundri, heresi, leagu, palatin, navi, indi, defens, portug, papist, religion, nation, invad, fleet, confeder, armi, worship, lowcountri, nobil

9. Political Strategy

Highest Prob: man, good, will, make, great, say, thing, upon, one, may, natur, can, time, much, shall, mind, like, yet, see, well, mani, come, part, virtu, take, therefor, use, person, first, fortun

FREX: envi, anger, dissimul, malum, felic, bewar, faction, evil, bold, tacitus, reprehens, cun, solomon, lover, secreci, fortun, gradus, discontent, reprehend, simul, virtu, precept, tiberius, friendship, demosthen, quoth, cicero, busi, machiavelli, eam

10. Dynastic Politics

Highest Prob: king, upon, make, great, time, will, shall, come, man, may, part, take, person, one, peopl, also, yet, unto, war, well, princ, england, think, good, lord, much, can, duke, give, peac

FREX: perkin, maximilian, duke, earl, plantagenet, ferdinando, york, french, flander, margaret, ambassador, treati, richard, castill, charl, britain, ladi, rebel, ambassag, king, fillip, henri, lovel, london, john, duchess, bruge, stanley, tower, castl

11. Classical Thought

Highest Prob: thing, man, may, natur, also, shall, say, seem, god, see, will, one, yet, unto, make, matter, can, time, great, like, take, come, mani, first, kind, well, fabl, much, jupit, upon

FREX: prometheus, jupit, proserpina, page, orpheus, miss, pan, cupid, siren, typhon, pentheus, sphinx, parabl, albeit, perseus, moreov, fabl, nemesi, giant, palla, bacchus, cere, muse, allegori, atalanta, monster, hercul, proteus, hell, icarus

12. Physics, Energy

Highest Prob: motion, heat, bodi, natur, instanc, water, will, air, also, must, may, fire, place, can, part, let, one, cold, first, like, flame, yet, substanc, great, spirit, differ, observ, thing, power, appear

FREX: magnet, instanc, expans, similar, class, howev, anim, rapid, latent, liquid, heat, predomin, ignit, exist, ebb, homogen, heterogen, migrat, perpendicular, negat, expand, conspicu, investig, ray, excit, concret, motion, sphere, flame, exclus

13. Physics, Air & Sound

Highest Prob: wind, sound, air, will, make, one, may, blow, thing, great, motion, water, part, bodi, upon, see, like, likewis, also, much, sail, caus, place, sea, man, come, shall, yet, south, two

FREX: wind, string, sound, brass, sail, rain, tone, blow, south, echo, percuss, bell, mast, east, pipe, nois, north, presag, articul, concav, audibl, dram, lute, west, cloud, nurseri, gale, loud, engend, tin

14. Botany

Highest Prob: tree, will, upon, plant, fruit, make, may, earth, water, also, put, come, ground, grow, root, caus, forth, like, great, herb, seed, flower, set, leav, see, kind, bear, one, therefor, much

FREX: sap, plum, cherri, tree, moss, oak, pear, herb, bough, holli, stalk, peach, dung, radish, fig, graft, blossom, cucumb, plant, lettuc, rose mari, mushroom, wheat, vine, escul, colewort, compost, mistleto, turnip, fruit

15. Life & Death

Highest Prob: man, life, year, long, live, age, thing, old, also, hundr, spirit, bodi, may, yet, great, time, death, one, part, much, now, young, creatur, will, last, touch, shall, good, mani, without

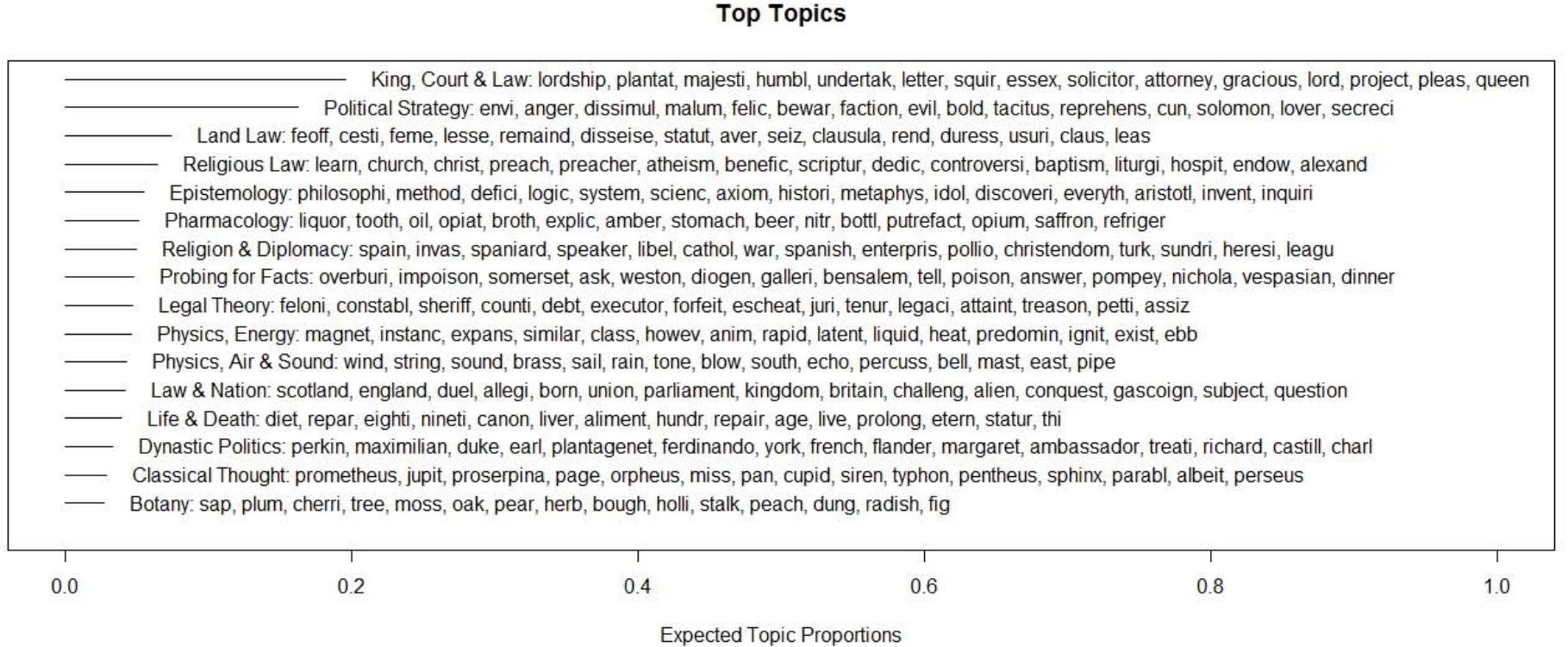
FREX: diet, repar, eighti, nineti, canon, liver, aliment, hundr, repair, age, live, prolong, etern, statur, thi, youth, vital, life, desicc, seventi, old, long, short, year, fifti, function, consubstanti, ghost, jesus, consumpt

16. Pharmacology

Highest Prob: bodi, spirit, will, water, part, may, make, upon, see, caus, also, heat, air, thing, great, therefor, like, take, much, use, man, natur, time, motion, cold, put, littl, good, one, come

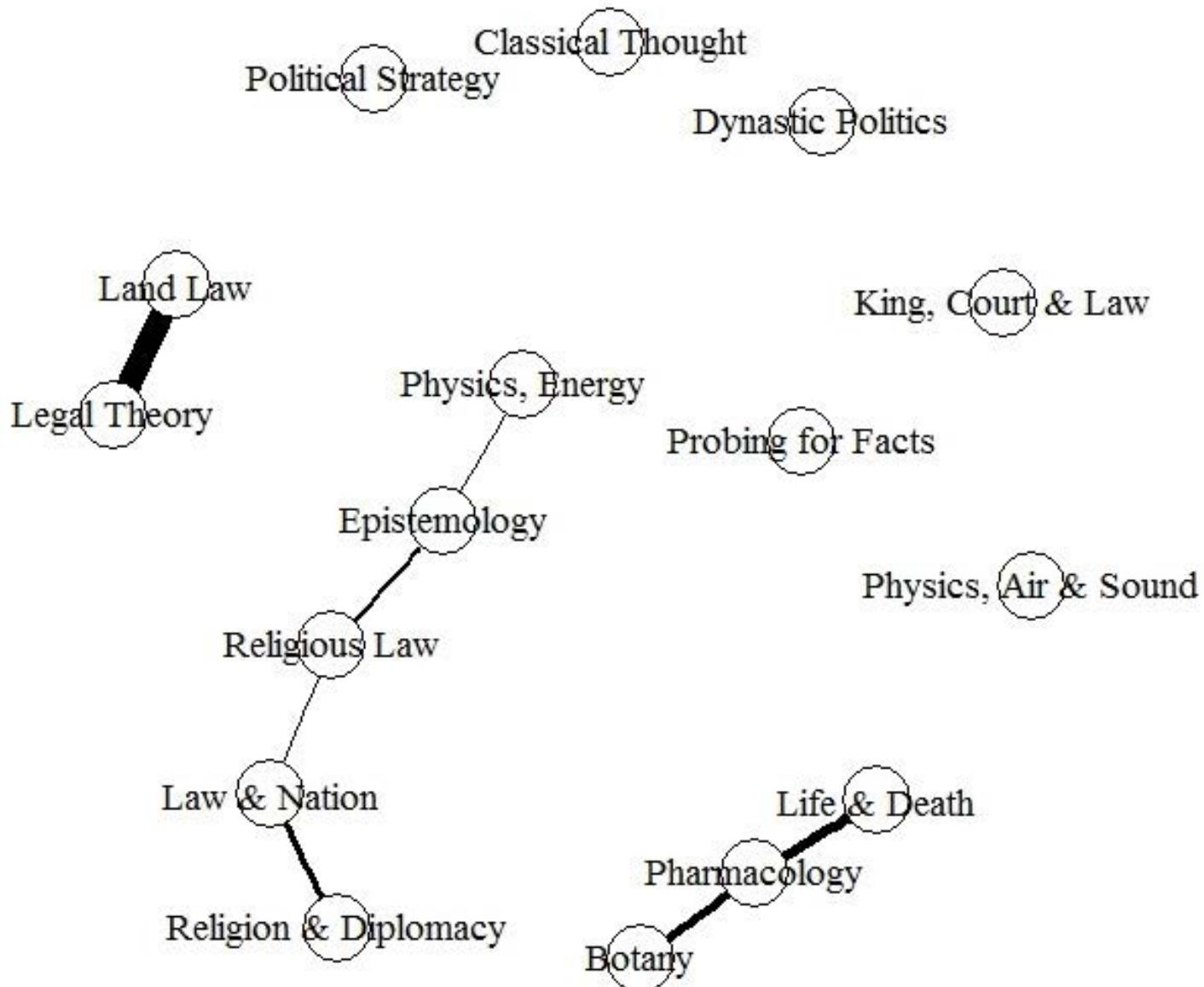
FREX: liquor, tooth, oil, opiat, broth, explic, amber, stomach, beer, nitr, bottl, putrefact, opium, saffron, refriger, sugar, wine, milk, intener, astring, malaciss, purger, indur, smell, sweat, vinegar, infus, drink, candl, spirit

Figure 1: Expected Values for Topic Proportions in the Bacon Corpus



For each topic, the figure displays the assigned names and the top fifteen FREX words. The size of the bars to the left of each topic is proportional to the probability that a random word drawn from the whole corpus has been generated by that particular topic.

Figure 2: Positive Topic Correlations



Note: The relative thickness of links reflects the magnitude of (positive) correlations between respective topic pairs.

Figure 3: Vocabulary Use Across Topic Pairs: Epistemology vs. Physics, Energy and Religious Law

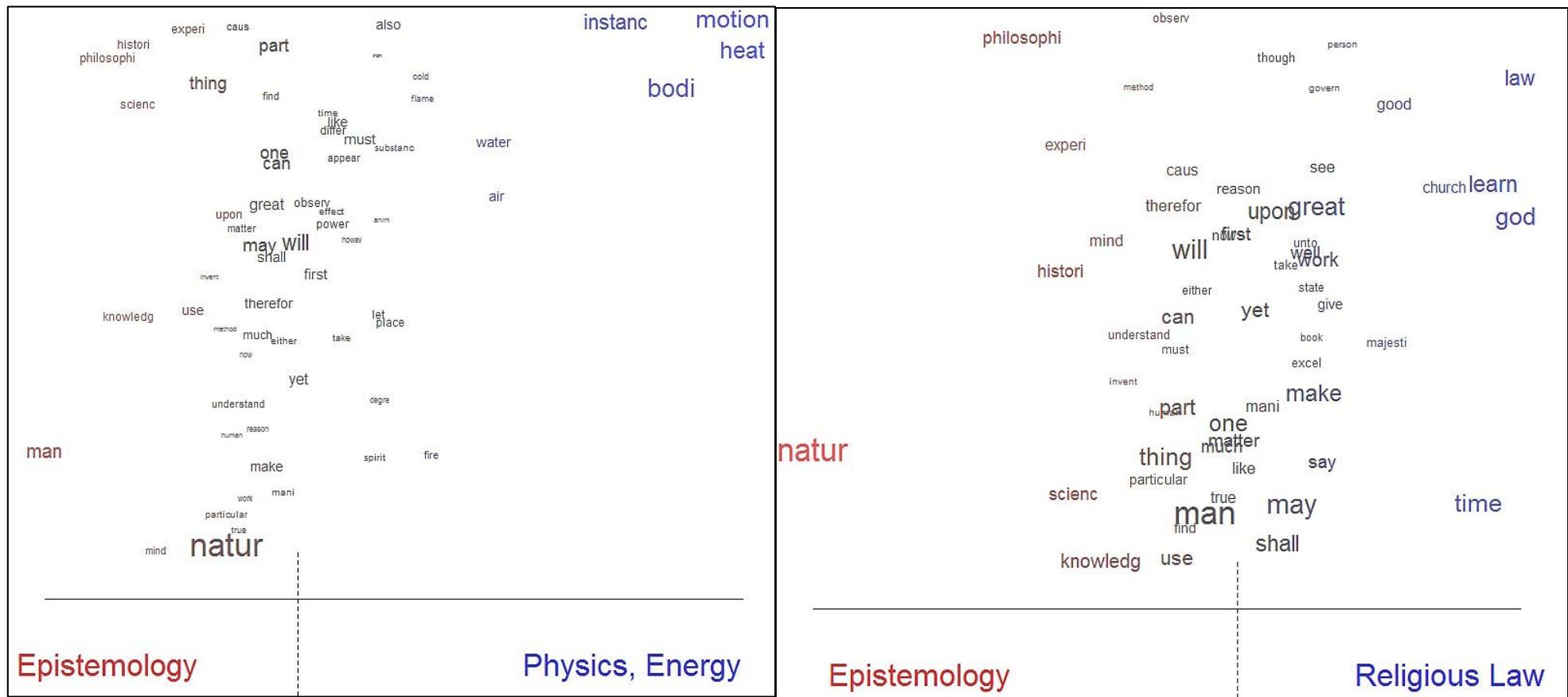


Figure 4: Vocabulary Use Across Topic Pairs: Epistemology vs. Botany and Legal Theory

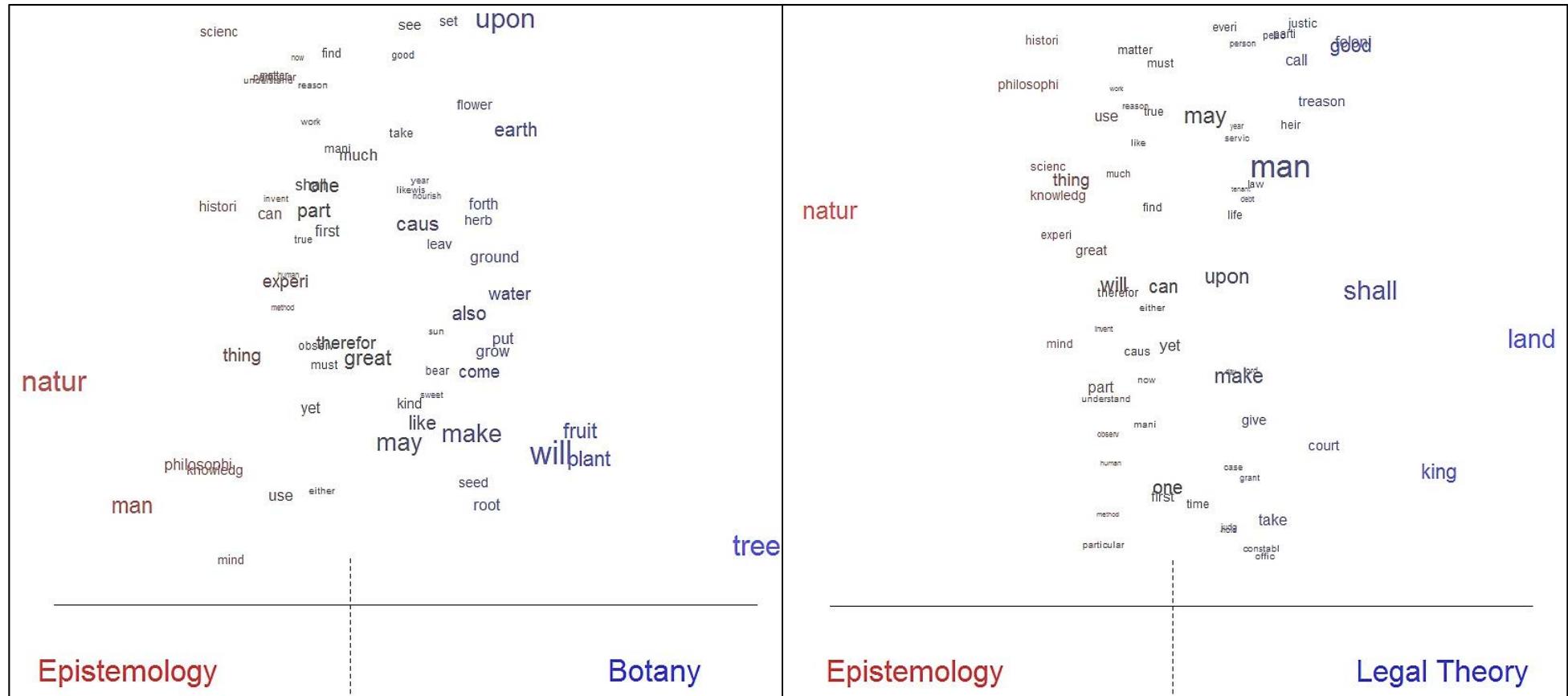


Figure 5: Vocabulary Use Across Topic Pairs: Probing for Facts vs. Physics, Energy and Religious Law

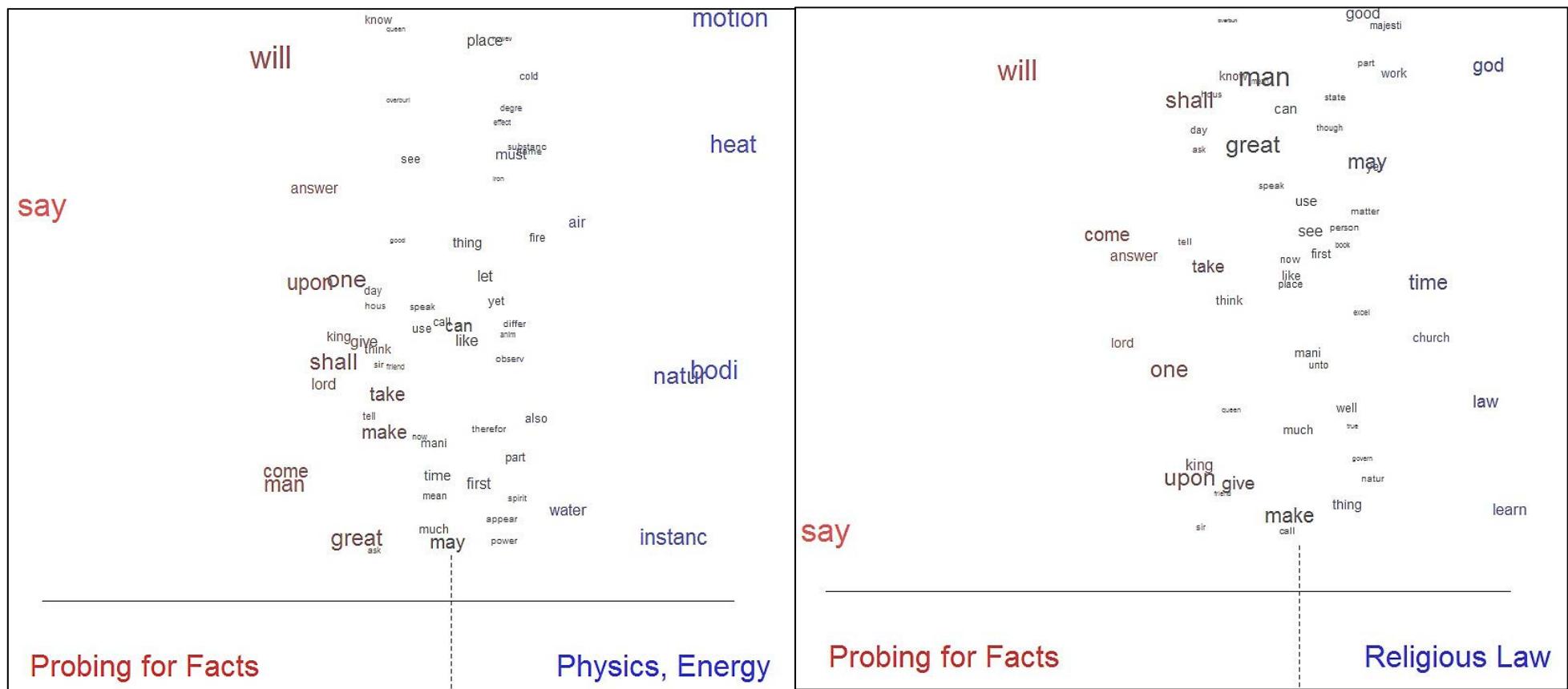


Figure 6: Vocabulary Use Across Topic Pairs: Probing for Facts vs. Botany and Legal Theory

