Religion and the Rise and Fall of Islamic Science

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Abstract

This paper documents a decline in scientific output in the medieval Islamic world and empirically links the decline to the political empowerment of religious leaders. A contraction in secular bureaucratic structures strengthened conservative religious elites who altered institutions to discourage the study of topics that undermined their societal control. The decline geographically tracks these institutional changes from east to west, providing additional evidence that rent-seeking religious leaders contributed to the decline of Islamic science. (*JEL* H70, N15, O30)

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"O Lord! Increase me in knowledge" -Quran (20:114)

"For indeed faith, with ignorance, is sound"[1] -Muslim Religious Elite, 12^{th} Century CE

A period of rapid intellectual development preceded and shaped the Industrial Revolution (Mokyr, 2005). Although the Industrial Revolution originated in Europe, its knowledge base built upon advances made in the Islamic world centuries earlier. In fact, during the Middle Ages this region witnessed a period of sustained scientific development, anticipating Renaissance and Enlightenment-era discoveries by centuries. Scholars have long debated why these medieval developments did not lead to an Islamic Scientific or Industrial Revolution, yet there is little agreement regarding when, why or even if scientific output declined.

This paper documents the evolution of scientific production in the Islamic world over time, demonstrates that Islamic science declined, proposes a theory to explain the basic empirical patterns and provides additional evidence in support of this theory.

To do this, this paper combines three datasets containing over 40,000 historic authors to measure the proportion of authors who worked on scientific topics over time. The left-hand panel of Figure 1 details the evolution of this metric. The right-hand panel provides a similar graph for *madrasa*-affiliated authors —those whose livelihoods were linked to institutions controlled by conservative religious elites. This inverse relationship be-

[1]Cited in Makdisi (1985, p. 47).

tween scientific production and *madrasa* affiliation is robust to both varying definitions of science and to restricting the analysis to historical Islamic sources.

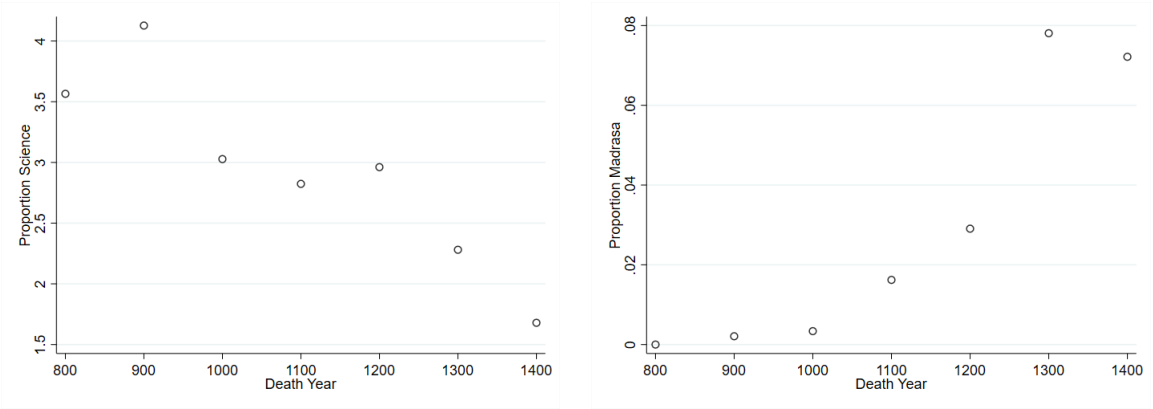

Figure 1: **Proportion Scientists and Madrasa-Affiliated Authors 800-1500**

These empirical patterns provide new facts for understanding the evolution of human knowledge over the past millennium and for evaluating hypotheses regarding the relationship between Islam and human-capital development. On the one hand, the results weigh against the essentialist view that Islam and science are inherently incompatible (Jones et al., 2019). On the other, the data are not consistent with recent scholarship relating the decline to European colonialism or arguing that scientific output did not decline in the medieval period (Saliba, 2007; Brentjes, 2018). Similarly, regional variation does not support hypotheses stressing the central role of external military shocks such as the Crusades or Mongol invasions in the decline (e.g. Saunders, 1962, p. 711). Instead, the data seem most consistent with theories attributing the decline of

Islamic science, at least in a proximate sense, to the opposition of increasingly influential religious elites.