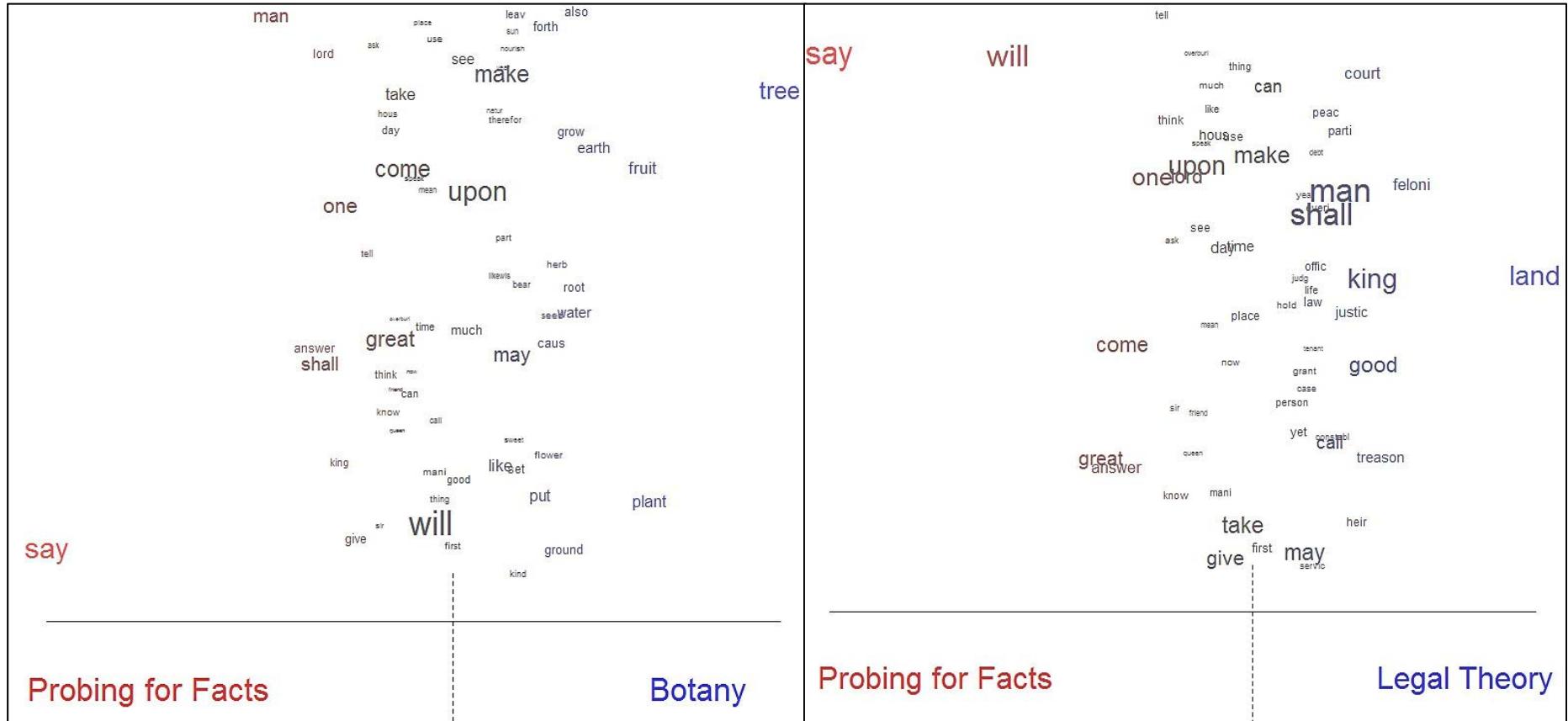
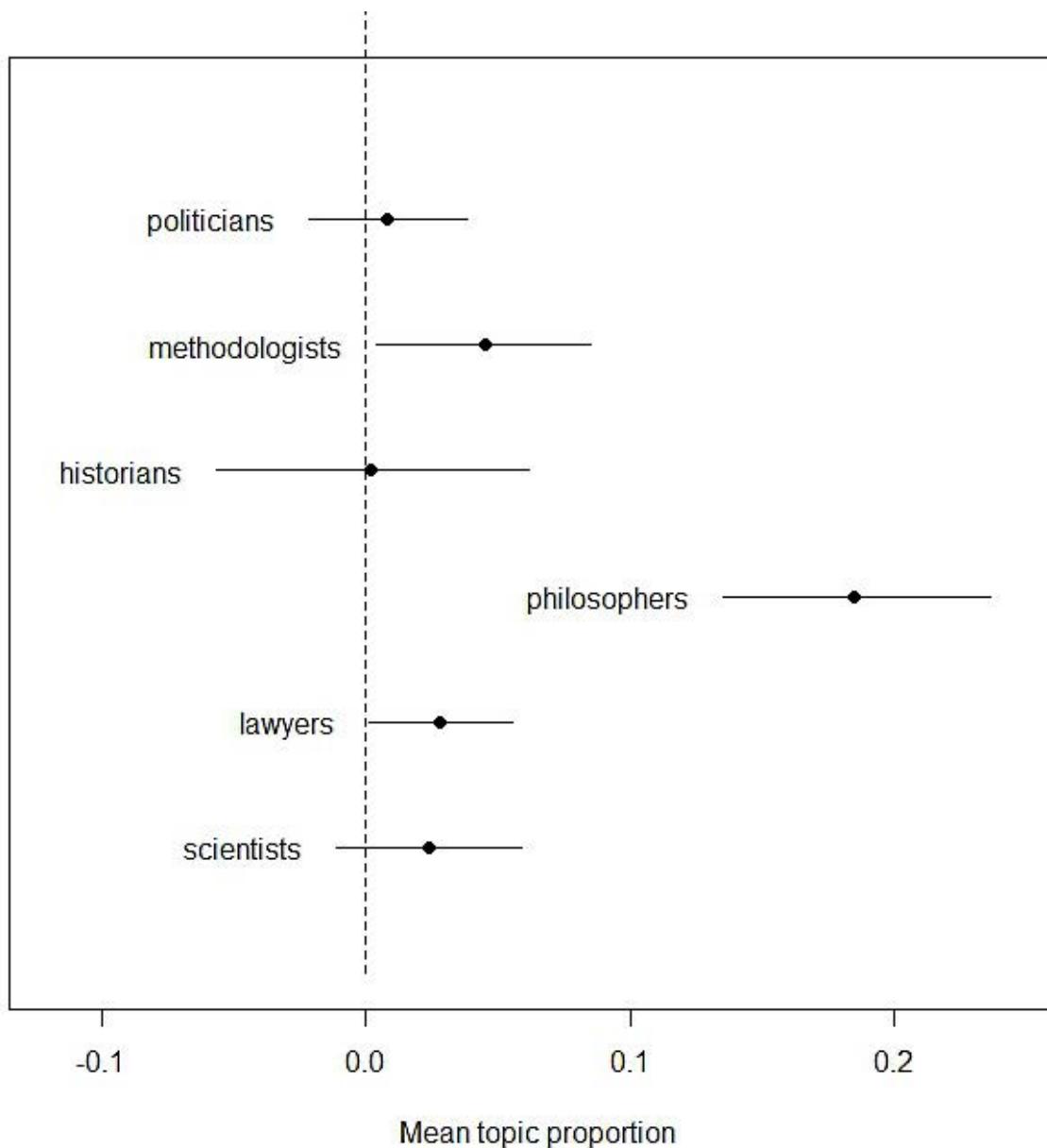
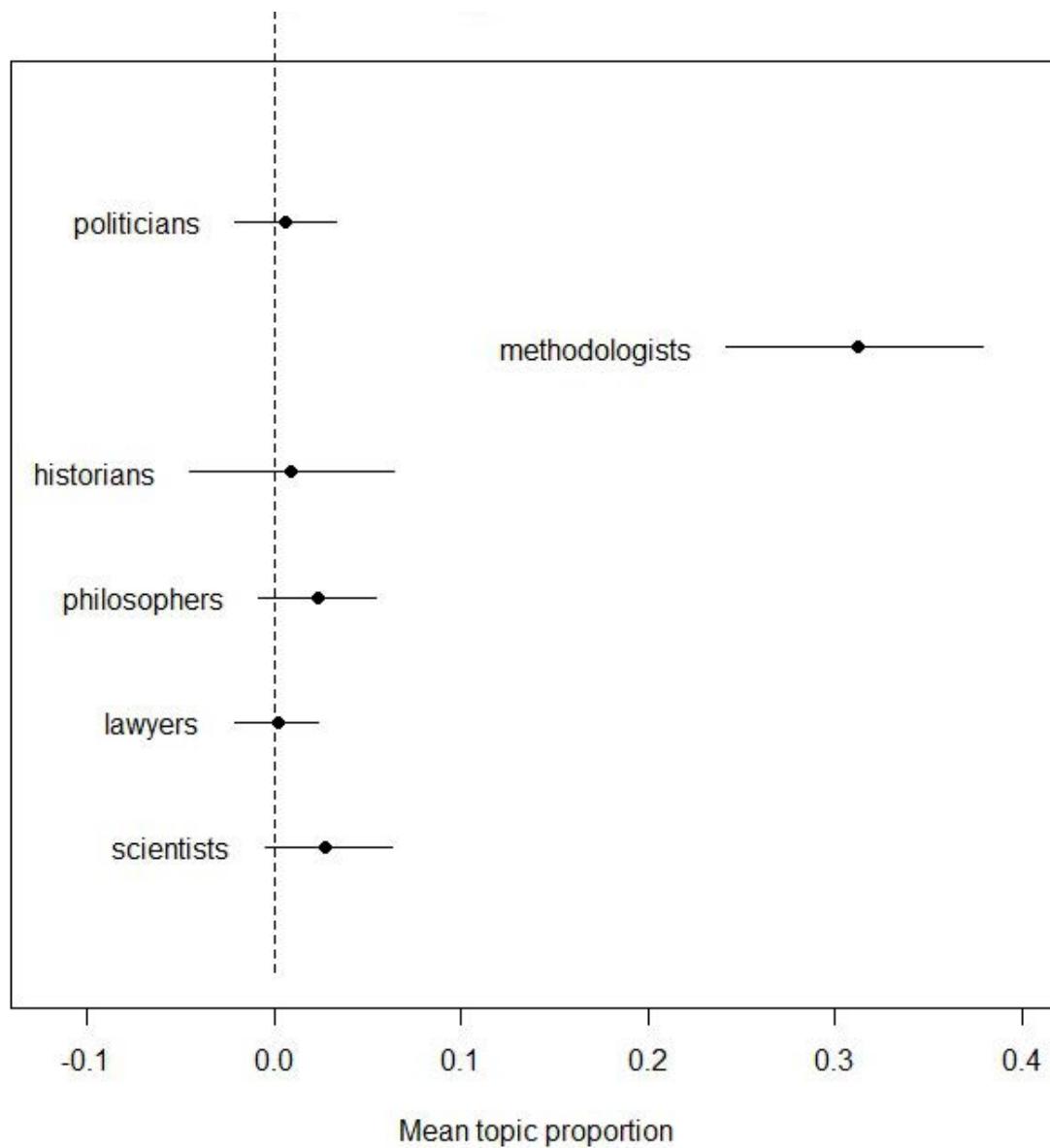


Figure 7: The Effect of Audience on Prevalence of Probing for Facts



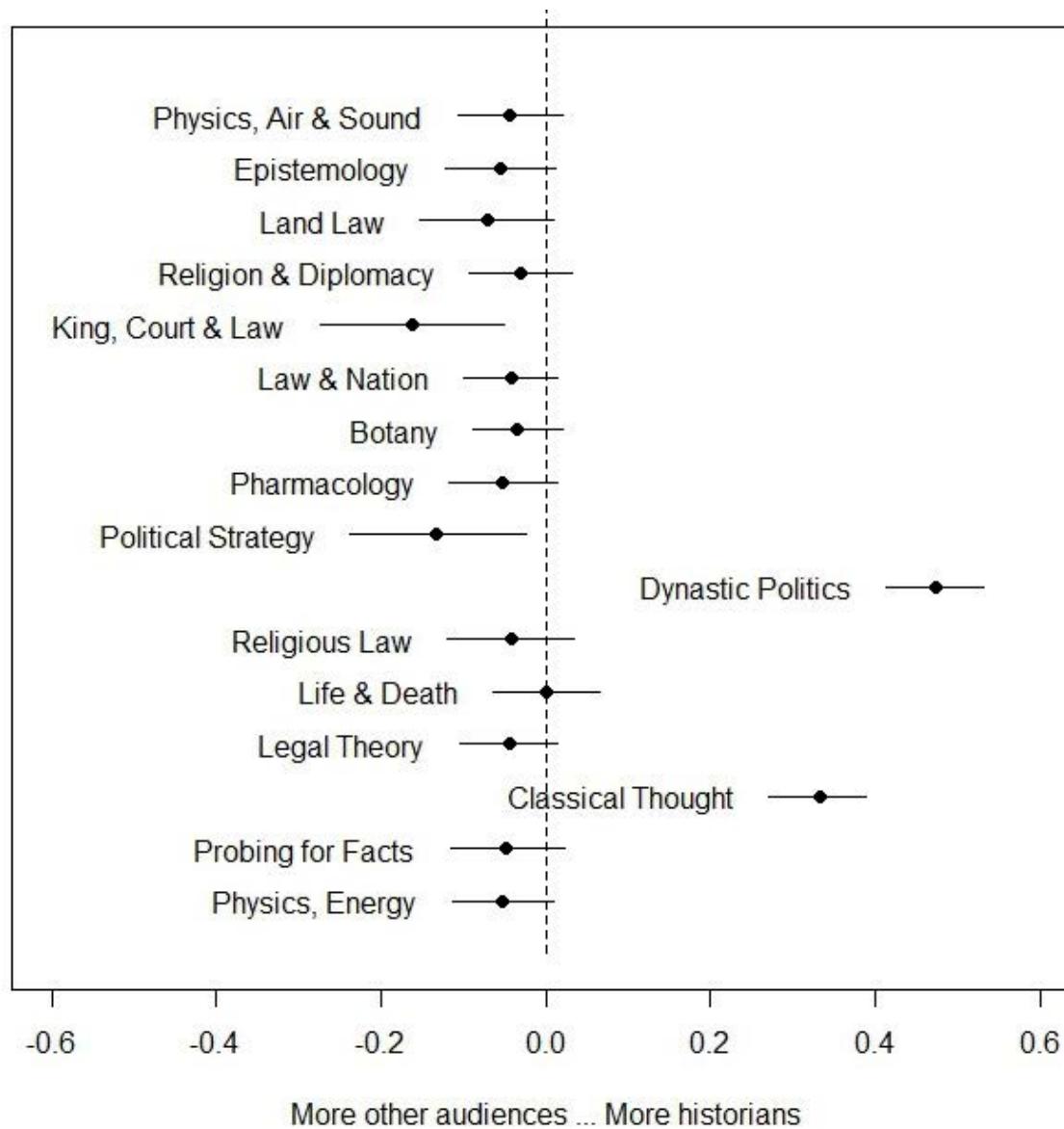
Note: The figure shows the point estimate and 80% confidence interval of the mean topic proportions of Probing for Facts for each type of audience.

Figure 8: The Effect of Audience on Prevalence of Epistemology



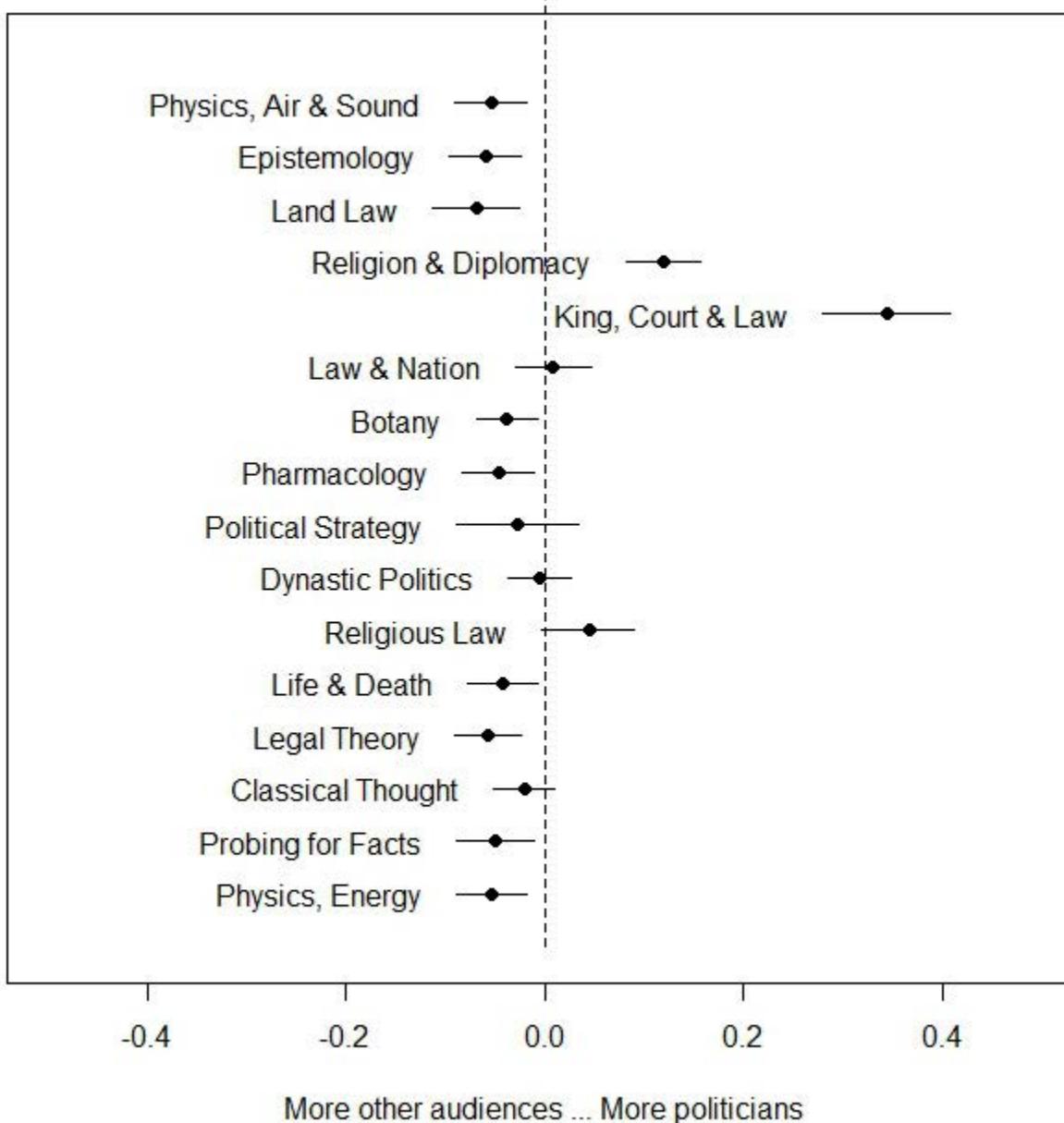
Note: The figure shows the point estimate and 80% confidence interval of the mean topic proportions of Epistemology for each type of audience.

Figure 9: The Effect of Audience, Historians



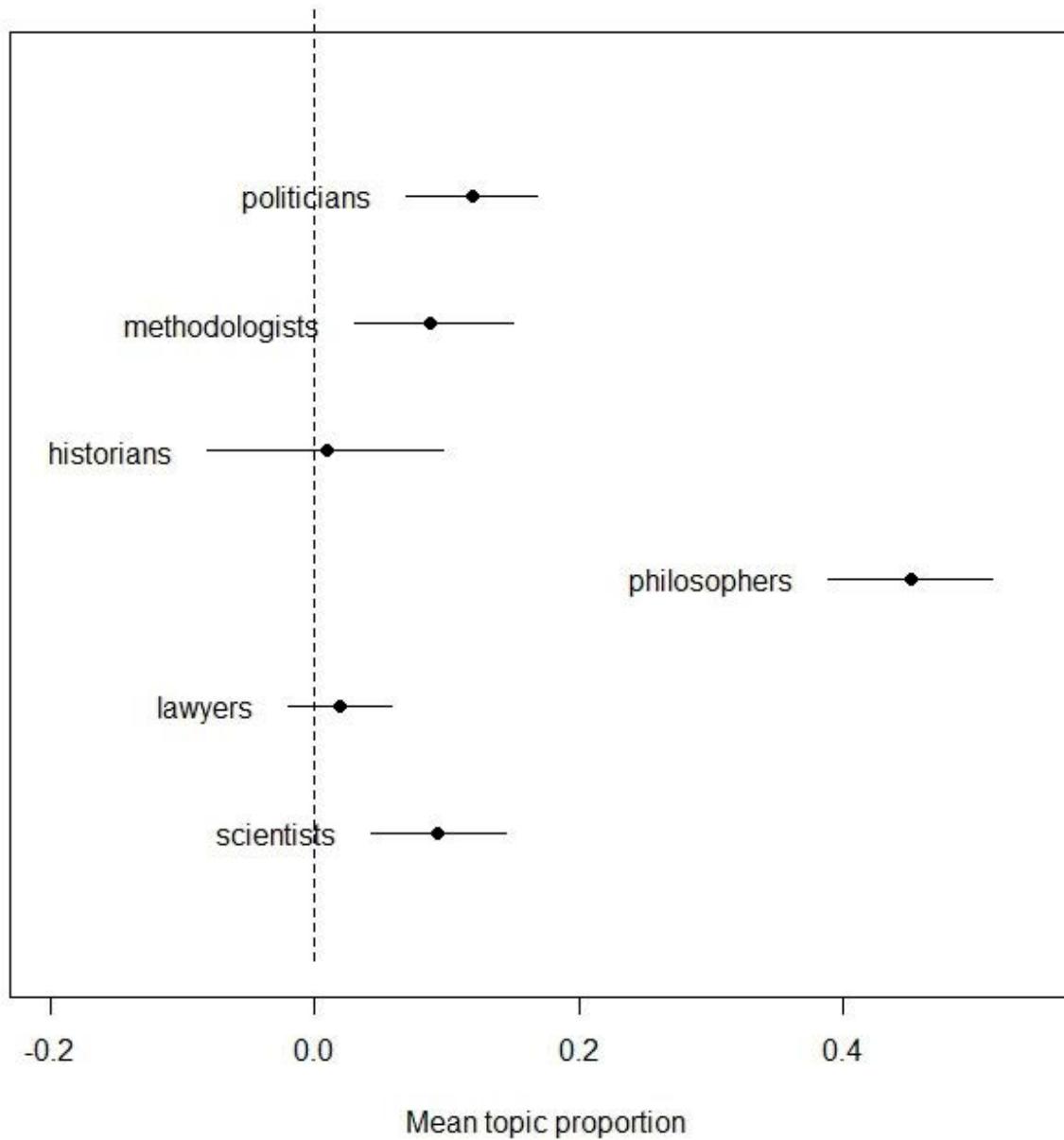
Note: This figure shows the point estimate and 80% confidence interval of the mean difference in topic proportions for works for which historians are the intended audience compared to works addressed to all other audiences.

Figure 10: The Effect of Audience, Politicians



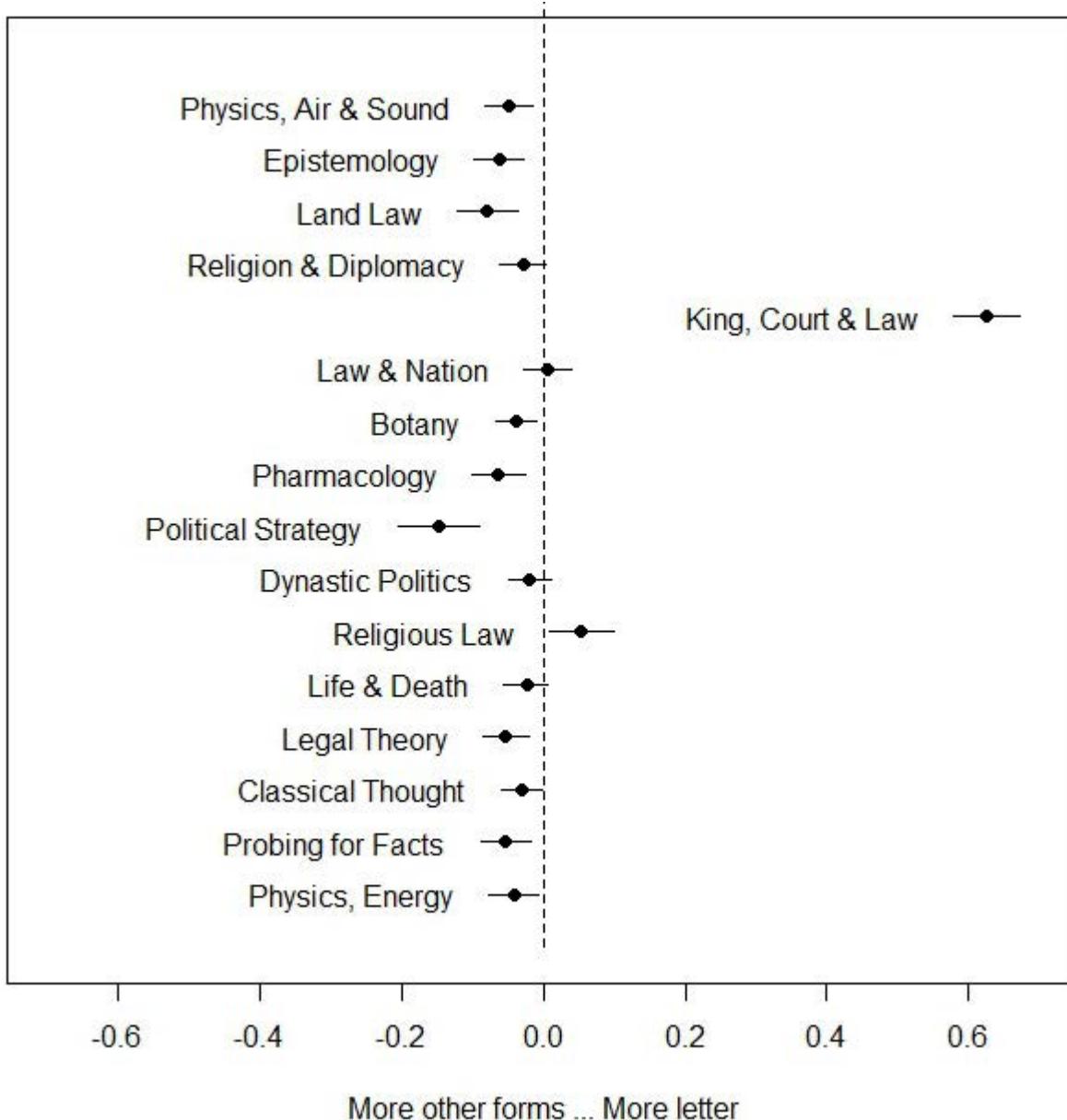
Note: This figure shows the point estimate and 80% confidence interval of the mean difference in topic proportions for works for which politicians are the intended audience compared to works addressed to all other audiences.

Figure 11: The Effect of Audience on Prevalence of Political Strategy



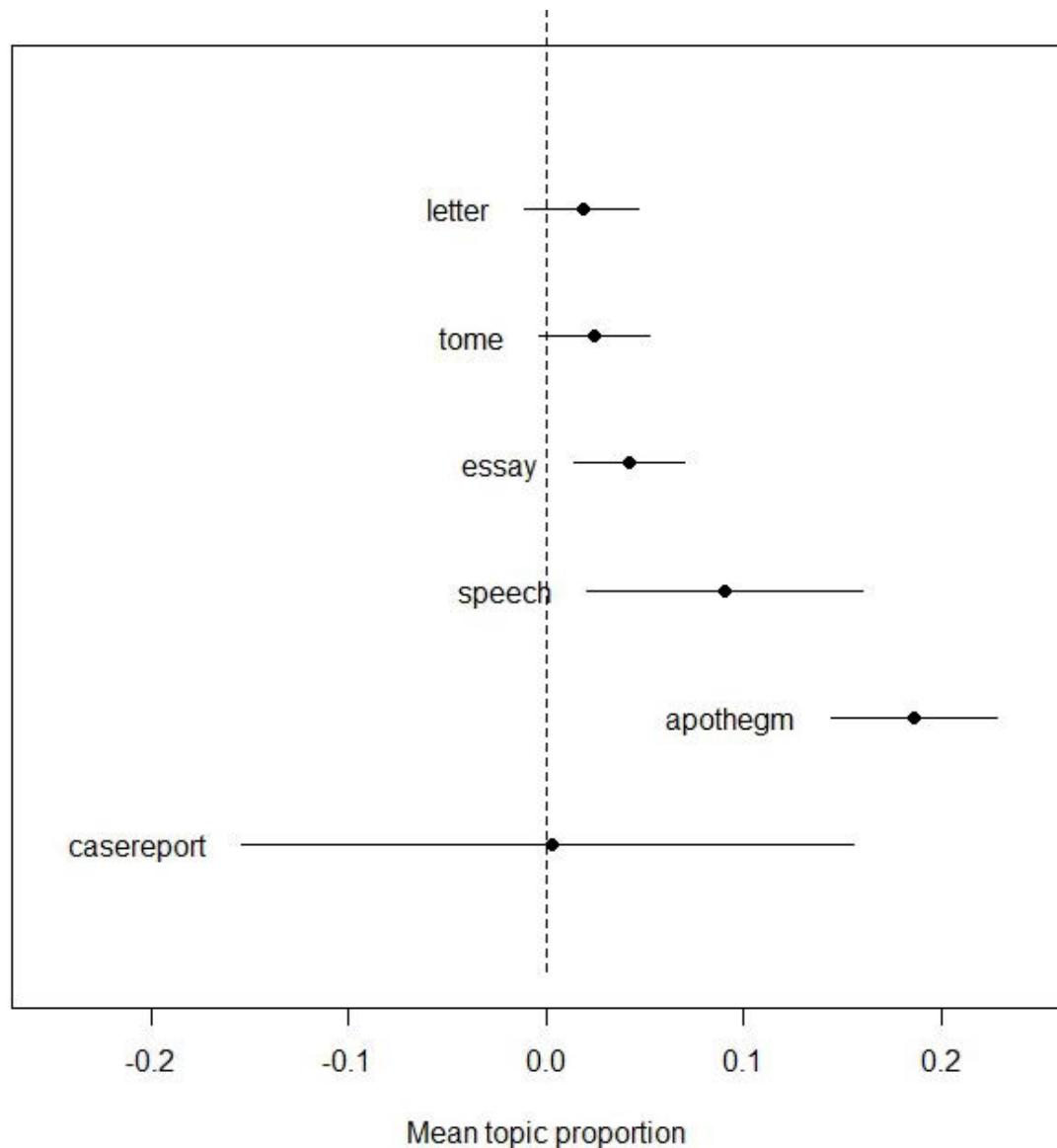
Note: The figure shows the point estimate and 80% confidence interval of the mean topic proportions of Political Strategy for each type of audience.

Figure 12: The Effect of Writing Form, Letter



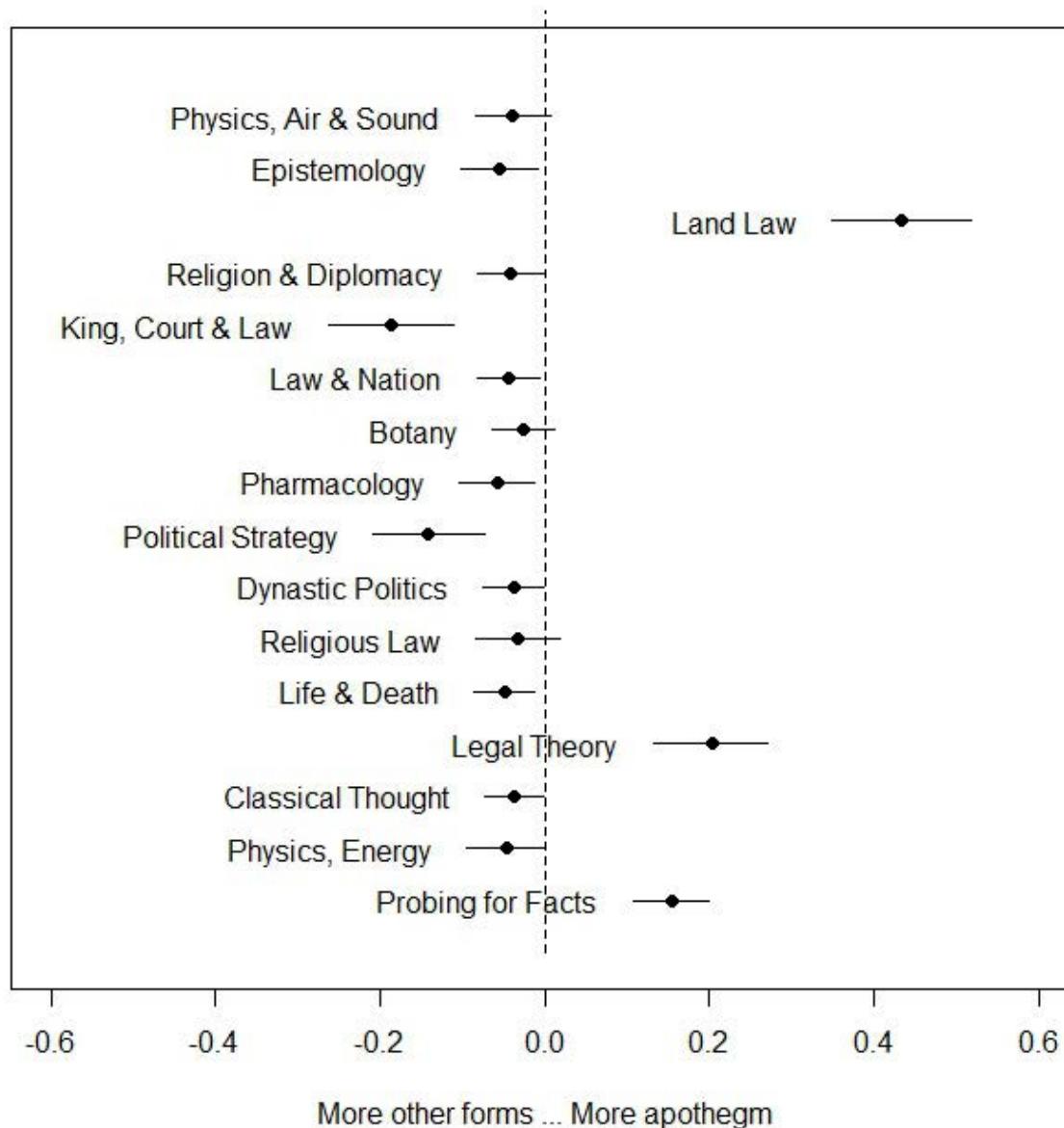
Note: This figure shows the point estimate and 80% confidence interval of the mean difference in topic proportions for letters compared to all other document types.

Figure 13: The Effect of Writing Form on Prevalence of Probing for Facts



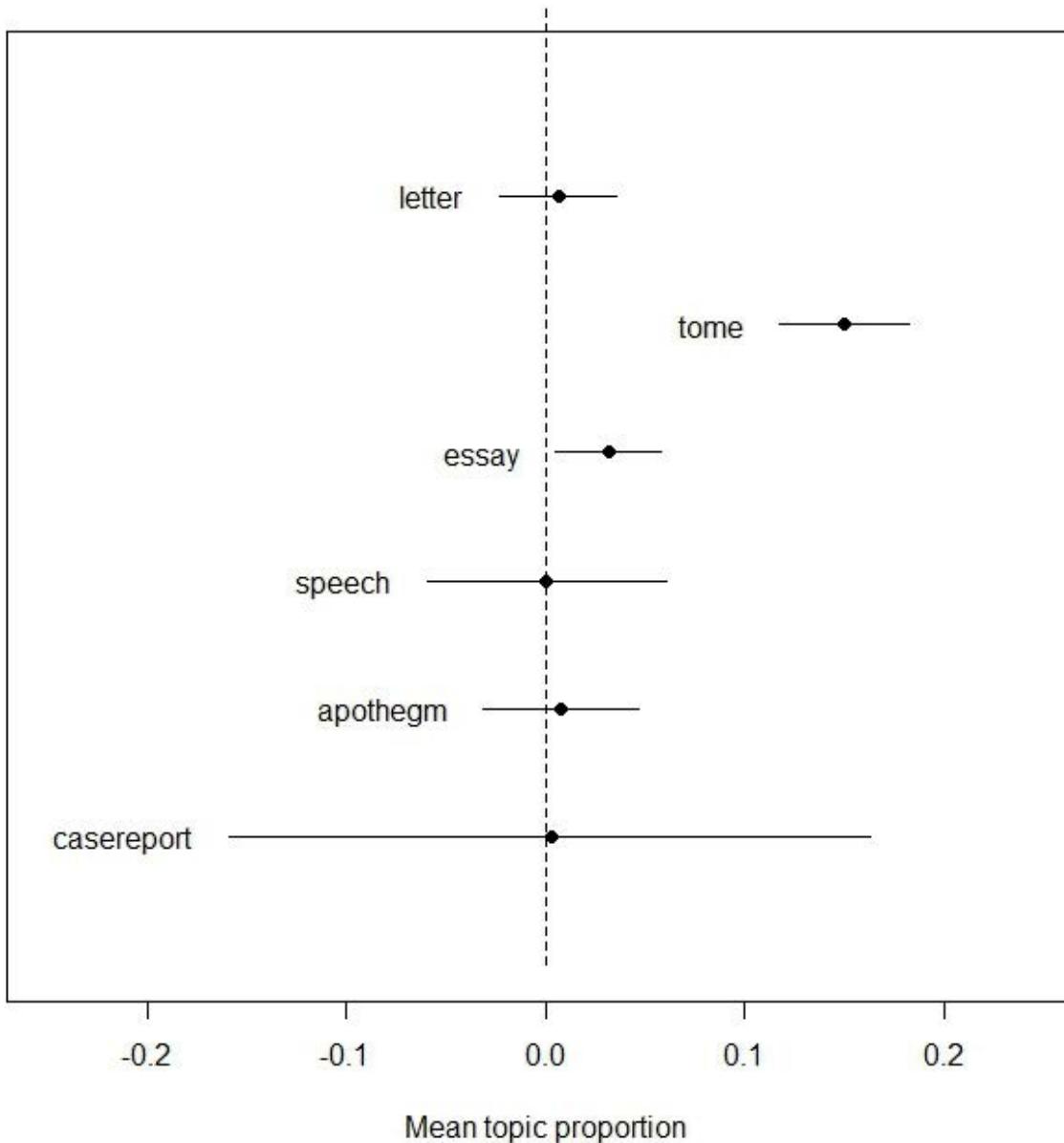
Note: The figure shows the point estimate and 80% confidence interval of the mean topic proportions of Probing for Facts for each type of writing form.

Figure 14: The Effect of Writing Form, Apothegm



Note: This figure shows the point estimate and 80% confidence interval of the mean difference in topic proportions for apothegms compared to all other document types.

Figure 15: The Effect of Writing Form on Prevalence of Epistemology



Note: The figure shows the point estimate and 80% confidence interval of the mean topic proportions of Epistemology for each type of writing form.

Appendix A: The connections between Bacon's law and his scientific method in the literature

This appendix provides evidence for the validity of three claims made in the Introduction of the paper. First, we show that the arguments about the existence of a connection between Bacon's scientific methodology and his jurisprudential background, made by a small subset of Bacon scholars, have been neither widely considered nor widely accepted in the vast literature on Bacon. In fact, the claims of such a connection remain contentious. More generally, we document that scholarship on the origins of Bacon's ideas about the scientific method has devoted remarkably little attention to the possible influence of Bacon's legal background. This point is important because the genesis of Bacon's ideas about scientific methodology has been a topic of enduring interest for Bacon scholars, generating much controversy. For example, many scholars portray Bacon as a one-of-a-kind genius alone as the 17th century began (see, e.g., Rees 2004, Urbach 1987: 24, Jardine 1974: 2). Others suggest that Bacon's ideas were heavily influenced by factors such as his religious beliefs, alchemy, magic, natural crafts, and classical philosophy, rhetoric, and science (see, e.g., Peltonen 2004, Rossi 1968: xii, 15, 39, 71; Zagorin 1998: 28; Henry 2002: 11). Our claim, therefore, is not that the broad Bacon scholarship has simply ignored the connection between Bacon's law and his scientific methodology, while somehow accepting it. Rather, one must conclude that much of the extant literature either has not even considered this connection to be a possibility or, alternatively, has deemed any such influence to be of no substantive importance.

The second claim on which this Appendix provides evidence is that among those few scholars who have commented on a possible connection between Bacon's legal background and his scientific methodology there exists considerable heterogeneity concerning which specific aspect of Bacon's scientific methodology may have been influenced by his immersion in law. Therefore, even for those accepting a connection between Bacon's law and his scientific methodology, there remains controversy concerning the answer to the question of which elements of Bacon's scientific methodology have their origins in law. This question is in need of further investigation, to which our paper makes a contribution.

The third claim is that there is a lack of agreement about which aspect of Bacon's jurisprudence was most influential, even among that small subset of scholars who have noted the existence of a connection between Bacon's scientific methodology and his jurisprudential background. The most important disagreement is whether it is Bacon's knowledge of the civil law tradition that is important or whether his immersion in the common-law was the crucial factor.

To collect the supporting evidence for our claims, we conducted a detailed search of the literature on Bacon published within the last 30 years. Specifically, we searched for all JSTOR entries in which the word 'Bacon' appears in the title and that are classified in any of the following fields: British Studies; Classical Studies; Economics; General Science; History; History of Science and Technology; and Political Science. We examined all identified articles. Given the central role of book reviews in many of these fields, this process allowed us to identify books published in the last 30 years that focused on Bacon. We examined these books also. In addition, where the

identified articles or books referred to any other articles and books that might have been relevant to this exercise (regardless of the publication date), we examined all so-identified publications.

Our survey of the literature shows that the scholarship on Bacon can be organized into the following four broad strands. The first (strand I) consists of an overwhelmingly large number of contributions that either do not devote any attention to Bacon's legal background or, alternatively, mention Bacon's legal background but do not connect it to any aspect of his scientific methodology. The second (strand II) includes contributions that explicitly dismiss the possibility that Bacon's legal background may have shaped his scientific methodology. The items in strand II therefore support our claim that the link between Bacon's legal background and his scientific methodology is not well accepted and, hence, worthy of further examination. The third strand (strand III) comprises contributions that conjecture or otherwise comment on some form of connection between Bacon's legal background and some aspect of his scientific methodology, but do not explicitly and purposefully investigate such a hypothesis in any detail. The final strand (strand IV) involves a small set of contributions that explicitly hypothesize and investigate a connection between Bacon's legal background and some aspect of his scientific methodology.

In what follows, we provide an overview of the literature grouped in the above-identified four strands. In doing so, we focus on those aspects of the literature that are relevant to the three claims articulated above.¹ The final section of this appendix summarizes our findings.

Strand I: Contributions that either do not devote any attention to Bacon's legal background or, alternatively, mention Bacon's legal background but do not connect it to any aspect of his scientific methodology.

The scholarship on Bacon is voluminous. A large majority of works (original contributions or book reviews) on different aspects of Bacon's scholarly and other engagements never mention Bacon's background in law or legal work and, hence, seek no connection between Bacon's immersion in law and his scientific methodology. These contributions include Manzo (2006), Strazzoni (2012), Corneanu et al. (2012), Georgescu and Giurgea (2012), Lancaster (2012), Dzelzainis (2006), Park (2008), Vickers (1992), Vickers (2001), Manzo (2003), Muntersbjorn (2002), Studer (1998), Milner (1997), Rees (2002), Jalobeanu (2012), Anstey (2012), Langman (2012), Walton (2007), Kepple-Mamros (2007), Russell (1955), McCaskey (2009), Jones (2009), Manzo (2006), Solomon (2004), Anstey (2003), Jacob (2002), Wolfe (2002), Henry (2002), Harkness (2005), MacLean (1997), Achinstein (1997), Manzo (2000), Barnaby (2001), and van den Berg (1998).

In the introduction to what is perhaps the most comprehensive current overview of Bacon's contributions (Peltonen 1996c), Peltonen (1996a) only briefly mentions Bacon's legal opus and jurisprudential thought, and then only in the context of law reform. Neither Peltonen (1996a) nor

¹ For brevity we omit references to specific page numbers when providing direct quotations from the surveyed readings. Because we provide detailed bibliographical information on all surveyed readings, interested readers should be able to easily identify the exact position of any stated quotation within the pertinent reading.

any of the other chapters in Peltonen (1996c) explicitly link Bacon's legal thought to the core of Bacon's scientific method. Indeed, in Peltonen (1996c), the only reference to Kocher (1957) [classified in strand IV] is the following comment: "That certain statements of a general nature could be fruitfully applied to more than one case may well be a conviction deriving from his belief in the power of maxims in Jurisprudence" Kusukawa (1996). This is not followed up by any other statements about the origins of Bacon's views in Peltonen (1996c).