The idea that religious authorities contributed to the decline of Islamic science goes back centuries. For example, one strain of Enlightenment thought argued that Islamic science fell victim to the forces of "priestcraft and fanaticism" and viewed this episode as a lost battle in the "epic contest" between reason and religious authority (Israel, 2006, pp. 103, 615-634). Although a number of scholars have since echoed this theme (e.g. Huff, 2003), the degree to which religious elites contributed to the decline of Islamic science remains poorly understood.

I hypothesize that the empirical patterns in Figure 1 reflect, at least in part, the political empowerment of conservative religious leaders. Starting in the eleventh century a series of institutional changes led to the decline of secular bureaucratic structures and the rise of a salaried class of religious elites. These changes —culminating in the thirteenth century— strengthened and enriched adherents of conservative interpretations of Islam, increasing their control over institutions of learning and intellectual production. Through this channel, these elites decreased the relative payoff to producing works that contradicted their preferred interpretations of Islam, contributing to the observed decline in scientific production (Baumol, 1990).

In support of the claim that religious elites contributed to the drop in scientific output, I document that the decline coincides with an increase in proxies for the political power of conser-

vative religious leaders. My hypothesis also predicts that the decline in scientific output coincides with a decrease in adherence to non-conservative interpretations of Islam. I find the data also support this prediction.

It is impossible to completely rule out all alternative explanations for the results. Nevertheless, if the basic trends are spuriously driven by time-varying selection then this selection is shared by modern libraries and historical Islamic sources —some of which were composed prior to the documented decline in scientific output. In addition, this time-varying selection generates secondary empirical patterns that are consistent with historical evidence that the political empowerment of rent-seeking religious leaders drove the decline. For example, the proportion of authors employed in secular bureaucratic structures largely mirrors the decline in scientific output.

The central premise underpinning my interpretation of the results is consistent with the recent literature highlighting a negative relationship between religion and human capital development (e.g. Squicciarini, 2020; Benabou et al., 2022). While existing work stresses the tension between scientific discovery and religious belief, to my knowledge this paper is the first to empirically document a negative relationship between the political empowerment of religious leaders and scientific production. From a conceptual standpoint, it suggests that religious elites have incentives to block innovations that undermine their political power (Benabou et al., 2022), linking the culture and eco-

nomics emphasis on the importance of beliefs (e.g. Fernández, 2011) to the thesis attributing backwardness to the actions of threatened political elites (e.g. Acemoglu and Robinson, 2000).

In other words, this paper highlights that the institutions empowering religious elites —not Islam itself— contributed to the decline of Islamic science. By providing evidence that religious elites played a central role in the decline of one of history's most scientifically advanced societies it adds to the growing literature highlighting the centrality of the emergence of constraints on religious leaders in the western world's institutional and economic rise (e.g. Chaney, 2013; Rubin, 2017; Benabou et al., 2022).

The remainder of the paper proceeds as follows. Section 1 uses the historical record to develop the paper's central hypothesis. Section 2 briefly describes the data and provides evidence for the robustness of the time plot in Figure 1. Section 3 presents additional empirical evidence in support of the hypothesis. A final section concludes.

1 The Hypothesis

I hypothesize that the political empowerment of conservative religious elites starting in the eleventh century contributed to the decline of Islamic science.[2] The institutional changes as-

[2]Throughout, I use the term Islamic science to refer to scientific production done under Islamic rule regardless of an author's religious affiliation. I prefer this term to Islamicate science for expositional ease.

sociated with this political empowerment dismantled much of the bureaucratic complex that emerged in the centuries following the Arab-Muslim conquests.[3] While there is little consensus regarding the reasons behind the emergence of this "secular bureaucracy" (Goitein, 1957, p. 597), there is growing evidence it played a central role in the Islamic world's scientific development.[4]