The *Stanford Encyclopedia of Philosophy* and the *Internet Encyclopedia of Philosophy* both concentrate on Bacon's non-legal writings, but provide a significant amount of detail on Bacon's legal career. Neither entry on Bacon, however, in any way connects his legal background with his work on scientific methodology. The same applies to Applebaum (2000), a further encyclopedia entry on Bacon.

Among the many themes and questions examined by Bacon scholars, one particular issue of enduring interest has been the genesis of Bacon's ideas, especially his ideas about scientific methodology. As the ensuing paragraphs show, the analysis of the origins of Bacon's ideas on scientific methods has devoted remarkably little attention to his legal background. For example, Rossi (1968) focuses on investigating the cultural environment influencing Bacon, exploring many such influences—classical culture, magico-alchemical inquiries, astrology and Copernican astronomy, atomistic theories of matter, classical mythology, religious conceptions of knowledge, existing philosophy, sixteenth century rhetorical writers, and pagan and evangelical moralities—but, importantly, not the law. Rossi (1968) concludes his arguments by "stressing the connections between Bacon's new logic and the tradition of Renaissance rhetoric" when analyzing "the historical and cultural environment in which Bacon's philosophy developed...".

Gaukroger (2001, 2006) is also interested in the cultural influences on Bacon. He does not ignore law, but rather emphasizes that Bacon treated natural philosophy and law in analogous ways, rather than viewing one as providing inspiration for the other. For Gaukroger, Bacon aimed to reform both law and natural philosophy as part of his overall project of creating and using a new method for the production of knowledge. In Gaukroger's reading (2001, 2006), for both of these reform projects and for Bacon's new method, it is renaissance humanism, English renaissance culture, and the rhetorical tradition, emphasizing psychology, that provide inspiration and models. "Since our interest is in the ways in which Bacon's concern with legal questions bears upon his program in natural philosophy, it is important we begin by asking what the connection between law and natural philosophy could be. To understand this connection we need to introduce a third ingredient: rhetoric, conceived as the general discipline of the rules of discovery and presentation driving classical humanism. We need to understand the relation between law, natural philosophy, and the general kinds of claim made about discovery and the organization of inquiry in the theories of rhetoric that make up the core of classical humanist learning. Without this, I suggest, law and natural philosophy simply do not have a relation beyond that of analogy—and Bacon clearly intends far more than that. What underlies his reform of natural philosophy is a distinctive stance within traditional humanism. The connection between natural philosophy and the law is mediated

by rhetoric, for rhetoric contains the art of discovery that underlies both law and natural philosophy...[Therefore in Bacon's aims the] *law itself, particularly legal procedure and the source of legal authority, is transformed*, [emphasis added] so that it coheres with the aims of the reformulated humanism and can act as an exemplification of the values of the humanist. In this way, it can be made to bear the weight of the wholly general claims that humanist theories of rhetoric made about discovery and presentation...[The law] was therefore the natural place to which to return, *if one was starting again from scratch, as was Bacon* [emphasis added]; and his general understanding of the aims and procedures of humanism led him to ask what forms of legal inquiry, argument, and organization meet these aims and procedures, to envisage what the legal system reformed along fundamental lines might look like and what practically might be done to remedy defects in the current practice of law" Gaukroger (2001).

Harkness (2007) characterizes Bacon as appropriating the experimental culture of the ordinary citizens of the City of London for his own ends. Nevertheless, her chosen foil for Bacon is Hugh Prat, a lawyer, whose profession Harkness (2007) does not link to Prat's avid collection of facts. Rees (2004) praises Bacon's contributions to scientific methodology, but sees no role for law as a potential contributing factor: "...*the Baconian form of eliminative induction seems to have been altogether original* [emphasis added]. There seems to be nothing of the kind in ancient, scholastic or humanist logic. There may be precedents for some of the apparently novel features of Bacon's thinking on this question, but if such there be I have yet to find them." Furthermore, "Bacon's was as sharp and as clean a break with certain versions of the past as it was possible to make. And the break involved not just a philosophy of knowledge but also a reinscription of human possibility."

Henry (2002) is explicitly interested in the genesis of Bacon's scientific method, but emphasizes its distinctly non-legal origin: "In the mysterious case of Francis Bacon, we will see that the story of how he came to do what he did takes us through unexpected and unfamiliar territory—through realms that now seem to have little or nothing to do with natural science, but that were once intimately connected with it. These are the realms of religion and magic." The role of law in the formulation of Bacon's scientific methodology is considered only briefly in Chapter 12: "It has been suggested that the interrogation of witches was seen by Bacon as a model for the interrogation of nature, and that the use of mechanical devices in experimental investigations was seen as a way of extracting nature's secrets by torture, comparable to the use of the rack or other machines of torture supposedly in use in the legal process." Yet Henry (2002) concludes with: "...it is important to bear in mind the magical and religious antecedents of Bacon's thought".

Perez-Ramos (1988) notes that his "inquiry is primarily an investigation into the key notions or 'ingredients' that, [according to him], make up Bacon's idea of science...". Law is awarded no place in Perez-Ramos's inquiry, even though he devotes attention to subjects such as astrology, astronomy, Copernican theory, corpuscularianism, craftsmanship, experimental tradition, mathematics, the technocratic view of science, etc. Minkov (2010) argues that his "aim is to show that an inquiry into what is good for man is the foundation and core of Bacon's thought".

Even though Minkov's (2010) treatise includes a chapter entitled "Bacon on justice and death", there are no references in the chapter to Bacon's law, and especially to the connection between Bacon's legal background and his scientific methodology.

Matthews' (2008) central thesis concerning the genesis of Bacon's ideas revolves around the influence of religion, not law: "Over the last ten to twenty years there has also been a trend toward understanding Bacon as a creature of his context, and this implies taking his theological statement seriously and interpreting them in the light of the religious fabric of Tudor and Stuart England." Harrison (2009) in a review of Matthews (2008) notes: "This is a welcome volume that makes a good case for the influence of theology on Francis Bacon's thought and sheds light on the nature of his religious convictions."

Solomon and Martin (2005), as the editors of a volume commemorating *The Advancement of Learning*, note that "five of our essayists take up Bacon's more or less successful efforts to forge a coherent and creative relationship with past intellectual, rhetorical, or religious traditions", but do not comment on Bacon's legal background. Instead, the edited volume refers to Bacon's indebtedness to, among other influences, the history of exploration, Neoplatonism, the ancient tradition of atomism, transcendental mysticism, Ockhamist nominalism, and transcendental traditions. Hogan and Schwartz (1983) comment on prior work by Wheeler (1983) [classified in strand IV] who "shows that in the field of law and jurisprudence, Bacon used his *new method* [emphasis added] to produce the 25 maxims, and he believed they possessed scientific validity. This method, as applied to law, we have described below under the making of a maxim." They, however, do not argue that Bacon's jurisprudence is a source for his scientific methodology.

Cohen (1982) combines the discussion of Bacon's common-law background with Bacon's scientific methodology but never explicitly suggests the former may have influenced the latter: "Francis Bacon, who made the first attempt at a systematic study of variative induction, laid great stress on its significance for legal and moral reasoning as well as for reasoning about the facts of nature. Wishing to produce a systematic digest of the common law, Bacon saw judicial decisions as the ultimate singular facts that could be taken to support a restatement of the law in general terms. Bacon held that as a common lawyer arrived at greater and greater generality in the formulation of his legal rules—as he moved higher and higher up what Bacon called 'the pyramid of axioms'—the lawyer would find his rules beginning to approximate to standard moral principles....So for Bacon all the basic patterns of inductive reasoning could be applied in a normative context just as well as in a factual one: variation of evidential instances, increase of certainty via increase of generality, avoidance of trivial increases in generality via the requirement that every increase should lead to new knowledge, and so on." Huxley (2004) and Cardwell (2002) discuss Bacon's legal writings but make no attempt to connect them to Bacon's scientific methodology.

McKnight (2007) likewise sees no role for law in the emergence of Bacon's scientific methodology. He argues that "Bacon's so-called scientific utopianism is grounded in his religious convictions that his age was one of Providential intervention and that he was God's agent for an

apocalyptic transformation of the human condition". Similarly, Sargent (2012) does not refer to Bacon's legal background when noting that "What did set Bacon apart was the way in which he produced a popular synthesis of the many examples of practical knowledge that flourished in his time and constructed a powerful argument for a transformation of the Aristotelian philosophical framework that dominated the universities."

Lewis (2012) focuses on Bacon's ingenuity, but sees no contributing role for law. In fact, his very discussion rejects such a possibility in noting that "...Bacon asserts that the more ingenious one is, the less likely one is to arrive at true knowledge of things: a strong ingenium will more often than not cause one to desert the light of nature for the dark caverns of the imagination.... Although exerting oneself ingeniously to maintain doubt is perfectly licit for a lawyer pleading a case or for a student involved in a university disputation, the natural philosopher should apply as much ingenuity to resolving doubt as he does to identifying it."

Martin (1993) in a book review notes that "John C. Briggs...argues for an intimate relationship 'between Bacon's famous reform of scientific method and his less well-known conceptions of rhetoric, nature and religion', and he proposes to display this relationship by discussing Bacon's debts to, and radical adaptations of, several 'normative Renaissance traditions'. These traditions, which Briggs gathers up and dubs the 'Timaeic' tradition, include the Wisdom Literature, the Pauline Epistles, old philosophies of organic nature, and the ideas of the Greek atomists. Informing all of them are Bacon's adaptations of ancient and Renaissance philosophies of rhetoric...". He makes no reference to Bacon's engagement in law.

In commenting on the origin of Bacon's scientific method, Pesic (2014) emphasizes Bacon's "use of Aristotelian philosophy and ancient myth as points of departure for what he called his 'new organon'" and does not mention any role for law. Turner (2013) examines "the political imaginary of Bacon's philosophy of nature as elaborated in the *Novum Organum* (1620)", but does not draw a connection between the latter and Bacon's legal background.

Bacon's legal background is similarly not referred to in Giglioni (2014), who notes that "In Bacon's system of knowledge, philosophy, as the domain of reason, starts from historiae and fabulae, once memory and the imagination have fulfilled their cognitive tasks". Commenting on the origin of Bacon's methodological approach, Pastorino (2011) suggests that "Bacon's ideas...can be tied to experiments for the determination of specific gravities born in a monetary context: Bacon's investigation was very likely a generalization of Jean Bodin's experiments". Neither Giglioni (2014) nor Pastorino (2011) mention law.

Vickers (1978) emphasizes Bacon's "intensely practical mind, not much inclined to abstract speculation", without suggesting that this attitude might have been derived from legal experience—even though Vickers later emphasizes how Bacon's personal success was shaped by his training in law, in particular "...the faculties which brought [Bacon] to eminence in that profession, intellectual penetration coupled with imagination and eloquence. Bacon's whole life-work was one of persuasion, whether as a lawyer or parliamentarian, counsellor to the monarch, or advocate of the new science. He was the master-rhetorician of his day in the sphere of public

life." Similarly, in a review of multiple new works on Bacon, Vickers (2004) mentions no role for law in the origins of Bacon's scientific methodology.

Peterfreund (2000) emphasizes the Calvinist, not legal, origins of Bacon's thought. In a book review of Jardine's work, Manzo (2001) mentions Jardine's "claims that Bacon the politician and Bacon the philosopher are interconnected", but never comments on Bacon the jurist. Snider (1991) comments, but never elaborates, on the following: "The equation of natural with civic law hinges on Bacon's dual authority, his capacity to function in the political and philosophical realms according to a unified code of impartiality and evenhandedness."

In an essay about Bacon's concept of objectivity, Zagorin (2001) notes that Bacon "was thoroughly acquainted with objectivity in the sense of impartiality as one of the requirements of truth and justice in both law and history, and sought to practice it himself in his activities as a judge, a writer on jurisprudence and a historian". However, Zagorin (2001) does not postulate a link between Bacon's legal background and his scientific methodology. In a review of Solomon (1998) [grouped into strand III below], Daston (1998) notes that "Solomon's reading of Bacon admirably attempts to bring together Bacon the pragmatic politician with Bacon the visionary natural philosopher, and to situate both in the tumultuous world of early modern commerce", not law.

Hale's (2013) goal is to "examine the place of the New Atlantis in Bacon's larger project and its place in the founding of modern political philosophy, briefly showing the ways Bacon's thought relates to Plato, Machiavelli and Hobbes". She does not discuss the potential influence of Bacon's legal background on his scientific methodology. The same is true of Price (2002). In a review of Sargent's work, Vickers (2001) makes no connection between Bacon's law and his scientific methodology, but notes that "Sargent rightly stresses the importance of Bacon's religious view". Peltonen (2001), Snider (1994), Ellis (2015), and Funari (2011) similarly never connect Bacon's law with his scientific methodology.

In a comparative survey of Bacon's natural and civil history, Manzo (2012) cites Kocher (1957) and Martin (1992) [grouped into strand IV] but notes that "Bacon's ideas about the origins of legal norms deserve a discussion in their own right, which lies outside the purpose of this article". In a further contribution that focuses on Bacon's legal thought, but does not draw a connection between Bacon's legal thought and his scientific methodology, Manzo (2014) examines "in what sense Bacon understood legal certainty". Indeed, her aim is to "...explore Bacon's views on certainty in his legal thought and practice, hoping that it may lead to a better understanding of the epistemological side of his legal thought and *prompt further studies* [emphasis added] to examine its possible connections to his treatment of certainty as it applies to the laws and facts of nature."

Wormald (1993) argues that Bacon wrote about policy using a similar methodology as when he wrote about natural science: history provided the set of facts from which theories of policy could be made. Indeed, Wormald contends that Bacon's scientific method was developed to examine the relationship between history and policy as much as to examine the relationship

between observations and scientific knowledge. Although for Wormald the history of the common-law is part of history in general, the use of the common-law is purely as history rather than any connection being drawn between the methodology of the common-law and natural science epistemology. Box (1994) in a review of Wormald (1993) comments on the author's "attempt to polish Bacon's tarnished scientific reputation by, in effect, substituting civil history for natural history as the basis of Baconian science. The former is paramount on the assumption that it contributes to parallel programmes in natural and civil science. ... however, the category of civil history is so expansive and the purpose of civil science so vague that far from enhancing Bacon's stature, this reinterpretation actually makes [Bacon's] scientific importance seem even more dubious."

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Strand II. Contributions that explicitly dismiss the possibility that Bacon's legal background may have shaped his scientific methodology.

Several prominent scholars of Bacon explicitly reject the possibility that Bacon's ideas about scientific methodology might have been influenced by his immersion in law. One highly acclaimed contribution in this strand of the literature is Zagorin (1998). Brian Vickers in the *Times Literary Supplement* describes Zagorin's (1998) book as "A concise but detailed analysis of [Bacon's] whole range of thought.... This penetrating account of Bacon's work can be

recommended as the best single-volume study available". In his review of Zagorin (1998), Peltonen (1999) notes: "All in all...Zagorin's book is amongst the best introductions to Bacon's philosophy.... In his balanced account of Bacon's natural philosophy, Zagorin gives short shrift to two particular claims: that Bacon's philosophy was indebted to Giordano Bruno's influence and that it was by and large based on a political ideology.... Bacon is said to have 'modeled his natural philosophy upon, commercial and technological practices, norms, and behaviors'.... This claim is repeated several times and its exposition takes up most of the book."

Although Zagorin (1998) discusses Bacon's legal career, he does not draw any connection between Bacon's legal background and his scientific methodology, including in a chapter entitled "The Genesis of Bacon's Project". Zagorin (1998) notes that "[Bacon's] intellectual formation drew on a great diversity of sources [including leading philosophic schools and thinkers of antiquity from the pre-Socratic's onward, ancient medical and scientific writers, the poets and mythology, the ureters and moralists, the historians and political writers of the ancient world, many noted modern philosophers and scientists, the occult sciences, astrology, alchemy, natural magic, European travel literature recent and contemporary foreign office, Protestantism, the Bible, as well as, interestingly, the legal and historical literature of his own country, and Roman law], many of which are obscure and others doubtless no longer recoverable."

Yet, according to Zagorin (1998), Bacon's law and his scientific methodology share no common link: "A common misconception among authors who have written about Bacon's work on law is that his legal philosophy was founded on his scientific method and the use of induction. This error is compounded in some of these authors by a second, *even bigger misconception, which supposes that Bacon's natural philosophy was actually the product of his legal ideas and experiences as a lawyer* [emphasis added]." Here, Zagorin (1998) takes issue with the work of Kocher, Wheeler, and Coquillette ("[his] mistaken understanding of the relationship between Bacon's legal thought and his natural philosophy"), and Martin ("while [Martin's work] includes some interesting and useful matter, [it] also introduces exaggerations and misconceptions arising from the author's thesis that Bacon's natural philosophy stem from his experience and ideas as a lawyer") [grouped in strand IV]. He further takes issue with "other authors [who] have imagined that Bacon's work as an interrogator of suspects and criminal examinations was the source of his conception of Inquisition into nature, or that he adapted the procedures he prescribed in natural philosophy from the procedures of English law....These views are not only based largely on specious verbal analogies but spring from a superficial knowledge of Bacon's natural philosophy and its intellectual genealogy."

Zagorin's (1998) disapproving view of the conjecture that law may have had anything to do with Bacon's scientific methodology is perhaps best summarized with the following statement: "[Bacon's] concept of the true method of advancing the knowledge of nature originated not in his study or practice of law but in his critical reflections on dialectics, on the failings of syllogistic logic as an instrument of discovery, and on the limitations of the traditional kind of induction. His empiricism probably owed a considerable amount to his interest in natural magic and the

operations of the various crafts. He had no need to draw on his legal experience of examining suspects to form his idea of the interrogation of or Inquisition into nature."

In a review of Gaukroger (2002), Zagorin (2002) reiterates his own views by noting that "Gaukroger...attributes considerably more importance to rhetoric and law in the development of Bacon's natural philosophy than is justifiable." Expressing further doubt about the relevance of Bacon's legal background for his scientific methodology, Zagorin comments: "In general, it would be surprising if Bacon, who repeatedly insisted on the necessity of making a fresh start in the investigation of nature, should have found much help in pursuing this goal in the old and long-established disciplines of rhetoric and law".

Similarly, Vickers (2003) in his review of Gaukroger (2002) adamantly rejects the possibility of an influence of Bacon's law on his scientific methodology: "As for law, Gaukroger has been influenced by Julian Martin's claim that Bacon's thinking in science was formed by his legal training, but, as I pointed out..., Bacon regularly rejected any language-based approach to natural phenomena. This consideration disqualifies much of Gaukroger's discussion."

In a review of Martin (1992) [grouped in strand IV], Vickers (1994) characterizes as no more than a "superficial parallel" Martin's argument that "Bacon's plans for legal reform have the same goal (serving the imperial monarchy ad nauseam), and the same organizational structure as 'Solomon's House', the research institute described in the New Atlantis, both plans involving a bureaucratically organized hierarchy of committees". He further dismisses the possibility of a role of Bacon's legal background by arguing that "Martin quotes some passages where Bacon uses legal terminology in his scientific writings..., but fails to realize that Bacon's usages in law are literal, in science only metaphorical".

Finally, referring to De Morgan (1915) [grouped in strand III], Agassi (2013) also completely rejects the possibility of a connection from Bacon's legal background to his scientific method: "No Bacon text justifies De Morgan's characterization of his philosophy as conceived by a person with the mentality of a lawyer...". Marwil (1976) takes this even further by suggesting that Bacon's legal education must have produced a mind-set that would have been counter-productive for science.

Works grouped in strand II

Agassi, Joseph. 2013. *The Very Idea of Modern Science, Francis Bacon and Robert Boyle*. New York, NY: Springer.

Marwil, Jonathan. 1976. *The Trials of Counsel—Francis Bacon in 1621*. Detroit, MI: Wayne State University Press.

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Strand III. Contributions that conjecture or otherwise comment on some form of connection between Bacon's legal background and some aspect of his scientific methodology, but do not explicitly and purposefully investigate such a hypothesis in any detail, and do not therefore produce any persuasive evidence.

The connection between Bacon's scientific methodology and his legal background has wider currency as a hypothesis that has not been thoroughly investigated. As we demonstrate below, one subset of this strand of the literature suggests that causality may flow from Bacon's legal work to some aspect of his scientific methodology (as is the case in the contributions grouped in strand IV); another subset, however, views causality as flowing in the other direction, from Bacon's scientific methodology to his jurisprudence. Furthermore, much like the contributions that have explicitly investigated the influence of Bacon's immersion in law on his scientific methodology [strand IV], the literature in this strand exhibits significant heterogeneity with respect to which specific aspect of Bacon's scientific methodology is posited as connected to which aspect of Bacon's jurisprudence.

Holdsworth (1927) merely notes that "it is at least arguable" that Bacon's training in law "had some influence on his inductive system of experimental philosophy". Stone de Montpensier (1968) remarks that Bacon's logic of reasoning in *Maxims of the Law* resembles his scientific method. Sargent (1989) focuses on Robert Boyle (1627-1691), who was influenced by Bacon, and comments that the "experiential procedure of common law...influenced Bacon's thought". When discussing Bacon's emphasis on facts of nature, Desroches (2006) comments, but does not investigate the issue further, that it is "no great leap to suggest...that Bacon's conception of fact, construed in the context of his scientific programme, demands to be understood in terms similar to those governing its legal conception". None of these authors delves deeper into the empirical basis of their conjectures.

Coquillette (1992) focuses exclusively on Bacon's law and jurisprudence, but does not explore the possibility that Bacon's legal thought shaped his scientific methodology. If anything, Coquillette (1992) suggests that the latter may have shaped the former (rather than vice versa): "...my concluding thesis will be relatively simple. This thesis is that Bacon was the first truly analytical and critical jurist in the Anglo-American tradition. *He was also the first to dare to apply an empirical, inductive analysis to lawmaking* [emphasis added]. This new methodology, which he termed the 'Novum Organum' or 'new tool', had a direct and acknowledged effect on some of the most exciting legal thought in the next three centuries... No English jurist before Bacon looked at the law in this way."

Several scholars have written book reviews on Coquillette (1992). Given the absence of an emphasis in Coquillette (1992) on the potential link from Bacon's jurisprudence to his scientific methodology, it is not surprising that scholars commenting on Coquillette's work, such as Walker (1994), Cardwell (1995) and Harris (1993), do not even mention the possibility of such a link. Walker (1994), for example, comments that "Coquillette has provided a fine study which expands our understanding and appreciation of the Bacon legacy. Thus this book is necessary reading for those interested in the emergence of modern legal processes and in the neglected aspect of Bacon as a jurist". Harris (1993) notes that "Sir Francis Bacon, though otherwise he might have outshone them all, has largely had his legal works, like his mortal remains, buried in obscurity. The task undertaken by Daniel R. Coquillette has been to resurrect Bacon." Interestingly, Levack (1995) does note a connection between Bacon's law and his scientific methodology, but consistently with Coquillette's own emphasis, interprets the direction of causality as flowing from the latter to the former (rather than vice versa): "Bacon's jurisprudence, therefore, involved the application of his scientific and philosophical methods to the law." In this same vein, when Boyer (1994) comments on Coquillette (1992), he states that "Bacon applied to issues of law reform a methodology that reflected its author's scientistic outlook". This is similar to Marwil's (1976) claim that Bacon's personality and intellect fueled his development of a common methodology that was applied to the method of investigation of both science and law.

In a more recent article, Coquillette (2013) further emphasizes the importance of Bacon's legal work: "Bacon's genius as the literal inventor of modern inductive social science, his extraordinary power as a writer, and his rise politically to be the second most powerful man in the England of his day, Vice Regent to James I, has historically overshadowed the fact that, first and foremost, he was a lawyer". Coquillette then hypothesizes that Bacon's experience in a non-common law court and his new scientific method led to his theory of law reform: "Bacon invented modern, scientific rulemaking [i.e., the making of rules in a legal context] by fusing his new theories of inductive, empirical research with the traditions of equitable [i.e., non-common-law] pleading...". Using an examination of two of Bacon's writings produced in the later stages of Bacon's life, Coquillette suggests that Bacon owes a "*great debt to Roman jurisprudence and Renaissance critical thinking*" [emphasis added].

Martin (1992) [grouped in strand IV] is one of the very few contributions that have, at least in part, examined the link between Bacon's law and his scientific methodology. Martin (1992) specifically argues that Bacon's natural philosophy should be understood as reflecting Bacon's political plans for the reform of the law and the state (as opposed to more narrowly his common-law background): "...this study insists that Bacon's legal and political career was crucial in the creation of his natural philosophy and that his natural philosophy cannot be separated from his political ambitions".

Martin's emphasis on the importance of Bacon's legal and political career (as opposed to his legal background and scholarship understood more narrowly) for his planned reform of natural philosophy (as opposed to his scientific methodology more specifically) has been noted by his

reviewers. Rothschild (1994) comments: "A summary judgment strongly suggests that Bacon's programs of reform proceeded without deviation from the legal and political experiences of a career in public service; that his vocation served as a channel of inquiry into the availability of expedients for better government and expansion of the kingdom...". Rees (1994) notes that "Francis Bacon was first and last a statesman in the Tudor Cromwellian mold who devoted all his energies to strengthening an imperial British state and its central institution, the monarchy. This, according to Julian Martin, is what unifies the various components of Bacon's public and intellectual life and, above all, his endeavors in the fields of legal reform and natural philosophy." Shapiro (1993) states that Martin's "...important study attempts to provide a contextual analysis of the origin and character of Francis Bacon's natural philosophy. Julian Martin argues that Bacon's natural philosophy should be understood as a subordinate part of a much larger reform program appropriate to a centralizing monarchy." Furthermore, she argues that by "investigating the political context of early modern natural philosophy", Martin (1992) "has drawn attention to the *still-neglected question of what the 'new philosophy' owed to the legal tradition* [emphasis added]".

Vickers (1994) [grouped in strand II], who also reviews Martin's work, dismisses Martin's argument about a connection between Bacon's law and his natural philosophy.

Interestingly, three further reviewers of Martin (1992) interpret Martin's work as drawing a more direct connection between Bacon's law and Bacon's scientific methodology than arguably professed by Martin himself. Croft (1995) notes that "Martin convincingly demonstrates how many of Bacon's procedures in natural philosophy were adapted from the law." Ahnert (2001) comments on Martin (1992) that "Bacon assumed the nature of the common law to be similar to that of the laws of nature. [Bacon] believed that much of the common law was hidden, that it was rational, and that men learned in the law could discover it. The same was true of the natural world; the principles of nature were hidden, yet they were capable of being discovered by the learned and licensed investigator." Hall (1993) notes that "It is hardly strange that [Bacon's] idea of the way to arrive at scientific truth was an adaptation from his ideal process 'for acquiring knowledge about the law'".

Recall that Gaukroger (2001, 2006) [grouped in strand I] examines the cultural influences on Bacon, emphasizing that Bacon viewed natural philosophy and law in analogous ways, rather than viewing one as providing a clear influence on the other. Several scholars have reviewed Gaukroger's work. Jacob (2002) does not at all mention the possibility of an influence of Bacon's law on his scientific methodology. Shapin (2002) credits Gaukroger for having "made a very great contribution to understanding the intentions driving Bacon's project". Interestingly, he then comments that: "Nevertheless, if we want to understand who the seventeenth-century English natural philosopher actually was, we have to leave Gaukroger's preferred world of close textual analysis and enter the world of social and cultural history". Although Shapin does not mention this point, it is certainly the fact that Bacon's social and cultural world was enormously influenced by the legal profession, the practice of the law, and the culture of the common-law.

Zagorin (2002) and Vickers (2003) [grouped in strand II] in their reviews of Gaukroger both reject the possibility of an influence of Bacon's law on his natural philosophy and scientific method.

Jardine (1974) argues that her "aim is to provide a consistent rather than a revolutionary reading of Bacon's works. By reconstructing the intellectual backcloth against which Bacon posed the particular methodological questions which engaged his attention, I believe we are led to appreciate the originality and ingenuity of his solutions...". Jardine (1974) is skeptical about Kocher's (1957) [grouped in strand IV] reasoning and, furthermore, attributes to Kocher an argument that is, in fact, the reverse of Kocher's original argument: "P. H. Kocher uses [a particular] analogy in support of the thesis that Bacon proposed an inductive method for use in jurisprudence." (Kocher argues that Bacon's law influenced his epistemology.)

In a book that is not specifically about Bacon, De Morgan (1915) conjectures, but never explores, the possibility of the importance of Bacon's legal background for his scientific methodology: "We think it possible that Harvey [who had noted that Bacon writes (natural) philosophy like a Lord Chancellor] might allude to the legal character of Bacon's notions: we can hardly conceive so acute a man, after seeing what manner of writer Bacon was, meaning only that he was a lawyer and had better stick to his business.... We do ourselves believe that Bacon's philosophy more resembles the action of mind of a common-law judge—not a Chancellor—than that of the physical inquirers who have been supposed to follow in his steps."

Solomon (1998) devotes considerable attention to Bacon's legal engagements, but never thoroughly investigates the possibility that Bacon's immersion in law may have influenced his scientific methodology. When commenting on the genesis of Bacon's scientific ideas, Solomon notes, for example, that "[Bacon's] scientific ideas were shaped by his own political and legal interests as a court official. Once James came to the throne, Bacon forged a scientific program that he hoped would gain intellectual acceptance and financial support from the reigning monarch." That is, it is "political and legal interests", not his legal background, that shaped Bacon's scientific program. She also asserts that "Bacon's formulation of a discourse of scientific objectivity is a complex, dialectical, often contradictory, and ambiguous exercise. This discourse mediates between the political and intellectual culture of the Jacobean court and the wider commercial culture that both shaped and was shaped by monarchy." However, when Solomon refers to work by Kocher, Wheeler, Simonds, Martin, and Shapiro [grouped in strand IV], who have hypothesized an influence of Bacon's legal, particularly common-law, background on his scientific methodology, she discounts arguments about the potential importance of Bacon's common-law background for Bacon's epistemology by noting that, during Bacon's era, "In truth...common-law procedures for the discovery of facts was still largely rudimentary....". If anything, Solomon appears to view Bacon's involvement in the non-common-law Court of Chancery, again coupled with his political ambitions, as exerting an influence on his science: "...the practice of common—and especially Chancery—law fueled Bacon's scientific particularism, but he also had broader

political reasons for utilizing the empirical particular as a legitimate of knowledge: namely, the desire to defend the prerogative of the crown...".

In Cassirer's (1953) book-length study of the contributions of the Cambridge School to modern philosophy, Bacon is awarded very limited space. Cassirer notes that "Bacon has become...the herald and precursor of the modern English spirit, of that spirit which, as early as the seventeenth century, entered into and diffused itself through all fields of intellectual culture—science as well as politics, philosophy as well as religion. Bacon himself understood the new philosophy which he represented, not so much as a work of genius as a 'birth of Time'." In a short passage where he comments on Bacon's natural philosophy, Cassirer states that "Bacon's induction is not a scientific, but a juridical process....Bacon sits as a judge over reality, questioning it as one examines the accused.... This procedure is not simply observational but strictly inquisitorial." Cassirer, however, never subjects his claims to any kind of careful scrutiny. Multiple authors have written a review of Cassirer's book. From the seven book reviews available on JSTOR, none in any way refers to the above-quoted passages in Cassirer's work; indeed, four out of seven reviewers do not even mention Bacon in their review.

In an Introduction to their edited volume, Daston and Stolleis (2008) emphasize the importance of natural law [an unwritten body of universal moral principles that are an inherent part of nature; to be distinguished from written positive law] as "an essential element of the conceptual vocabulary of modern science and philosophy" and, hence, view natural law as an important source of ideas in the development of both natural and social sciences. They note: "The impulse to systematization, with natural law supplying the first principles, was notably strong in both 17-century jurisprudence and natural philosophy. In the case of jurisprudence, this impulse often took the form of codification of laws, and it is suggestive that natural philosophers who were legally trained, such as Francis Bacon and Leibniz, were often involved in such attempts." An emphasis on codification would, of course, be reflective of civil-law jurisprudence rather than common-law ideas.

In the same edited volume, Stolleis (2008) notes the possibility of a connection between law and scientific methodology; however, according to him, causality flows from the latter to the former: "The Scientific Revolution from the mid-sixteenth century onwards—in mathematics, physics, astronomy and medicine, to name but a few disciplines—directly affected jurists as the constructors of the normative world. The emergence of 'natural sciences' shaped by 'laws', set forth in a 'Book of Nature', inevitably poses the question as to whether such laws might not also be found in the social order." Articulating an analogous point in the same edited volume, Steinle (2008) further comments: "One of the most influential programs for a 'new science' was presented in Francis Bacon's 1620 *Novum Organum*. Bacon here used the concept of laws of nature that was closely connected to his idea of 'form' and was thus not more sharply defined than the latter. Rather than stressing theological considerations, Bacon emphasized the analogy to the legal realm." Steinle also notes the possibility of an influence from Bacon's legal—specifically common-law—background and his scientific methodology: "Bacon—lawyer and politician, after all—dealt

with those questions and acted as a proponent of authoritative legislation. In transferring these legal concepts to natural philosophy he was careful to differentiate between different types of statements that play different roles and had to be established in different ways. [Customs] could only be recognized by empirical means and were valid even without being derived from our general principles. 'Laws', by contrast, were central parts of a larger structure of argumentation. It is striking to realize that Bacon, being one of the few to draw an explicit analogy between natural philosophy and matters of legislation, did exactly not refer to the tradition of natural law, but to the separate common-law tradition, so prominent in England." Maintaining focus on the importance of the natural law tradition, however, Steinle does not pursue any further investigation of this hypothesis.

Daston (1991) draws an analogy in Bacon between investigation through torture and experimentation: "When Bacon likened experiment to putting nature on the rack, it was a lawyerly analogy, for torture was the chief means of investigation for 'secret' crimes like heresy, theft by night, and adultery. Nature and the culprit must be forced to 'confess', for the deed seldom had witnesses." Daston, however, does not examine this issue in further detail. The possibility of a connection between torture as investigation and Bacon's experimentation is also a topic of interest for Merchant (2008). Focusing on the notion of a controlled experiment, Merchant (2008) argues that "Bacon was striving toward the idea of the contained, controlled experiment in which a natural object is forced by art or technology to yield its secrets", noting that "his concept of experiment emerged" from "the mechanical and practical arts". Merchant also draws a connection between Bacon's emphasis on experimentation and his juridical background as one of the factors that may have shaped Bacon's views on experimentation: "...Bacon's concept of the contained, controlled experiment arose out of three influences: the juridical tradition, the idea of nature in bonds (*Prometheus*), and the idea of extracting the secrets of nature." In particular, she comments that "Bacon used the term 'trial' to characterize an experiment. The interrogation of nature is analogous to a judicial trial, in which the subject on the witness stand is forced to answer questions in order to extract the truth ('the inquisition of truth').... Nature per se cannot speak but is privy to the facts and knowledge (secrets) to be extracted....By analogy, the scientist designs an experiment in which nature is 'put to the question' in a confined, controlled space where the correct answers can be extracted through inquisition." Much like Daston (1991), however, Merchant (2008) does not connect Bacon's legal background to his broader scientific method in any precise way, and focuses on the procedures for ascertaining facts rather than the epistemological process of drawing broader lessons from those facts. In a similar vein, Shapin (1993) suggests that Martin's (1992) work concerns the connection between courts pursuing facts and scientists investigating nature. "[Martin] deepen[s] our appreciation of the concrete courtroom practices which, [Martin] argues, provided Bacon with institutionalized repertoires whose perceived effectiveness and cultural legitimacy might be transferred to the practice of natural philosophy." These works, therefore, all emphasize the fact-finding aspect of Bacon's scientific method, rather than his inductive epistemology.

Park (1984) notes that Bacon "stood clearly within the mainstream of Renaissance logic and rhetoric, which rejected the technicalities of the scholastic tradition in order to emphasize the practical applications of these disciplines for effective communication. But whereas the humanist scholars upon whose ideas Bacon was drawing tended to emphasize the problems of communication in the classical arenas of politics and law, Bacon—both a politician and a lawyer—looked beyond to apply the same skills to science, a discipline previously seen as remote from the public domain." She, however, does not elaborate on the possible connection between Bacon's law and any specific aspect of his scientific methodology, and therefore does not add evidence to the conjecture.

Finally, Whitney (1989) is concerned with the following research question: "...to what degree does Bacon's appropriation of a rhetoric of political domination in his use of *instauratio* compromise his philanthropic and pragmatic science?". In addressing the question, he makes, but does not elaborate on, the following interesting comment in which he invokes Bacon's legal background: "The language of land ownership in medieval Latin, as a matter of fact, actually conflates *instauro* and the verb *instruo*, instruct, furnish, or supply, from which *instrumentum* is derived. The Magna Carta, with which Bacon the lawyer was familiar, decrees that when an heir comes of age the steward must turn over to him the land 'totam *Instauratam de carucis et omnibus aliis rebus'*, 'fully furnished with valuables and all other things'....Because of the importance of instruments, says Bacon, we must "instruct" (*instruemus*) the mind with the *Organum*, the tool of method....: that is, instaure it by instructing with instruments that probe instances." However, Whitney offers no further exploration of the connection between Bacon's law and Bacon's scientific methodology.

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Strand IV. Contributions that explicitly postulate and investigate a connection between Bacon's legal background and some aspect of his scientific methodology while offering supporting evidence in favor of such connection.

Only a very small subset of the multitude of Bacon scholars has attempted to explicitly investigate a connection between Bacon's scientific methodology and his background in the law. This strand of scholarship on Bacon consists of contributions by Kocher (1957), Wheeler (1983), Simonds (1986), Cardwell (1990), Martin (1992: 164-171), Shapiro (2000: 107-112), and Serjeantson (2014: 701-704). However, much like in the case of contributions grouped in strand III above, even within this group of scholars there is broad disagreement on which aspects of Bacon's scientific method may have been most shaped by his legal ideas and which aspect of Bacon's legal background was most influential.

Shapiro (2000), for example, argues that Bacon's legal training may have influenced his scientific method primarily in the emphasis on the careful collection of facts by observation and experiment. She comments that "Bacon was ideally suited to appropriate legal-historical methods to the cause of natural philosophy". And further notes: "'Matters of fact', broadened by Bacon to include virtually all natural phenomena either observed or created experimentally, were to provide the basis for what he felt to be an entirely new natural philosophy....Only after the facts and experiments were properly verified and recorded, with the same or perhaps even greater certainty than facts in the courtroom, would the *New Organon*, itself derived at least in part from legal interrogatories, be implemented by sophisticated professionals." For Shapiro, Bacon's familiarity with both common and civil law procedures was crucial, and the procedures of the courtroom were central.

In contrast, Kocher (1957) and Wheeler (1983) suggest that Bacon's jurisprudence was central to his inductive reasoning and, thus, his broader epistemological framework (as opposed to Shapiro's focus on courtroom procedures and the collecting of facts). Wheeler (1983) argues that "...in his own investigations into the law, Bacon developed a hybrid research method that combined civil law and equity principles with those of the common law. That is, he combined a

method that rested upon hypothetico-deductive principles with one that was radically inductive....When Bacon turned to the problem of devising a new logic of inquiry that would be applicable to all empirical investigations in the natural as well as in the social sciences, he drew upon the methods that had proved effective for him in his civic law researches. He generalized the same 'natural history' research method for all science, social and natural alike. This was the empirico-deductive approach Bacon had already developed for the law and applied in the *Maxims [of the Law]*." Wheeler, therefore, seems to suggest that both the process of induction within common-law law-finding and the deductive principles within the civil-law tradition were important for Bacon's scientific epistemology. Moreover, whereas Shapiro focuses on the parallels between the legal and scientific determinations of facts, Wheeler focuses on the effect of the disparate common- and civil-law jurisprudence of developing the law itself.

Kocher (1957) generalized from Bacon's use of maxims (also referred to as aphorisms; short, pithy statements expressing a general truth or rule of conduct), "the generalizations or axioms of that middle order which Bacon throughout his philosophical writings describes as most fruitful for works". Kocher (1957) comments: "In natural science the utility of the middle axiom is to state a rule applicable to new physical situations. In jurisprudence the utility of the maxim is similarly to provide the premises upon which new cases can be decided, contradictions in existing cases erased, and analogies more safely followed out....But this is not the only significant resemblance between the legal maxim and the middle axiom of natural science. Both are derived by induction from accumulations of individual cases and then, once formulated, are applied back to determine particulars...Since the *Maxims of the Law* is...the earliest of all Bacon's known writings to champion the aphorism and certainly the earliest to display it in active use, we must reckon seriously with the possibility that he was much influenced towards it by his legal studies, and specifically by his study of the Civil Law." Thus, whereas Wheeler emphasizes the joining of the disparate civil- and common-law traditions within Bacon's analysis, Kocher emphasizes the similarity between the common-law process of finding the law and the civil-law epistemology of ascertaining scientific rules.

Martin (1992) mentions inductive epistemology and fact-seeking in the context of Bacon's legal theorizing but argues that Bacon's natural philosophy should be understood as reflecting Bacon's political plans for the reform of the law and the state rather than his common-law background per se: "...this study insists that Bacon's legal and political career was crucial in the creation of his natural philosophy and that his natural philosophy cannot be separated from his political ambitions". Furthermore, "...[Bacon's] reform of natural philosophy, no less than his proposed reform of law, was always governed by his political perspective...". When referring to Bacon's legal background, however, Martin very clearly points to Bacon's immersion in English common law (as opposed to continental civil law) as the particular legal source of influence on Bacon's thought. To understand Bacon, Martin argues it is "...important to remember that he was an experienced and learned Elizabethan common lawyer...". Martin repeats this point in commenting on Bacon's epistemology: "For Bacon, 'discovering' (i.e., uncovering) the truths of natural philosophy involved several stages, for each of which an exactly parallel feature existed

within the law as he practiced it...." Thus, in Martin's view, "...Bacon's procedures in natural philosophy were adapted by him from procedures in English law."

Finally, Simonds (1986), Cardwell (1990), and Serjeantson (2014) suggest that Bacon developed his ideas about the importance of fact-gathering and investigation exclusively based on his knowledge of continental civil and canon law. (That Bacon was well-read in and influenced by continental civil law is also noted by Wheeler (1983) and Kocher (1957); see above.) For example, Simonds (1986) comments that "...it was largely Bacon's civilian learning and professional experience that led him to an understanding of [the scientific] method". Cardwell (1990) argues that "...in administrative inquisition [as emphasized in the continental legal tradition] Bacon found a structure appropriate to his scientific enterprise, and in the inquisitorial procedure of preliminary legal examination Bacon saw language used in the way he thought the natural philosophers should use it in their commerce with Nature". Serjeantson notes that his research supports the view that "...Bacon's knowledge of the law might have helped shape his philosophy of science. Among recent scholars the rather different work of Harvey Wheeler and Julian Martin, in particular, come to mind. But this account has differed from the ones offered by them in emphasizing the significance of the civil law rather than the common law, reflecting the fact that...Bacon...drew his inspiration from the rule-governed civil law rather than the comparatively formless common law".

The precise set of Bacon's works considered by scholars grouped in this strand is often not made explicit. Kocher (1957) refers to a number of Bacon's methodological works, but among these focuses almost exclusively on the *Maxims of the Law*. In his short contribution, Simonds (1986) refers to, but hardly scrutinizes, aspects of the *Maxims of the Law*, *Reading on the Statute of Uses*, and an unnamed legal dictionary. Wheeler (1983) mentions, but never discusses in detail, "an informal survey" that the author undertook for purposes of his analysis. In drawing the analogy between Bacon's inquisitorial practice in court and his later examination of nature, Cardwell (1990) is explicit in making it clear that he draws on parts of *Novum Organum* and a select set of further works. When using Bacon's own works to draw parallels between Bacon's law and science, Martin (1992) draws primarily on Bacon's contributions about reform of the legal system and the science: "Bacon's reformed science of the law and his reformed natural philosophy have the same purpose, the same techniques, the same vocabulary and the same hierarchical organization" Martin (1992: 170). Shapiro (2000) briefly refers to Bacon's legal work in the context of the need to establish facts in the legal system, but references no specific legal works by Bacon when discussing Bacon's contributions to the development of ideas on the importance of ascertaining facts in natural history (Shapiro 2000). In conjecturing that "Bacon's general theory of the 'interpretation of nature' may perhaps also be regarded as having a significantly legal foundation", Serjeantson (2014) draws a parallel between Bacon's study of nature and the role of investigation in the legal process in the context of "a little-studied treatise" included in a volume published decades after Bacon's death.