For example, the origins of the translation movement of scientific works from Greek and other languages into Arabic —generally viewed as the start of sustained scientific development in the Islamic world (e.g. Saliba, 2007, p. 64)— are increasingly traced to the expansion of bureaucratic institutions around the Abbasid revolution of 750.[5] Bureaucratic elites were among the most important supporters of translations and scientific activity for a number of reasons (Gutas, 1998, pp. 95, 111-115, 128). First, research leading to advances in subjects such as trigonometry and algebra facilitated secretarial work. Second, scientific knowledge was instrumental in bureaucratic appointments (e.g. Saliba, 2007, p. 65). Third, patronage of scientific and rational methods undermined the political power of con-

[3]Between 632 and 750 CE, Arab-Muslim armies conquered a vast geographic region reaching from modern-day France to Pakistan

[4]To save space, I refrain from reviewing the scientific advances pioneered in the medieval Islamic world as it is generally agreed that "from the eighth century to the end of the fourteenth, [Islamic] science was probably the most advanced science in the world, greatly surpassing the West and China" (Huff, 2003, p. 48).

[5]Although the causes of this revolution remain a topic of debate, as a practical manner it weakened the hold of Arab-Muslims on governmental structures and strengthened non-Arab bureaucratic elites. It has been described as ending the "Arab caste supremacy" (e.g. Lapidus, 2014, pp. 76, 265) that emerged following the Arab-Muslim conquests in favor of a more ethnically and religiously inclusive institutional framework.

servative religious elites who represented a threat to secular bureaucratic structures (Watt, 2001, p. 121).

Conservative religious leaders rose to prominence in the decades following the adoption of settled state structures by the Arab-Muslim conquerors in the seventh and eighth centuries. During this period marginalized groups rallied around conservative elites to resist the movement away from egalitarian forms of tribal leadership (e.g. Hallaq, 2005, p. 180). These religious authorities began to craft Islamic law as an alternative to state-based forms of societal organization (Hallaq, 2005, p. 204). Faced with the challenge of organizing a fractious tribal society, they worked to limit the use of human reason (Makdisi, 1963, p. 22) through the invention of "traditions" (*hadith*s or purported actions and sayings of the prophet Muhammad) which were used to construct religious authority and stifle dissent (e.g. Hallaq, 2009, pp. 36, 49, 70-71).[6]

Many educated Muslims, including those employed by the bureaucracy of the newly-formed state, rejected this movement and its religious authorities (Crone, 2006, pp. 23-24). Instead, they adopted interpretations of Islam (which I henceforth refer to as rational Islam) which emphasized the precedence of human reason over religious authority (e.g. Kraemer, 1992, pp. 43, 65, 68). These Muslims tended to cooperate with the state

[6]Throughout the paper I use the terms conservative and traditionist interchangeably to refer to the religious elites that headed this movement. In addition, I often drop the terms conservative or traditionist for expositional ease given that adherents of rational Islam were often skeptical of religious authority.

and resisted conservative attempts to weaken state structures (Crone, 1980; Gibb, 1982).

Rational modes of thought aided in this conflict by undermining the authority of conservative religious leaders through at least two channels. First, followers of rational Islam and those trained in rational methods more broadly exhibited less uniform religiosity: they frequently disagreed, were less dogmatic and more tolerant of those who held different beliefs (Crone, 2006).[7] This was rooted, in part, in rational Islam's quest to demonstrate its superiority through the use of reason and the realization that many contradictory religious claims were, from a rational standpoint, equally valid (e.g. Kraemer, 1992, p. 15). This tolerant attitude encouraged widespread interactions across religious lines and scandalized conservatives who believed it undermined religious authority (Andalusi, 1997, pp. 96-97) by eroding popular belief and encouraging doubt (Kraemer, 1992, pp. 72, 190).

In addition to weakening conservative Islam indirectly by decreasing religious uniformity, rational Islam directly confronted the conservative claim that religious authority passed upon the prophet Muhammad's death to religious leaders (Athamina, 1992, p. 154). For example, the idea that Islam was rooted in reason and personal judgement undercut the idea that conservative leaders were Islam's only valid interpreters. In so doing,

[7] al-Ghazali (1980, p. 64), for example, argued that most who studied mathematics lost their religion and "the restraint of piety." For religious skepticism during this period see Stroumsa (1999).

it transferred power away from these religious elites (e.g. Gutas, 1998, p. 99).