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Summary

In sum, four conclusions stand out on the basis of a survey of the literature that makes some form of connection between Bacon's legal background and some aspect of his scientific methodology. First, there is a significant number of authors who comment on such a connection, but the number of authors who actually produce any detailed evidence in support of the connection (those in strand IV) is very small compared to the number who make brief comments (those in strand III). Second, there is no agreement in the literature on the nature of causality: sometimes the changing methodologies of law and science are viewed as parallel products of some other set of intellectual ideas; sometimes Bacon's scientific method is viewed as stimulating a new approach to the law; sometimes Bacon's knowledge of civil law is viewed as an ingredient in the invention of a new scientific method; and only in a very small minority of cases is Bacon's knowledge of the common-law viewed as an ingredient in the invention of a new scientific method. Third, among those few Bacon scholars who view his law as providing some input into the development of his scientific method (those in strands III and IV), there is disagreement on which aspects of Bacon's scientific method are most affected by his legal ideas. A majority of such scholars focus on analogies between the process of ascertaining facts in specific legal cases and experimentation in nature. Fewer focus on the similarity between the epistemology of finding/creating the law (or laws) and the use of induction to find scientific rules. Fourth, among those few Bacon scholars who view his law as providing some input into the development of his scientific method, there is disagreement about whether the common-law or the civil-law was most influential.

Our paper strives to shed new light on the connection between Bacon's legal background and his scientific methodology by examining a large corpus of Bacon's works and using novel analytical methods.

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Appendix B: Robustness checks

Purpose and summary of findings

This appendix reports findings from a series of robustness checks, mentioned in Section 4.2 of the paper. We investigated if an emphasis in Bacon on either the utilitarian promise of science or the centralized organization of the scientific quest, which cannot be detected in STM models with 16 topics, can perhaps be detected in estimates of an STM with a much larger numbers of topics. Increasing the number of topics decreases standard measures of both model-fit and the average coherence of estimated topics, rendering such models clearly inferior to our chosen 16-topic STM. However, the estimation of models featuring a number of topics larger than 16 allows us to explore whether an emphasis on utilitarianism and centralized organization of science can perhaps be discovered at a greater level of topic granularity than suggested by standard criteria for the choice of the number of topics.

We estimated models with 32, 48, 64, and 100 topics, examining the topics within each. For each estimated model we followed the same process for examining the topical content as described earlier in this section. In particular, after closely inspecting the word lists for all estimated topics for a given model, we read the twenty documents that featured a given topic most prominently for all those estimated topics for which the highest probability and FREX words were even remotely suggestive of ideas that could be potentially linked to utilitarianism or organization of science.

The key insight obtained on the basis of this exercise is that, even when estimating STMs at much higher levels of granularity, we continue to see no emphasis in Bacon on either of the two ideas, the utilitarian promise of science or its centralized organization. For the 32-topic, 48-topic, and 64-topic STMs, respectively, we found no evidence whatsoever of an emphasis by Bacon on utilitarian ideas or centralized organization of science. We found virtually no indication of such ideas even in the 100-topic STM, the highest level of granularity that we explored.

Below, we detail the process that we followed when examining the content of topics estimated in the 100-topic model, the highest level of granularity that we explored. For example, the 100-topic STM contains a topic where Bacon discusses (what we might term today) social-welfare criteria. Yet there is no evidence of an emphasis on the utilitarian promise of science in that topic. In fact, in a document from Novum Organum that features this topic particularly prominently, Bacon articulates a distinctly non-utilitarian view: "Truth, therefore, and utility, are here perfectly identical, and the effects are of more value as pledges of truth than from the benefit they confer on men" (Bacon 2014, Section CXXIV). Similarly, in another topic where Bacon surveys the tasks required in generating and evaluating evidence, there is no discernible emphasis on the centralized organization of the scientific quest. Indeed, in a document featuring that particular topic Bacon comments: "...in the habits and regulations of schools, universities, and the like assemblies, destined for the abode of learned men and the improvement of learning, everything is found to be opposed to the progress of the sciences" (Bacon 2014, Section XC). Finally, neither

of these two topics from the 100-topic STM were in the top half of the ranking of topics based on their relative importance in the corpus (see Figure B2 and the discussion below).

Detailed analysis of 100-topic STM

Figure B1 illustrates that increasing the number of topics above 16 results in a very significant decrease in the standard measures of both model-fit and the average coherence of estimated topics, rendering such models clearly inferior to our chosen 16-topic STM. An implication of the reduction in coherence (internal consistency) of the estimated topics in STMs with a large number of topics is that it is in general more difficult to pin down the precise content of, and hence assign names to, the estimated topics.

Panel B1 lists the highest probability and FREX words for all 100 topics in the 100-topic STM. A close inspection of the word lists revealed that in the overwhelming majority of topics, there exists absolutely no trace whatsoever of ideas about either the utilitarian promise of science or the centralized organization of scientific quest. Indeed, we found no word list that readily suggested topics that corresponded to either of these ideas. We therefore decided to investigate further any topic whose word lists contained any hint whatsoever of these two ideas. We identified five such topics: 89, 18, 73, 63, and 84 (as highlighted in Panel B1). Figure B2 shows the relative importance of these topics in the corpus based on the expected topic proportion, indicating that, among these five topics, only topic 18 is ranked in the top half of all topics. For each of these five topics, we identified the top twenty documents in which a given topic is featured most prominently. We then carefully examined each of those documents in order to ascertain the core of each topic's content and in particular if we could detect any emphasis on the two sets of ideas. (The process for these five topics matched the process for labeling the 16-topic model described in Section 4 of the paper.)

Topic 89 is about (what might today be referred to as) social welfare criteria. The documents featuring this topic prominently include *The Beginning of the History of Great Britain*, *The History of the Reign of King Henry the Eighth*, a section from *The History of the Reign of King Henry the Seventh*, three sections from *Novum Organum*, an essay on nobility, and a series of private letters. In these documents, Bacon discusses judgments on how well countries are doing and how rulers are performing, as well as elaborates on the capacities that signify people as good rulers or servants of rulers.

In the first among the documents from *Novum Organum* that feature topic 89 prominently, Bacon discusses criteria in pursuing knowledge, as in: "Yet men are hurried on with the same senseless energy and useless combination in intellectual matters". In the second among the documents from *Novum Organum* that feature this topic prominently, Bacon comments on the ways through which mankind can establish dominion over nature: "For man, by the fall, lost at once his state of innocence, and his empire over creation, both of which can be partially recovered even in this life, the first by religion and faith, the second by the arts and sciences. For creation did not become entirely and utterly rebellious by the curse, but in consequence of the Divine decree, 'in the sweat of thy brow shalt thou eat bread', she is compelled by our labors (not assuredly by our

disputes or magical ceremonies), at length, to afford mankind in some degree his bread, that is to say, to supply man's daily wants." Thus, sciences represent one, but only a secondary, path for mankind to reconquer nature.

In the third document from *Novum Organum* that features this topic prominently, Bacon comments on the value of inventions—but never articulates a utilitarian view of science per se: "...we should notice the force, effect, and consequences of inventions, which are nowhere more conspicuous than in those three which were unknown to the ancients; namely, printing, gunpowder, and the compass. For these three have changed the appearance and state of the whole world: first in literature, then in warfare, and lastly in navigation; and innumerable changes have been thence derived, so that no empire, sect, or star, appears to have exercised a greater power and influence on human affairs than these mechanical discoveries....". In the same document, Bacon in fact argues that truth *is* utility¹: "Another objection will without doubt be made, namely, that we have not ourselves established a correct, or the best goal or aim of the sciences (the very defect we blame in others). For they will say that the contemplation of truth is more dignified and exalted than any utility or extent of effects;Let men learn (as we have said above) the difference that exists between the idols of the human mind and the ideas of the divine mind. The former are mere arbitrary abstractions; the latter the true marks of the Creator on his creatures, as they are imprinted on, and defined in matter, by true and exquisite touches. *Truth, therefore, and utility, are here perfectly identical* [emphasis added], and the effects are of more value as pledges of truth than from the benefit they confer on men." Even though this topic concerns social welfare criteria, it definitely does not provide a perspective that emphasizes the utilitarian promise of science.

Topic 18 is about positive individual qualities, either in people or in things. This topic is featured prominently in a number of Bacon's letters and in two essays, one on innovation and one on nature in men. In these, Bacon discusses people, processes, and objects in isolation, as opposed to within the context of society as a whole. This topic is also featured in a passage from the *New Atlantis* and a passage from the *Novum Organum*. In the former, Bacon lists items for scientific uses appearing in Bensalem, elaborating on what specific items or people do and/or are good for. In the latter, Bacon evaluates the qualities of the scientific process (e.g. "The advantage, by which these instances excel the more ordinary, regards specifically either theory or practice, or both"). Further documents featuring this topic prominently are a passage from *A Collection of Apothegms New and Old* where Bacon reviews stories that illuminate the personal qualities of people. In none of the documents featuring this topic prominently can we find comments indicative of the utilitarian aspects of science or the centralized organization of scientific quest.

¹ The OED entry characterizes 'utility' as "the fact, character, or quality of being useful or serviceable; fitness for some desirable purpose or valuable end; usefulness, serviceableness. In frequent use c1540–1650, and from c1755". The first time that 'utility' is defined as "the ability, capacity, or power of a person, action, or thing to satisfy the needs or gratify the desires of the majority, or of the human race as a whole" is dated to 1751. Another use of 'utility' in Bacon's time is "the quality of being advantageous or profitable, profit, advantage".

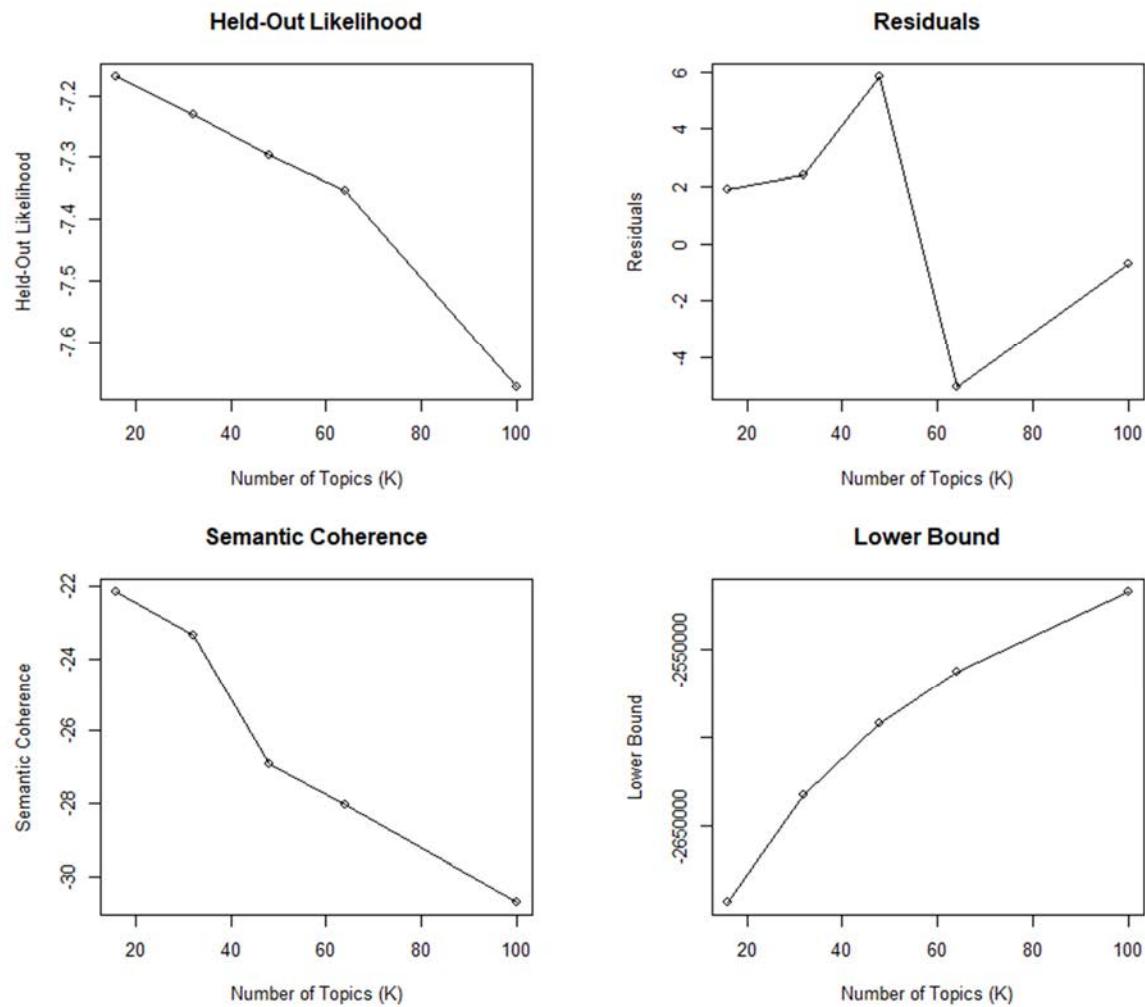
Topic 73 is about tasks in generating and evaluating evidence. It entails a delineation of the tasks involved in such processes, with Bacon emphasizing their onerous and challenging aspects. For example, in the document featuring this topic most prominently, *A Preparatory to the Natural and Experimental History*, Bacon notes that "...nor can it be compassed without vast labour and charges, as that which stands in need of many mens endeavours...For, as for the business itself of the intellect, possibly we shall be able to conquer that with our own strength; but the materials of the understanding are of so large an extent, that those must be gain'd and brought in from every place.... Besides we esteem it as a thing scarce worthy our enterprize, that we ourselves should spend time in such a business as is obtainable by almost all mens industries." Nowhere does Bacon suggest anything about centralization and organization. Indeed, in a passage from the part of *Novum Organum* that is ranked 20th among those featuring this topic prominently, Bacon actually remarks: "...in the habits and regulations of schools, universities, and the like assemblies, destined for the abode of learned men and the improvement of learning, *everything is found to be opposed to the progress of the sciences* [emphasis added]." Based on the same part of *Novum Organum*, one could argue that Bacon, if anything, advocated *decentralization* of the scientific quest: "If, therefore, there be any one who is more disposed and prepared for mechanical art, and ingenious in discovering effects, than in the mere management of experiment, we allow him to employ his industry in gathering many of the fruits of our history and tables in this way, and applying them to effects, receiving them as interest till he can obtain the principal." Even though this topic focuses on the processes of science, it definitely does not provide a perspective that emphasizes centralized organization.

Topic 63 could be best described by Bacon himself as "a small globe of the intellectual world", a phrase Bacon uses in one of passages from *The Advancement of Learning* that features this topic prominently. In that document, Bacon focuses on pointing out "...those errors and vanities which have intervened amongst the studies themselves of the learned, which is that which is principal and proper to the present argument; wherein my purpose is not to make a justification of the errors, but by a censure and separation of the errors to make a justification of that which is good and sound, and to deliver that from the aspersion of the other." This topic is also featured prominently in Bacon's essays, for example, on subjects such as studies, innovations, discourse, seeming wise, dispatches, atheism, superstition, cunning, beauty, and adversity. The common thread of these works is that Bacon offers classifications, and discusses the properties, of good and bad. This topic is not about organization of science and also not about the overall goals of scientific endeavor. Indeed, the closest Bacon comes to a discussion that resembles elements of utilitarianism and centralized organization is in *A Speech Touching the Recovering of Drowned Mineral Works*. In this work, ranked as low as 20th on the list of documents that feature this topic, Bacon addresses the parliament with the following proposition with which he hopes to draw "...his majesty into a serious consideration of the mineral treasures of his own territories, and the practical discoveries of them by way of [his] philosophical theory". Bacon views the "recovering all such drowned mineral work" as "the most probable means to relieve all the poor thereof without any other stock or benevolence, than that which divine bounty should confer on their own industries and honest

labours". Thus, Bacon argues, "...by this unchangeable way...have I proposed to erect the academical fabric of this island's Salomon's House, modelled in my New Atlantis. And I can hope...that my midnight studies to make our countries flourish and outvye European neighbours in mysterious and beneficent arts, have not so ingratefully affected the whole intellects, that you will delay or resist his majesty's desires, and my humble petition in this benevolent, yea, magnificent affair." Note, however, that Bacon's argument here is focused on the specific pursuit of mining and *not* on the scientific quest per se.

The theme of topic 84 is individuals interacting. Bacon emphasizes what happens when a small number of people (often only two) interact—in politics, in legal affairs, in government, in economic situations—and makes value judgments about those interactions. Documents featuring this topic prominently are the essay *A Fragment of the Colors of Good and Evil*, which features a general discussion of different types of arguments, whether they are good or bad, and whether they work or not; several *Maxims of the Law* (e.g. on when several persons' actions when viewed as a whole can be taken as lawful); a speech upon a noble's appointment to Lord Chief Justice of Ireland (where Bacon among others emphasizes that working together with others is important); and a number of other essays (e.g. on suitors, on discourse, on deformity, on superstition). None of the documents featuring this topic prominently involve a discussion of either the utilitarian promise of science or the centralized organization of scientific quest.

Figure B1



Panel B1

Topic 1 Top Words:

Highest Prob: sound, air, make, water, will, string, one, give, great, upon, voic, caus, bodi, tone, motion, nois, note, strike, may, percuss, hear, part, dram, wind, shall, weigh, two, man, grain, though

FREX: tone, string, percuss, dram, nois, sound, articul, concav, tripl, pipe, diapason, bell, loud, interior, grain, trunk, barrel, bullet, weigh, lute, overweigh, voic, strike, exterior, air, outsid, unison, bellow, music, sauncer

Topic 2 Top Words:

Highest Prob: histori, learn, man, may, natur, great, will, time, shall, well, can, therefor, work, use, see, make, yet, part, like, state, book, memori, action, thing, mani, one, command, small, mind, much

FREX: histori, defici, immort, profici, stori, journal, learn, narrat, design, virgil, usag, brotherhood, magnific, commentari, monument, endow, writer, memori, personag, relianc, detur, ultra, illumin, univers, oblivion, memor, hippia, reader, extant, chronicl

Topic 3 Top Words:

Highest Prob: law, shall, feoff, yet, make, act, use, land, will, die, heir, therefor, say, statut, limit, enter, bind, purchas, condit, upon, servic, devis, seiz, first, part, take, dissent, rend, caus, hold

FREX: dissent, compuls, feoff, devis, purchas, duress, knight, pursuanc, fee, dagger, limit, feme, lesse, survivor, remot, fitzherbert, dyer, impuls, joint, descent, emerg, act, useless, enter, heir, rend, seiz, leas, pistol, condit

Topic 4 Top Words:

Highest Prob: law, war, nation, make, will, shall, say, may, man, yet, upon, natur, christian, speak, peopl, whether, part, though, govern, now, take, first, great, pollio, god, case, can, true, without, one

FREX: pollio, infidel, pirat, christian, nation, worship, propag, turk, idolatri, christendom, war, reproach, defac, signori, vindic, methink, mexico, enterpris, freeman, heresi, idol, societi, tempor, extirp, ottoman, obligatori, gentil, barbarian, holi, peru

Topic 5 Top Words:

Highest Prob: lordship, majesti, upon, may, will, honour, shall, great, make, now, lord, good, humbl, time, know, matter, yet, can, rather, war, take, unto, one, like, come, therefor, much, think, self, thing

FREX: lordship, humbl, peril, william, treasur, honour, includ, presum, agendum, merit, ormond, harvest, popular, aspect, accept, irish, soev, solicitor, burghley, brograv, shelf, fran, cecil, earl, subsidi, singular, reconquest, tie, reduct, vouchsaf

Topic 6 Top Words:

Highest Prob: majesti, may, shall, good, self, will, think, toward, servic, time, move, poor, thing, princ, ever, heart, gracious, miseri, leav, great, now, god, king, give, way, though, hand, one, often, far

FREX: miseri, murrey, gracious, prize, relief, nineteen, majesti, thrice, piti, poor, sovereign, prosper, pieti, grace, move, comfort, pull, fault, often, merci, almighty, advers, sentenc, fountain, gentleman, beseech, humbl, heart, improvid, offend

Topic 7 Top Words:

Highest Prob: caus, water, bodi, make, will, spirit, see, part, upon, may, great, tooth, come, thing, man, can, also, like, shall, put, motion, turn, stone, one, sweat, find, use, therefor, take, time

FREX: tooth, sweat, tickl, expel, marrow, shell, coal, beak, skin, moistur, nail, skull, compress, leaf, worm, horn, laugh, bone, lassitud, cantharid, basen, quar, drunken, pale, pensil, leg, groan, char, coral, visual

Topic 8 Top Words:

Highest Prob: spirit, man, bodi, part, old, young, thing, oil, heat, also, live, one, will, long, self, motion, wine, forth, water, air, substanc, see, much, blood, canon, flame, now, can, yet, three

FREX: commix, vitriol, vital, oil, refriger, dram, canon, explic, cell, almond, detent, spirit, perspir, milk, petroleum, gross, intener, young, suffoc, mouldi, pluck, vivif, eel, milki, old, wine, leg, ventricel, hair, connatur

Topic 9 Top Words:

Highest Prob: man, good, natur, mind, like, great, shall, make, will, use, give, thou, virtu, much, upon, come, kind, excess, affect, littl, show, light, take, can, let, one, habit, toward, therefor, part

FREX: chariti, doctor, excess, angel, facil, shine, mke, ungraci, portraitur, imprint, compliment, italian, strait, habit, thou, invest, malign, puls, timber, hit, collater, opportun, behaviour, boy, pattern, dog, draught, bewar, articl, gain

Topic 10 Top Words:

Highest Prob: king, upon, great, make, will, time, shall, man, peopl, princ, come, take, part, also, perkin, well, one, year, may, england, much, can, yet, earl, person, give, unto, say, two, put

FREX: perkin, castill, ferdinando, fillip, chamberlain, katherin, rebel, empson, ken, duke, aragon, treati, earl, stanley, warwick, exet, suffolk, cornwal, scottish, cornishmen, arthur, clifford, arch, dudley, flander, napl, bray, castl, duchess, fatherlaw

Topic 11 Top Words:

Highest Prob: learn, say, make, man, speech, alexand, will, use, great, princ, king, upon, excel, time, one, thing, virtu, name, give, yet, shall, unto, caesar, see, can, come, note, may, speak, word

FREX: trajan, alexand, antoninus, callisthen, antipat, homer, falinus, learn, diogen, xenophon, commodus, parmenio, adorn, caesar, predecessor, vener, succeed, vox, eloqu, silenus, pleasu, speech, nerva, emperor, dictat, cassandra, cashier, metellus, darius, quirit

Topic 12 Top Words:

Highest Prob: year, man, live, hundr, age, life, nourish, one, great, eighti, long, also, old, time, nineti, woman, may, mani, well, upon, twenti, four, creatur, seven, yet, five, will, thirti, three, less

FREX: nineti, eighti, hundr, seventi, fifti, thirti, live, nourish, year, rhetorician, fourscor, eight, marcus, age, fulfil, simeon, graft, woman, affabl, xenophan, sixti, twenti, austar, calm, aaron, betwixt, flood, veneri, elder, weep

Topic 13 Top Words:

Highest Prob: grant, land, name, true, yet, one, thing, pass, unto, addit, patent, word, fals, refer, shall, day, tenur, demonstr, whereof, upon, although, good, parish, certainti, part, law, therefor, rule, first, counti

FREX: falsiti, indentur, varianc, denomin, dale, parish, tenur, annex, addit, patent, specificat, rubi, burst, grant, date, certainti, appel, gentlewoman, specifi, demonstr, counti, meum, manor, dunstan, indentura, box, precinct, fals, refer, promontori

Topic 14 Top Words:

Highest Prob: law, shall, will, time, now, can, one, may, make, natur, born, man, first, reason, custom, point, mind, see, work, case, say, occas, without, therefor, either, write, self, put, like, take

FREX: born, ant, unwis, post, union, noos, restrict, madam, yoke, custom, expect, succeed, spectat, droit, baptism, latin, privileg, legitim, occas, payment, articul, expir, pair, wherea, hostil, summar, daughter, zeal, compil, acquir

Topic 15 Top Words:

Highest Prob: bodi, water, will, part, make, draw, see, air, upon, nourish, great, cold, also, like, therefor, may, natur, spirit, heat, littl, time, put, caus, first, shall, take, glass, well, flame, much

FREX: amber, purger, version, urin, rub, clay, indur, ice, gut, attract, rhubarb, pebbl, dens, pellet, tangibl, stomach, electr, nourish, minc, yolk, cream, mesenteri, wool, purg, infus, cow, foment, staunch, cold, windi

Topic 16 Top Words:

Highest Prob: say, will, one, answer, man, upon, great, come, lord, king, sir, take, make, shall, ask, queen, give, tell, may, see, can, like, know, much, time, think, hous, mean, use, friend

FREX: nichola, pompey, vespasian, madam, cardin, diogen, yes, raleigh, ask, lacedaemonian, archbishop, crassus, sir, answer, pyrrhus, walter, captain, pillow, uva, inn, ladi, pillori, boot, peasant, pope, queen, aristippus, rabelai, rescript, whitehead

Topic 17 Top Words:

Highest Prob: tree, will, upon, plant, fruit, make, earth, may, put, water, root, grow, caus, forth, ground, come, herb, also, seed, great, like, leav, flower, set, see, kind, one, therefor, bear, much

FREX: sap, dung, moss, herb, bough, oak, cucumb, stalk, tree, graft, mushroom, lettuc, fig, plant, sprout, colewort, mistleto, plum, radish, vine, prickl, escul, baiz, pear, chalk, seed, tion, gilli, holli, peach

Topic 18 Top Words:

Highest Prob: new, good, make, can, man, year, letter, experi, god, give, inventor, practic, shall, great, gift, self, mind, mean, call, love, think, may, sinc, hous, preced, first, use, also, lordship, long

FREX: inventor, innov, aspir, recommend, gift, unknown, ceremoni, june, pray, fellow, statu, sorri, music, davi, axletre, engin, sake, experi, astronomi, repos, gravil, ducat, new, practic, preced, gunpowd, visit, letter, wing, conceal

Topic 19 Top Words:

Highest Prob: heat, natur, bodi, cold, fire, hot, air, thing, will, make, instanc, flame, water, burn, warm, degre, also, yet, glass, let, first, may, one, appear, motion, self, must, like, tabl, upon

FREX: warm, ignit, heat, hot, perpendicular, negat, ray, expans, exclus, burn, howev, cold, reject, flame, liquid, sparkl, weather, dung, tube, instanc, tenuiti, subjoin, attrit, decreas, fire, potenti, anim, apron, glass, friction

Topic 20 Top Words:

Highest Prob: god, man, thou, thi, shall, work, time, holi, will, earth, spirit, lord, day, word, creatur, unto, make, natur, thing, good, yet, one, law, may, can, christ, great, world, first, etern

FREX: thi, etern, ghost, thou, creation, psalm, christ, holi, mediat, jesus, uniti, righteous, translat, bide, redempt, sing, carol, godhead, reveal, everlast, wick, prais, pour, god, regener, creat, along, miracl, soul, brittl

Topic 21 Top Words:

Highest Prob: man, shall, will, king, may, upon, think, say, undertak, good, parliament, thing, make, hous, lie, can, truth, mind, like, suspicion, light, much, know, well, find, opinion, yet, natur, must, self

FREX: suspicion, undertak, pack, fort, card, silent, parliament, committe, rumour, protest, truth, messag, giddi, woo, suspect, fede, brambl, diffid, smother, shrink, dress, hous, buzz, falsehood, dust, poplar, betray, price, coin, stout

Topic 22 Top Words:

Highest Prob: land, make, shall, use, estat, man, heir, life, statut, entail, can, will, upon, tenant, leas, good, may, seiz, convey, give, call, felonii, fine, three, son, forfeit, debt, time, year, parti

FREX: entail, viii, forfeit, leas, tail, liveri, debt, feesimpl, convey, revers, recoveri, tenant, land, chattel, wardship, escheat, heir, bargain, felonii, remaind, attaint, attaind, estat, seiz, cestui, sale, soccag, outlawri, owner, fine

Topic 23 Top Words:

Highest Prob: land, heir, shall, call, servic, man, king, tenant, inherit, upon, knight, hold, make, son, lord, day, court, tenur, one, judg, may, can, first, die, seiz, take, give, person, enter, everi

FREX: tenur, inherit, knight, escheat, soccag, heir, prius, attaint, nisi, ancestor, tenor, tenant, land, juri, uncl, manor, ken, assiz, capit, verdict, plough, freehold, sue, writ, sister, sheriff, harvest, descent, escuag, acr

Topic 24 Top Words:

Highest Prob: lord, overburi, will, impoison, poison, shall, somerset, first, upon, man, may, murder, must, make, can, secret, king, give, great, time, act, three, proof, tower, part, say, natur, ladi, mean, self

FREX: overburi, somerset, impoison, empoison, poison, tower, murder, weston, displac, ladi, hatr, proof, abet, lieuten, peer, keeper, trap, prison, malic, lord, secret, evid, gradus, friendship, steward, packet, jargon, defenc, intox, divert

Topic 25 Top Words:

Highest Prob: court, law, man, shall, say, upon, may, honour, case, judg, will, make, caus, person, duel, majesti, great, time, take, challeng, lord, justic, like, offend, punish, give, general, think, much, though

FREX: duel, challeng, combat, court, punish, fight, quarrel, decre, advoc, attorney, censur, martial, priest, contum, misdemeanour, offend, fortitud, depos, combin, judg, murder, lion, capit, certif, disgrac, proclam, surrey, clerk, insidi, homicid

Topic 26 Top Words:

Highest Prob: law, case, will, may, time, rule, shall, man, author, good, work, use, reason, yet, make, judgement, cours, majesti, book, great, new, one, now, matter, better, first, doubt, mani, set, either

FREX: student, lawyer, vacant, resp, innov, incertanti, civilian, languag, penal, text, recompil, obsolet, exposit, yearbook, quotat, rule, vouch, abridg, repetit, debat, law, book, regist, decis, unprofit, author, finch, compos, institut, commonlaw

Topic 27 Top Words:

Highest Prob: say, will, man, one, come, shall, upon, answer, take, great, king, like, now, wise, sir, reveng, pass, make, time, friend, father, give, hear, never, wrong, mani, better, day, use, gentleman

FREX: aristippus, seaman, themistocl, owl, antigonus, reveng, pater, falinus, cato, florenc, udg, vindict, pericl, maker, forgiv, harbinc, spartan, fool, alcibiad, wager, grand, horn, mad, coward, popham, truce, fabius, shave, pace, wrong

Topic 28 Top Words:

Highest Prob: use, statut, feoff, law, upon, case, shall, make, will, say, take, time, trust, remedi, consider, commonlaw, good, may, give, reason, therefor, one, conscienc, cesti, land, possess, right, matter, find, noth

FREX: cesti, feoff, statut, commonlaw, subpoena, notic, trust, conscienc, chanceri, mortmain, covin, regina, tenanc, richard, collus, henri, cap, relief, praecip, creditor, remedi, consider, use, herbert, possess, quaer, exposit, provisor, recontinu, case

Topic 29 Top Words:

Highest Prob: majesti, shall, make, will, king, lord, must, great, may, justic, upon, god, good, judg, one, think, take, much, self, speak, busi, fear, coke, know, first, tabl, opinion, law, say, honour

FREX: coke, matthew, patent, owen, tabl, compani, relgion, amiss, peacham, penalti, recus, essay, fear, subscrib, sergeant, addit, exchequ, acquaint, majesti, judg, scale, justic, crook, bench, pieti, lest, flatter, warrant, paper, revenu

Topic 30 Top Words:

Highest Prob: king, shall, law, man, inquir, therefor, take, offend, god, three, concern, first, will, make, person, peopl, present, time, unto, life, say, within, upon, treason, hous, may, second, part, church, felonii

FREX: verg, recus, supremaci, inquir, offend, capit, unlaw, jesuit, oath, perjuri, mile, safeti, weapon, witchcraft, seminari, felonii, malici, stab, monitor, wil, treason, impun, fraud, carpet, offend, robberi, yard, disguis, profan, aswel

Topic 31 Top Words:

Highest Prob: natur, will, man, scienc, experi, one, philosophi, great, yet, may, can, hope, discoveri, shall, even, mind, new, observ, particular, thing, matter, upon, age, therefor, rather, make, first, time, caus, understand

FREX: instinct, unanim, discoveri, investig, system, mankind, axiom, philosophi, scienc, mode, theori, intermedi, meantim, induct, mechan, epoch, pueril, arrang, hesit, result, everyth, whatev, deduc, hitherto, afford, instaur, research, vagu, howev, notion

Topic 32 Top Words:

Highest Prob: will, metal, make, silver, iron, brass, ounc, gold, incorpor, glass, may, use, lead, bodi, stone, whether, inquir, weight, copper, first, colour, like, tin, sever, well, fire, mixturm, compound, half, melt

FREX: ounc, brass, tin, copper, metal, silver, calcin, incorpor, addita, quicksilv, iron, stuff, tough, melt, fixat, calaminar, gold, malleabl, cheap, vitrifi, luster, flint, compound, plate, item, glass, volatil, vitrif, electrum, steel

Topic 33 Top Words:

Highest Prob: instanc, bodi, motion, natur, water, will, heat, air, place, may, also, power, part, can, observ, spirit, must, one, great, like, substanc, differ, shall, let, effect, flame, first, appear, take, therefor

FREX: magnet, similar, instanc, expans, rapid, class, migrat, expand, conspicu, exist, contact, howev, tendenc, investig, sphere, anim, particl, deviat, homogen, format, concret, classif, liquid, predomin, imped, clandestin, compress, veloc, ebb, speci

Topic 34 Top Words:

Highest Prob: man, good, natur, great, part, duti, can, much, make, one, say, life, will, virtu, mind, thing, upon, write, knowledg, may, place, well, concern, felic, yet, see, whereof, opinion, first, give

FREX: needless, felic, duti, societi, passiv, socrat, sophist, activ, doctrin, conserv, resum, eam, perturb, exemplar, faculti, fruition, exalt, cabinet, divis, decid, vita, contempl, profess, fifteen, censur, honesti, everyth, cultur, presuppos, itch

Topic 35 Top Words:

Highest Prob: sound, will, make, bodi, air, see, one, echo, hear, may, much, shall, like, man, great, light, speak, pass, upon, visibl, string, voic, well, come, time, better, therefor, motion, side, stand

FREX: echo, visibl, audibl, medium, sound, pipe, string, bell, lute, speci, vial, repercuss, delat, reflect, sight, distanc, voic, concav, pupil, harp, line, cranni, purl, music, nois, grate, unison, local, yawn, wall

Topic 36 Top Words:

Highest Prob: man, say, make, natur, fortun, may, can, will, good, mind, time, see, upon, thing, knowledg, great, one, much, part, like, shall, yet, virtu, first, use, well, wisdom, govern, wherein, anoth

FREX: eam, lover, precept, sapien, fortun, livi, cato, decenc, moral, cicero, magnus, oneself, caution, pursuit, machiavelli, behaviour, animi, chanc, sinew, transgress, porta, virtus, knowledg, eleg, anyth, quomodo, handmaid, haec, defici, sulla

Topic 37 Top Words:

Highest Prob: law, time, upon, king, may, make, good, well, give, say, great, statut, majesti, first, work, will, part, thing, like, yet, speak, god, long, custom, caesar, theme, now, man, subject, mani

FREX: theme, lawgiv, compil, pembrok, commission, sulla, poster, lycurgus, scribe, graft, recompl, saxon, repeal, bid, mishap, callisthen, caesar, justinian, golden, edict, nil, alexand, discounten, prais, ordin, digest, decemvir, edgar, danish, solon

Topic 38 Top Words:

Highest Prob: king, spain, great, upon, majesti, will, shall, letter, matter, time, make, good, mean, man, take, first, say, servic, last, unto, like, one, also, may, can, antonio, know, find, manuel, receiv

FREX: antonio, manuel, spain, intellig, count, portug, invas, calai, emanuel, advertis, mendoza, evas, secretari, whither, confer, sum, apprehend, confess, realm, intercept, detest, franc, credenc, traitor, expostulatori, letter, cun, hostil, antwerp, reveal

Topic 39 Top Words:

Highest Prob: motion, bodi, thing, water, will, heat, part, may, one, natur, yet, togeth, air, must, great, can, come, place, first, desir, let, like, name, self, sea, well, upon, make, call, spirit

FREX: congreg, ebb, vacuiti, coition, motion, predomin, connexion, flow, load, magnet, gun, assimil, heterogen, dimens, homogen, excit, rotat, abhor, centaur, curb, numb, pole, lesser, shore, penetr, compress, bullet, atlant, florida, decisori

Topic 40 Top Words:

Highest Prob: king, upon, time, make, shall, great, will, part, may, britain, take, person, come, duke, lord, man, yet, peopl, french, also, law, one, first, parliament, good, think, peac, unto, war, much

FREX: duke, plantagenet, britain, french, lincoln, lovel, york, richard, maximilian, sanctuari, ambassador, succour, orlean, earl, briton, treati, battl, clarenc, coron, urswick, simon, flander, stafford, margaret, dowag, burgundi, rebel, councillor, charl, fight

Topic 41 Top Words:

Highest Prob: great, may, upon, war, peopl, state, will, plantat, make, man, thing, estat, like, let, roman, time, arm, can, yet, mani, common, world, natur, therefor, plant, subject, shall, countri, say, kingdom

FREX: plantat, jus, fiddl, martial, courag, expens, armi, effemin, victual, roman, ordnanc, popul, battl, timor, habilit, nobleman, sparta, peasant, empir, militia, war, warlik, veteran, stem, spread, lazi, persian, turk, penuri, decay

Topic 42 Top Words:

Highest Prob: great, one, natur, state, time, faction, make, union, man, bodi, kingdom, see, mani, yet, first, take, govern, common, upon, will, king, may, justic, motion, well, princ, particular, hold, like, much

FREX: faction, sedit, discontent, union, cassius, communiti, judah, unit, conjunct, sabin, sovereignti, candidaci, israel, opus, vote, subdivid, tacitus, earthquak, leagu, sign, convert, audaci, somewher, stock, epimetheus, mobil, leo, troy, aragon, unperfect

Topic 43 Top Words:

Highest Prob: king, make, upon, war, time, will, great, unto, franc, shall, peac, may, lord, thing, think, know, person, maximilian, can, good, now, england, yet, come, part, french, one, duke, well, give

FREX: maximilian, perkin, flander, bruge, york, duchess, ambassador, duke, charl, french, franc, ferdinando, richard, sluic, tirrel, john, britain, ladi, margaret, prior, frion, ravenstein, simnel, lambert, dismiss, tower, ambassag, napl, burgundi, confeder

Topic 44 Top Words:

Highest Prob: thing, man, natur, may, say, will, shall, unto, seem, also, jupit, time, god, see, mani, yet, much, prometheus, well, take, one, invent, fabl, great, like, neither, first, make, good, everi

FREX: prometheus, jupit, typhon, atalanta, parabl, page, bacchus, miss, moreov, pan, allegori, giant, gorg, scylla, icarus, arthur, fabl, torch, apollo, thunderbolt, mercuri, muse, chariot, serpent, sphinx, ball, wrest, mysteri, transced, insurrect

Topic 45 Top Words:

Highest Prob: counsel, king, man, great, thing, upon, danger, princ, will, one, first, like, counsellor, make, come, time, good, matter, person, use, second, author, common, take, may, mani, henri, sometim, let, father

FREX: counsellor, counsel, henri, solyman, danger, ripe, secreci, destruct, nero, neighbour, meti, noddl, sentinel, outrun, charl, memento, celer, toss, trade, skil, jealous, palla, cabinet, affair, fatal, committe, potent, depress, vespasian, consort

Topic 46 Top Words:

Highest Prob: church, shall, may, god, upon, bishop, time, man, thing, will, great, one, yet, good, well, matter, word, minist, say, give, make, caus, therefor, first, think, can, reason, majesti, see, law

FREX: preacher, church, pastor, liturgi, bishop, preach, jurisdict, baptism, minist, excommun, plural, prayer, ministri, primit, mainten, spiritu, benefic, ecclesiast, tith, nonlatin, reform, ecclesia, tempor, holi, dean, edif, impropri, grave, accus, extol

Topic 47 Top Words:

Highest Prob: knowledg, use, man, method, great, make, may, speech, will, therefor, reason, one, word, thing, part, good, shall, write, see, anoth, say, rhetor, matter, scienc, well, much, place, memori, tradit, can

FREX: method, rhetor, cipher, tradit, logic, eloqu, knowledg, defici, hieroglyph, aphor, deliveri, cogit, grammar, stammer, enfold, illustr, inquiri, gestur, transit, charact, emblem, everyth, memori, speech, danc, jest, tongu, malum, similitud, aristotl

Topic 48 Top Words:

Highest Prob: man, anger, will, natur, time, first, let, fame, well, therefor, thing, dissimul, great, make, upon, must, mani, can, three, may, open, secret, habit, take, say, mind, set, good, second, much

FREX: anger, dissimul, fame, simul, angri, folk, secreci, tiberius, vitellius, habit, contempt, asleep, mucianus, dissembl, froward, augustus, close, pick, appeas, injuri, refrain, disadvantag, wari, secret, legion, intermiss, historian, hide, spoil, whosoev

Topic 49 Top Words:

Highest Prob: thing, man, natur, say, may, make, see, one, will, shall, world, come, take, god, place, great, yet, child, like, two, first, mani, famili, pan, kind, time, also, order, work, part

FREX: bensalem, pan, perseus, herald, saturn, orpheus, pentheus, feast, thebe, famili, palla, giant, coelum, actaeon, shield, sister, harmoni, grape, goat, mantl, hunt, marriag, parent, enamel, endymion, jew, wanton, ivi, pace, luna

Topic 50 Top Words:

Highest Prob: war, upon, spain, great, will, man, come, make, time, part, state, shall, yet, spaniard, say, take, forc, fear, just, may, sea, year, ship, king, now, speak, english, land, armi, england

FREX: spaniard, palatin, navi, spain, spanish, valour, germani, parma, invas, defens, fight, war, armi, english, ship, drake, fleet, offens, thousand, bohemia, fort, retreat, lacedaemonian, syria, defeat, enterpris, duke, brave, milan, venic

Topic 51 Top Words:

Highest Prob: king, will, shall, man, law, may, upon, give, can, subject, princ, one, lord, great, time, make, pope, say, matter, justic, god, parliament, judg, take, like, yet, offenc, charg, opinion, peopl

FREX: pope, slander, benevol, sediti, depos, administ, cathol, major, prerog, subordin, allegi, irrit, doctrin, tempor, proscrib, contagion, sentenc, conspiraci, clemenc, excommun, aggrav, heresi, discret, offenc, papist, venom, rascal, channel, pontif, thn

Topic 52 Top Words:

Highest Prob: wind, air, blow, will, sail, motion, thing, great, one, part, sea, south, north, east, make, rain, may, place, water, sun, west, cloud, way, much, rise, come, also, likewis, name, begin

FREX: wind, sail, mast, south, east, north, blow, rain, nurseri, presag, cloud, west, gale, prognost, engend, moon, storm, mizon, monit, weather, stormi, alay, wave, whirl, vapour, top, whirlwind, optat, calm, impuls

Topic 53 Top Words:

Highest Prob: will, majesti, shall, may, great, like, work, man, upon, good, plantat, kingdom, make, mean, undertak, therefor, part, place, person, three, thing, mani, first, can, one, natur, wherein, peopl, estat, charg

FREX: plantat, hospit, undertak, ireland, project, sutton, beggar, town, discard, relief, harp, commod, provis, revenu, kingdom, desol, portion, build, endow, benefic, foundat, enterpris, consequ, reader, pervert, knighthood, want, habit, mass, charg

Topic 54 Top Words:

Highest Prob: natur, understand, man, philosophi, will, experi, bodi, must, thing, first, method, can, mind, axiom, human, scienc, great, upon, particular, sens, idol, system, instanc, therefor, notion, matter, howev, yet, caus, investig

FREX: idol, system, investig, abstract, theori, axiom, latent, dogma, similar, exist, howev, method, notion, primari, genuin, anticip, theoreti, prematur, deduc, sceptic, tendenc, process, transform, logic, sourc, philosophi, speci, format, greek, specif

Topic 55 Top Words:

Highest Prob: may, bodi, thing, take, spirit, will, much, use, upon, part, also, life, wine, good, touch, make, oper, littl, like, water, air, therefor, long, heat, juic, meat, oil, especi, let, drink

FREX: saffron, intener, bath, claret, grain, ale, broth, juic, anoint, aliment, meat, unction, stomach, decoct, wine, steep, powder, fricat, shirt, exclus, drink, baysalt, spoon, liver, oil, fat, boil, myrrh, skin, infus

Topic 56 Top Words:

Highest Prob: natur, will, shall, speaker, master, law, kingdom, say, may, peopl, time, upon, great, can, see, state, self, yet, first, therefor, man, make, now, never, king, much, answer, take, part, one