This conflict came to a head during the *mihna* (833-851) when the state, allied with adherents of rational Islam, sought to weaken the growing influence of conservative elites by force. Its failure demonstrated that conservative religious leaders had achieved permanent political power vis-á-vis the state (Lapidus, 2014, pp. 104-105) and helped catalyze societal transformations that culminated in the "Sunni Revival" centuries later.

1.1 The Sunni Revival and the Decline of Islamic Science

The term Sunni Revival is used to describe the spread of Sunni regimes across the Islamic world during the eleventh and twelfth centuries (e.g. Berkey, 2003, p. 189). At least since Gibb (1955, pp. 124-126) these developments have been associated with the decline of secular state structures in favor of religiously-dominated institutions. Although there is little consensus among historians regarding the fundamental causes of these institutional changes this is secondary to this paper's focus.[8] What is important for this paper is that the Revival empowered religious leaders at the expense of secular bureaucrats.

The rise of the *madrasa* system during this period concisely

[8]Traditionally, the Sunni Revival was traced to the actions of the Seljuks in the middle of the eleventh century. More recent scholarship has located the origins of the Revival at the start of the eleventh century (Makdisi, 1973, pp. 155-156).

illustrates this shift.[9] Although colleges specializing in Islamic law existed prior to the eleventh century, the expansion of *madrasa*s during this period is generally thought to reflect an increase in the political power of religious authorities (Hallaq, 2009, pp. 150-151).[10]

A drop in secular bureaucratic capacity (e.g. Lambton, 1968; Sellheim et al., 2012) accompanied these developments and led to the rise of what has been called an "orthodox bureaucracy" (e.g. Gibb, 1955, p. 126) dominated by religious and military authorities (Hallaq, 2009, p. 125). As religious scholars increasingly occupied positions of power (Crone, 2006, p. 33) the number of individuals interested in acquiring religious knowledge to obtain salaried positions rose sharply (Hallaq, 2009, p. 154) and Islamic law affiliation became a central feature of societal organization (Gilbert, 1980, p. 122).

These institutional changes enabled religious elites to restrict the use of rational methods in religiously-controlled institutions (e.g. Sabra, 1987, p. 233) and removed many bureaucratically-supported study circles and libraries (Kraemer, 1992). Overall, these developments encouraged "an instrumentalist and religiously oriented view of all secular and permitted knowledge"

[9]Makdisi (1973) argues that the Sunni Revival represents the broad institutional victory of conservative Islam. As such, other conservatively-controlled institutions —such as the *dar al-hadith* or Sufi *khanqah*s— also received increased patronage during this period.

[10]Throughout I follow Acemoglu and Robinson (2006, p. 173) and define political power as "a measure of how influential a particular group (or individual) is in the political arena when there is conflict over which policy should be implemented." In addition, drawing on qualitative (e.g. Hallaq, 2009, p. 135) and quantitative (e.g. Chaney, 2013) evidence I assume that elites sought greater control of resources.

(Sabra, 1987, pp. 240, 241) as those interested in pursing scientific activity first specialized in religious disciplines (Makdisi, 1981, p. 285).

The institutions of the Revival tended to spread across the Islamic world from East to West, arriving in the most western regions with a significant lag. For example, much of North Africa did not experience this institutional shift until the thirteenth century (Lapidus, 2014, p. 288) whereas the first *madrasa* did not appear until the fourteenth century in Islamic Iberia (Lapidus, 2014, p. 288).[11] This institutional lag has been used to explain the greater circulation of rational works in the Western Islamic world through the thirteenth century (e.g. Endress, 1999, p. 25).