FREX: speaker, master, nobil, provinc, surcharg, revolt, alien, scottish, commixtur, inconveni, famili, kingdom, canton, benefit, goth, parmenio, sureti, normandi, object, jus, union, privileg, pastur, swiss, solon, burgundi, pisa, nation, whosoev, swisser

Topic 57 Top Words:

Highest Prob: shall, majesti, scotland, england, may, will, law, whether, question, sever, make, one, point, britain, nation, part, parliament, time, kingdom, crown, name, yet, subject, first, alter, great, therefor, opinion, king, take

FREX: scotland, britain, england, nation, intern, articl, scot, admiralti, style, union, question, crown, merchant, nobil, divid, receipt, parliament, erect, whether, impost, royal, march, wale, dialect, languag, financ, scottish, merchandis, seal, english

Topic 58 Top Words:

Highest Prob: shall, grant, upon, take, law, life, die, make, now, condit, yet, seiz, tenant, disseise, common, remit, case, without, heir, rend, right, therefor, may, feoff, king, land, use, reason, remaind, can

FREX: disseise, remit, remitt, legal, lesse, impropri, remaind, atturn, incumb, grant, support, graunte, advowson, feme, neighbor, franketen, tenant, discontinu, cops, dower, notam, center, leas, rend, deer, claim, vie, companion, seiz, hay

Topic 59 Top Words:

Highest Prob: shall, come, great, say, may, land, will, one, man, upon, let, make, know, time, part, good, see, ship, place, side, take, day, give, littl, think, yet, stranger, also, countri, travel

FREX: boat, travel, galleri, pillar, front, ship, room, ark, navig, atlanti, diari, island, palac, america, voyag, sick, inund, china, stori, stranger, stair, turban, europ, aboard, window, cloister, scroll, fair, citi, chamber

Topic 60 Top Words:

Highest Prob: shall, word, error, take, upon, rend, rule, plead, therefor, bring, give, case, heir, acr, law, land, matter, plea, ambigu, good, reserv, will, grant, issu, may, reason, yet, writ, intend, make

FREX: ambigu, plead, acr, aver, plea, formedon, shill, rend, donor, warranti, attaind, error, demurr, warren, manor, ass, frank, entail, fealti, dale, reserv, writ, replic, bar, plaintiff, implic, moiety, graunte, discontinu, alleg

Topic 61 Top Words:

Highest Prob: spirit, life, long, thing, also, man, may, bodi, much, good, will, live, diet, use, shall, certain, take, like, great, opiat, old, yet, rather, age, touch, make, condens, heat, nitr, sleep

FREX: opiat, nitr, opium, condens, prolong, cool, statur, shorten, diet, flight, nitrous, venetian, subordin, spirit, grey, eager, sleep, liver, hair, cornarus, insight, abstin, spice, betoken, distil, obstin, treacl, juic, leg, lignum

Topic 62 Top Words:

Highest Prob: man, will, thing, say, make, busi, know, one, speech, good, may, come, time, take, anoth, wise, seem, dispatch, cun, let, speak, like, matter, much, studi, upon, point, question, mani, can

FREX: dispatch, cun, ware, surpris, trick, secretari, afraid, studi, troublesom, negat, speech, eyebrow, abil, forehead, amus, dart, busi, shift, fetch, wait, satir, declin, distil, discours, beatric, tale, iter, jesuit, ornament, wise

Topic 63 Top Words:

Highest Prob: man, knowledg, learn, time, matter, god, natur, first, one, make, see, great, upon, work, say, truth, philosophi, error, unto, use, two, anoth, scienc, author, part, may, shall, divin, will, much

FREX: knowledg, schoolman, antiqu, illustr, philosophi, learn, augment, contempl, nil, alterc, imag, aristotl, scienc, error, period, truth, degener, travail, alchemi, novelti, web, navig, curios, impostur, confut, relic, plato, badg, profound, angel

Topic 64 Top Words:

Highest Prob: use, statut, feoff, law, word, shall, estat, seiz, case, upon, may, person, possess, make, first, execut, heir, cesti, can, time, therefor, right, three, save, land, will, titl, king, take, life

FREX: cesti, feoff, statut, seiz, proviso, remaind, preamb, possess, commonlaw, conting, feesimpl, tail, use, save, execut, convey, regress, estat, infant, joint, fee, titl, purview, limit, feme, exclud, heir, vest, bargain, enrol

Topic 65 Top Words:

Highest Prob: squir, upon, shall, make, god, hand, one, man, time, yet, come, may, will, good, part, take, find, majesti, life, well, queen, think, now, confess, england, poison, earl, great, say, num

FREX: squir, num, saul, stabl, vow, jesuit, conspir, suborn, perswas, confessor, voyag, fugit, poison, earl, bladder, suspicion, slander, david, saddl, wick, heathenish, retract, confess, priest, belik, papist, hell, uttermost, richard, ride

Topic 66 Top Words:

Highest Prob: good, will, self, may, think, make, can, shall, much, letter, man, god, see, give, though, yet, true, know, part, friend, find, sinc, time, write, hand, therefor, one, great, upon, best

FREX: vacat, assault, attorney, friend, cross, wealth, repent, tide, unjust, access, advantag, hazard, cost, amend, pray, merci, beseech, befal, prophesi, mourn, mediocr, patronag, block, rip, puff, wound, sleight, opportun, sinc, leisur

Topic 67 Top Words:

Highest Prob: shall, man, law, edward, necess, one, life, yet, upon, case, excus, kill, action, anoth, can, maxim, therefor, will, statut, wast, punish, commit, malic, accessari, act, felon, come, rather, join, tenant

FREX: accessari, excus, rob, unpunish, trespass, malic, wast, justifi, maxim, necess, kill, steal, standf, edward, punish, penal, default, assail, fitzherbert, damag, crime, obedi, mad, salus, merchandis, feme, aunt, felon, murder, felon

Topic 68 Top Words:

Highest Prob: man, natur, part, knowledg, upon, mind, use, may, make, bodi, thing, shall, invent, one, will, great, can, yet, therefor, much, philosophi, imagin, like, two, particular, true, say, speak, find, first

FREX: defici, invent, anatomi, inquiri, medicin, calendar, variabl, imagin, induct, knowledg, magic, metaphys, proposit, prescript, mathemat, vicissitud, philosophi, elench, physician, artifici, predict, principl, neptun, delug, rhetor, earthquak, faculti, astronomi, abash, aristotl

Topic 69 Top Words:

Highest Prob: man, virtu, person, make, great, will, good, upon, bold, honour, one, follow, busi, may, prais, like, can, natur, much, part, certain, yet, see, first, common, say, time, beauti, mani, better

FREX: bold, mahomet, prais, deform, beauti, blaster, personag, hill, offici, virtu, flatter, painter, glorious, lucki, ishmael, scorn, secundus, decent, ostent, mountebank, factious, absurd, espial, virtuous, titus, vespasianus, superior, vaunt, counten, pretti

Topic 70 Top Words:

Highest Prob: will, shall, upon, may, court, king, great, majesti, justic, make, caus, lord, man, say, first, thing, take, chanceri, give, time, true, find, know, charg, much, offend, now, one, god, case

FREX: chanceri, weston, injunct, chancellor, impoison, poison, court, juri, decre, offend, pos, tanquam, pottag, justic, sergeant, praemunir, aggrav, client, overburi, commonlaw, lawyer, charg, pronounc, seal, bill, guilti, impeach, commission, verdict, gibb

Topic 71 Top Words:

Highest Prob: man, learn, make, great, say, may, time, can, mind, knowledg, natur, thing, will, give, one, friend, love, upon, true, well, shall, yet, person, god, much, state, fortun, mani, good, see

FREX: friendship, learn, solitud, cato, marcus, pedant, friend, poverti, nec, anxieti, lumen, knowledg, dionysius, tam, quintus, irresolut, sulla, minor, atheism, applic, swell, lover, virtuous, caesar, theatrum, tinkl, discredit, patron, dream, leisur

Topic 72 Top Words:

Highest Prob: king, law, natur, england, shall, say, case, subject, one, may, person, can, will, upon, time, first, reason, statut, therefor, make, kingdom, act, man, word, yet, two, parliament, bear, crown, come

FREX: allegi, conquest, gascoign, alien, england, submiss, normandi, descent, conquer, lieg, walter, infer, fol, homag, obeis, englishmen, scottishmen, born, signori, plead, foe, derogatori, anjou, privileg, crown, scotland, abridg, birth, subject, duchi

Topic 73 Top Words:

Highest Prob: thing, histori, natur, may, will, man, experi, shall, concern, inquisit, let, make, also, part, much, use, work, inquir, whether, must, upon, either, order, certain, great, four, three, time, fold, see

FREX: fold, histori, experiment, inquisit, med, breez, organon, alphabet, potenti, tropic, meteor, instaur, wherefor, interpret, prodigi, threefold, contribut, subjoin, west, semi, delta, cardin, inquir, volum, artifici, perspicu, celesti, experi, composit, east

Topic 74 Top Words:

Highest Prob: envi, man, upon, great, good, fortun, will, thing, person, time, busi, self, much, princ, less, may, public, use, ambiti, yet, natur, therefor, ever, state, think, shall, make, can, servant, note

FREX: envi, ambiti, envious, wri, briberi, eunuch, pull, banish, lover, con, crocodil, consol, public, screen, centr, epistl, fortun, alban, ambit, lame, vile, fascin, minist, witchcraft, infect, talon, evil, wheat, calam, discontent

Topic 75 Top Words:

Highest Prob: bodi, spirit, thing, part, repar, life, long, death, air, canon, therefor, may, way, repair, explic, will, last, man, inquisit, natur, aliment, forth, hard, can, without, come, much, time, also, make

FREX: repar, explic, canon, aliment, repair, malaciss, inanim, oili, wateri, consumpt, consubstanti, inquisit, dew, organ, renov, perspir, etern, durat, diet, prolong, porch, extern, arteri, membran, death, inhibit, detain, suppl, flame, prefac

Topic 76 Top Words:

Highest Prob: man, say, church, god, will, thing, shall, law, religion, part, good, great, upon, one, time, make, may, know, true, matter, can, controversi, person, well, much, see, non, yet, seek, first

FREX: controversi, preach, uniti, church, atheism, heresi, profan, atheist, superstition, religion, worship, zeal, dominus, idolatri, carnal, bishop, scriptur, apostl, partial, exhort, infer, preacher, posit, blasphem, deiti, doctrin, deform, holi, gentil, christ

Topic 77 Top Words:

Highest Prob: lordship, place, may, shall, will, majesti, good, humbl, man, think, pleas, servic, hope, lord, know, time, self, solicitor, much, chancellor, can, letter, king, therefor, well, father, salisbury, work, like, attorney

FREX: solicitor, salisbury, lordship, humbl, chancellor, attorney, fer, sergeant, finish, thank, hope, pleas, deserv, place, resolv, argument, servic, gracious, signif, egerton, father, further, planter, duti, favour, bill, letter, governor, kinsman, sure

Topic 78 Top Words:

Highest Prob: king, man, felon, treason, constabl, may, shall, justic, offic, peac, case, person, upon, make, realm, proceed, power, court, call, good, petti, punish, chap, land, take, law, commit, one, author, everi

FREX: constabl, chap, felon, treason, leet, abjur, petti, mispris, shire, praemunir, currant, jurisdict, realm, punish, peer, sanctuari, proclaim, oyer, affray, imprison, session, offic, forfeitur, coin, peac, forfeit, enabl, jailor, accessari, termin

Topic 79 Top Words:

Highest Prob: natur, man, part, caus, philosophi, divin, god, may, knowledg, histori, thing, therefor, upon, use, true, one, make, metaphys, will, physic, reason, accord, handl, scienc, matter, word, three, much, defici, whereof

FREX: metaphys, defici, poesi, theolog, philosophi, physic, divin, summar, effici, final, inquiri, propheci, exposit, ark, histori, basi, concept, scriptur, fabl, parabol, notion, satisfactori, inspir, handl, reced, terra, allus, contempl, feign, principl

Topic 80 Top Words:

Highest Prob: good, man, king, court, shall, justic, may, peac, take, will, debt, executor, everi, make, counti, law, parti, call, pay, judg, properti, one, upon, sheriff, administr, bind, land, constabl, legaci, give

FREX: executor, legaci, debt, indict, gaol, counti, administr, constabl, guilti, circuit, eyr, sheriff, pay, market, outlaw, properti, stray, session, intest, owner, juri, accus, assiz, recogniz, thief, steal, chattel, dioces, grand, executorship

Topic 81 Top Words:

Highest Prob: law, make, will, shall, repeal, non, former, claus, clausula, revoc, new, man, act, year, yet, good, stand, sheriff, statut, king, parliament, void, first, author, reason, corpor, can, present, without, take

FREX: repeal, clausula, revoc, claus, detractor, sheriff, oculus, revok, corpor, cap, non, damag, minor, corpus, menac, summon, trespass, testat, repugn, layout, void, depriv, apart, past, patent, aver, garment, aliv, restrain, dispens

Topic 82 Top Words:

Highest Prob: majesti, good, may, will, time, king, know, letter, shall, upon, lord, though, make, great, toward, commend, servic, profit, say, mean, self, sir, occas, can, brother, use, love, mind, hope, one

FREX: mutual, salut, compani, entranc, forese, commend, brother, interim, durham, faul, friendship, vivac, matthew, lake, profit, villier, sir, georg, disadvantag, deceas, project, letter, sow, reap, occas, husbandri, majesti, humbl, requit, recommend

Topic 83 Top Words:

Highest Prob: man, will, custom, exercis, use, upon, natur, exempl, thing, help, bodi, well, one, much, great, affect, forc, take, may, mind, see, mean, though, yet, first, power, action, work, perfect, true

FREX: extempor, tulli, shoe, custom, exercis, faber, halter, intellectu, engag, scourg, penanc, altar, rhetor, feat, similitud, pliant, whoever, transform, faculti, sophist, logic, learner, victori, suffoc, reform, breath, hermogen, voluntari, corrobor, mend

Topic 84 Top Words:

Highest Prob: good, quoth, will, man, thing, make, colour, one, take, may, seem, say, well, see, evil, back, non, therefor, mani, great, kind, part, yet, come, self, place, without, away, natur, shall

FREX: gradus, malum, reprehens, reprehend, quoth, autem, melior, qui, spur, blossom, colour, mayor, incept, citizen, evil, plural, minus, luck, start, realiti, absit, men, nam, mala, distant, burden, felic, comprehens, hereof, deceiv

Topic 85 Top Words:

Highest Prob: will, bodi, spirit, water, caus, see, part, make, heat, may, great, air, also, upon, therefor, putrefact, natur, time, good, come, littl, put, cold, like, much, forth, first, man, dri, creatur

FREX: putrefact, bottl, matur, beer, concoct, moistur, acceler, appl, congeal, liquor, portend, smell, candl, liquefi, shine, fragil, putrifi, clarif, moon, summer, wax, visual, percept, sugar, cotton, emiss, lee, putrefi, basen, vivif

Topic 86 Top Words:

Highest Prob: majesti, king, upon, great, time, man, make, state, spain, good, england, shall, say, may, one, will, never, unto, yet, mani, realm, part, much, year, war, like, honour, peopl, also, princ

FREX: libel, spain, cathol, sundri, untruth, lowcountri, realm, christendom, guis, invas, avouch, duke, nobil, franc, burleigh, treati, confederaci, invad, germani, faction, amiti, macedon, assay, ambassador, england, drift, successor, persecut, mari, turk

Topic 87 Top Words:

Highest Prob: long, year, life, bodi, live, age, creatur, dri, tree, will, spirit, bird, touch, thing, old, also, much, short, forth, part, man, one, young, last, air, water, make, may, bear, great

FREX: desicc, liver, durabl, tallow, wrinkl, dri, goos, bird, eagl, growth, creatur, swan, moistur, rust, arefact, womb, flesh, threescor, short, ambient, wither, raven, pertain, length, dove, nut, harden, wax, parchment, tree

Topic 88 Top Words:

Highest Prob: majesti, lord, will, may, king, time, upon, opinion, say, shall, think, well, chancellor, make, letter, day, give, busi, part, much, god, though, can, send, case, come, now, true, self, judg

FREX: chancellor, peacham, paper, majesti, advertis, indict, shrewsburi, pray, tyron, coke, bench, absent, yesterday, lord, feb, murray, projector, rhythm, forbear, sorri, cough, domini, garrison, april, privycouncil, presumpt, send, humbl, devot, mistrust

Topic 89 Top Words:

Highest Prob: man, may, one, natur, can, will, king, great, histori, matter, say, light, without, make, use, time, think, scienc, ancient, now, mind, caus, effect, thing, invent, yet, world, upon, general, discoveri

FREX: studious, mankind, system, discoveri, dignifi, uncertaini, exist, anxious, alik, steadi, everyth, correct, goal, valuabl, invent, talon, empir, interpret, histori, margaret, event, frequent, commonplac, scienc, useless, exert, probabl, adapt, enabl, benefit

Topic 90 Top Words:

Highest Prob: flower, tree, garden, may, alley, upon, sweet, like, part, come, side, set, astring, green, ground, rise, hedg, fine, read, white, fruit, fair, blossom, will, main, littl, leav, arch, foot, well

FREX: rose mari, heath, nard, pink, alley, hedg, astring, flux, mirabolan, asparagus, cypress, berberri, blossom, strawberri, laudanum, alo, bay, garden, gillyflow, quinc, musk, violet, carpent, arch, flower, myrtl, junip, daffodil, tulippa, pomegran

Topic 91 Top Words:

Highest Prob: also, make, divers, great, thing, man, will, natur, come, one, bodi, upon, likewis, mani, pleasur, use, kind, mean, like, see, earth, spirit, colour, place, proserpina, sever, light, without, well, set

FREX: proserpina, siren, cere, sphinx, velvet, chariot, entic, blue, song, anti, attir, salomon, scene, ulyss, silk, hell, page, pluto, plume, worm, enigma, torch, coagul, artifici, narcissus, wing, pool, marin, divers, imit

Topic 92 Top Words:

Highest Prob: lord, will, time, say, queen, shall, self, good, can, know, lordship, think, well, majesti, make, essex, take, upon, may, matter, man, part, tell, come, yet, ever, one, true, mani, mind

FREX: essex, northampton, queen, madam, lord, cion, ber, remem, con, dam, ireland, mat, rememb, tell, othersid, test, forsak, bee, rack, lordship, ous, ire, dissuad, satisfi, councillor, ration, member, incens, divert, sex

Topic 93 Top Words:

Highest Prob: shall, man, will, yet, may, time, state, thing, make, upon, take, reign, one, can, princ, religion, happi, peopl, queen, first, cours, king, life, long, without, age, place, see, well, much

FREX: con, albeit, irish, popish, felic, rebel, reign, penalti, toler, woe, happi, aswel, establish, religion, ireland, prin, queen, hap, prais, calentura, barbar, sex, poperi, henryth, blemish, munster, licenti, ous, scan, tune

Topic 94 Top Words:

Highest Prob: majesti, law, great, take, abus, may, time, unto, subject, king, yet, make, use, one, upon, good, excel, name, will, mani, royal, come, say, high, peac, natur, can, self, govern, reign

FREX: abus, royal, toga, majesti, vouchsaf, grievanc, provis, sacr, amend, price, justinian, reign, horac, germanicus, dread, enorm, progenitor, petit, british, ego, manifold, channel, mighti, purveyor, oppress, crave, eas, choir, vexat, pound

Topic 95 Top Words:

Highest Prob: will, may, king, shall, man, usuri, let, upon, can, make, much, take, must, good, matter, state, great, thing, person, give, trade, either, part, law, one, money, first, time, honour, place

FREX: usuri, trade, rate, borrow, usur, coloni, merchandis, merchant, lend, choic, commod, money, discommod, interpos, licenc, board, regul, employ, cost, vaniti, courtier, petit, suitor, interest, nativ, beseech, favourit, council, churchman, eas

Topic 96 Top Words:

Highest Prob: suit, make, man, law, will, act, contract, deed, may, interest, elizabeth, good, edward, time, can, grant, yet, attorney, mean, shall, use, perfect, year, blood, feoff, land, first, new, erudit, name

FREX: erudit, interest, suit, revok, demis, attorney, countermand, contract, liveri, deed, enrol, coven, elizabeth, atturn, surrend, bargain, suitor, edward, exchang, duress, consumm, ibi, sale, dissolv, challeng, oblig, transmut, nephew, charter, desert

Topic 97 Top Words:

Highest Prob: man, death, thing, may, can, natur, upon, shall, say, will, matter, yet, unto, die, think, make, begin, god, come, see, one, desir, well, also, self, like, even, power, hold, know

FREX: nemesi, mourn, proteus, labyrinth, page, cupid, daedalus, combat, achel, nox, aurora, hercul, bull, goddess, mechan, juno, atom, miss, jupit, death, obsequy, fabl, diomed, flock, lament, satieti, guest, miser, commiser, vicissitud

Topic 98 Top Words:

Highest Prob: man, upon, imagin, will, spirit, may, shall, thing, make, bodi, one, work, like, use, take, also, part, great, think, natur, experi, say, time, anoth, much, come, can, therefor, must, good

FREX: ointment, imagin, bead, wart, witch, plagu, magic, transmiss, emiss, perfum, card, juggler, belief, weapon, immateri, cramp, sympathi, wolf, ingredi, agu, anoint, hedgehog, jaundic, toad, brain, wear, smell, unburi, infect, dog

Topic 99 Top Words:

Highest Prob: man, great, rich, come, place, time, good, shall, think, say, may, thou, yet, will, best, upon, though, mean, certain, wife, make, can, one, thi, child, servant, well, propheci, use, much

FREX: propheci, rich, thyself, galba, dream, rough, thi, predict, thou, despis, wife, enrich, inquisitor, vespasian, hemp, chastiti, fleet, lad, philip, facil, briberi, unmarri, singl, pluto, accomplish, beforehand, ultima, chariti, childless, wors

Topic 100 Top Words:

Highest Prob: bodi, rather, health, one, find, man, diet, natur, best, will, exercis, thou, physic, sleep, mind, chang, therefor, good, shall, may, come, thing, use, sick, fit, littl, like, last, age, full

FREX: health, diet, physic, defi, sleep, patient, sick, eat, joy, exercis, thou, excess, novelti, safe, precept, physician, chang, cure, diseas, despis, studi, surfeit, knotti, illustri, mirth, combin, exhilar, cel, splendid, masteri

Figure B2