Did these institutional changes contribute to the decline of Islamic science? My reading of the historical evidence challenges recent revisionist characterizations of the time path of scientific production in the Islamic world over time. For example, recent work has questioned whether scientific output declined in the medieval period (e.g. Saliba, 2007; Brentjes, 2018). While not denying the Revival's central institutional changes, this qualitative literature produces examples of post-Revival scientific advances to argue that the emergence of institutions such as the *madrasa* did not result in a decrease in scientific activity (Brentjes, 2018, p. 11). Conclusively distinguishing between

[11]For a detailed discussion of scientific vitality in the Western Islamic world after 1000 through the thirteenth century see Bennison (2016, p. 259).

competing views is difficult, however, in the absence of systematic data on intellectual production.

2 Did Science Decline?

I use three datasets to measure intellectual production in the Islamic world over time (see the Appendix for details on the data construction). First, I assemble a collection of MENA (Middle East and North Africa) authors from the Virtual International Authority File (VIAF) database. This is a nearly comprehensive dataset of all authors whose works are contained in modern library collections. Second, authors working in the MENA region not covered by VIAF are drawn from 31 of the region's most well-known historical biographic dictionaries. Third, I supplement these sources with information on Western Islamic authors from the *Prosopografía de los Ulemas de al-Andalus* which contains Western Islamic authors taken from 248 biographic dictionaries.

The combined data provide information on over 42,748 unique authors, 31,888 of whom died between 800 and 1500 CE. I estimate that this sample constitutes roughly 40% of all authors working in the Islamic world during this period. It represents the largest collection of historic Islamic authors ever assembled.

Table 1 gives estimates of a number of variables by century between 800 and 1500.[12] The first row provides the proportion of

[12]I limit the analysis to the period before the Atlantic discoveries and Ottoman hege-

Table 1: **Summary Statistics**

	800	900	1000	1100	1200	1300	1400
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Scientist	3.50	3.99	2.97	2.71	2.96	2.01	1.43
	(18.37)	(19.59)	(16.97)	(16.24)	(16.95)	(14.04)	(11.87)
Madrasa	0.00	0.21	0.34	1.62	2.91	7.81	7.22
	(0.00)	(4.56)	(5.79)	(12.63)	(16.80)	(26.83)	(25.88)
Bureaucrat	3.01	5.15	8.18	5.99	3.31	1.56	0.86
	(17.08)	(22.10)	(27.41)	(23.73)	(17.89)	(12.38)	(9.22)
"Deviant" Islam	5.10	3.03	4.07	2.65	0.26	0.16	0.07
	(22.01)	(17.14)	(19.75)	(16.07)	(5.07)	(4.01)	(2.67)
Law School Affiliation	8.07	5.47	4.65	8.01	12.69	24.95	28.69
	(27.25)	(22.74)	(21.05)	(27.15)	(33.29)	(43.28)	(45.24)
Religious Title	1.08	0.91	1.39	8.53	33.29	42.83	46.05
	(10.35)	(9.49)	(11.71)	(27.93)	(47.13)	(49.49)	(49.85)
Religious Trait	4.12	3.37	1.87	2.06	2.85	2.66	0.93
	(19.89)	(18.05)	(13.53)	(14.21)	(16.64)	(16.08)	(9.59)
Source: VIAF	27.93	20.11	18.41	21.33	28.43	39.36	52.38
	(44.87)	(40.08)	(38.76)	(40.97)	(45.11)	(48.86)	(49.95)
Source: Biographical Dictionaries	63.44	60.83	57.46	42.12	46.20	48.27	46.20
	(48.17)	(48.82)	(49.44)	(48.16)	(49.86)	(49.98)	(49.86)
Source: Andalus	8.63	19.06	24.13	36.55	25.36	12.37	1.43
	(28.09)	(39.28)	(42.79)	(48.16)	(43.51)	(32.93)	(11.87)
Geo-referenced	76.41	80.23	81.09	85.08	78.22	75.48	68.70
	(42.47)	(39.83)	(39.17)	(35.63)	(41.28)	(43.03)	(46.38)
N	2,861	5,282	6,540	5,242	5,437	3,727	2,799

Notes: standard deviations in parentheses. All variables, which are indicator variables, are multiplied by one-hundred for expositional ease. Scientist is equal to one if an author was a scientist. Madrasa denotes affiliation with a madrasa if such an affiliation is noted. Bureaucrat denotes affiliation with a secular bureaucracy. "Deviant" Islam is equal to one if an author adhered to what conservative elites considered deviant interpretations of Islam. Law School Affiliation denotes information that the author belonged to one of the Hanafi, Hanbali, Maliki or Shafi'i law schools. Religious title indicates the presence of a title denoting religious authority (e.g. burhan al-din). Religious trait is equal to one if an author was noted as abnormally religious. Source: VIAF denotes that the author was drawn from the Virtual International Authority File database, Source: Biographical Dictionaries from the biographical dictionary database and Source: Andalus from the *Prosopografía de los Ulemas de al-Andalus* database. Geo-referenced is equal to one if an author was geo-referenced to have died in either the Eastern or Western Islamic world. See the Appendix for more detailed definitions and sources.

all authors identified as having engaged in scientific activity.[13] The evolution of the variables in the next 6 rows is broadly consistent with the historical narrative presented in the first section. The last section of the table shows the evolution of the proportion of observations from each of the three databases, the proportion of all authors successfully geo-referenced and the total number of observations.

To test the hypothesis that scientific production declined in the medieval period I estimate the following regression:

$$Science_i = \gamma + \sum_{h \geq g} \beta_h D_h + \epsilon_i \tag{1}$$

mony to maintain focus.

[13]Although the term scientist is anachronistic, I employ it throughout in place of the more precise "natural philosopher" for expositional ease. The Appendix provides a detailed discussion of the strings used to identify scientists and the other variables.

where $Science_i$ is an indicator equal to one if author i who died in the year t in 100 year bin h was a scientist.[14] This simple specification documents the evolution of scientific output by century, as the β_h compare the proportion of scientists who died in 100-year bin h to that on the interval [800,g) where g $\in \{1000, 1100\}$. I present both sets of results given that many of the Revival's institutional changes were gradual and there is uncertainty around their exact start date.[15] Because my focus is on the evolution of intellectual production in the entire Islamic world, I present regressions at the author level but demonstrate that the analysis is robust to using alternative levels of aggregation in the Appendix. Throughout, I multiply the estimated coefficients by one-hundred for expositional ease and cluster standard errors by decade.[16]

Columns 1 and 2 of Table 2 document the evolution of scientific production in the entire sample. The bottom row reports the p-value from the F-test of joint statistical significance of the century indicators. Column 1 includes century indicators after 1100 and column 2 adds the 1000 indicator. Both specifications show a decline in scientific activity in the medieval period, confirming the patterns documented in Figure 1. For example, the

[14]There are a few potential ways to measure scientific production. In this paper I concentrate on the scientist indicator because it can be constructed on all of the constituent datasets and is arguably measured with relatively little error. Alternative available metrics, such as the proportion of surviving works on scientific topics, have similar qualitative implications as briefly discussed below.

[15]I an unaware of evidence that the Revival's institutional changes began before the very end of the 10th century.

[16]In the Appendix, I show that the results are robust to alternative standard error calculations.

Table 2: **The Decline of Islamic Science (Authors)**

	Dependent Variable is One-Hundred if an Author is a Scientist and Zero Otherwise:							
	All, 800-1500		VIAF, 800-1500		Biographical, 800-1500		Andalus, 800-1500	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
[1000, 1100)		-0.87**		-0.58		-0.57		-0.18
		(0.37)		(1.12)		(0.56)		(0.31)
[1100, 1200)	-1.12***	-1.11***	-1.01	-1.24	-0.29	-0.53	0.06	-0.04
	(0.35)	(0.38)	(1.00)	(1.16)	(0.59)	(0.64)	(0.24)	(0.31)
[1200, 1300)	-0.59	-0.98**	-1.22	-1.45	-1.29***	-1.53***	0.89***	0.79**
	(0.41)	(0.44)	(1.21)	(1.34)	(0.37)	(0.44)	(0.28)	(0.34)
[1300, 1400)	-1.27***	-1.66***	-3.64***	-3.87***	-1.72***	-1.96***	1.18	1.08
	(0.39)	(0.42)	(0.91)	(1.07)	(0.38)	(0.45)	(0.81)	(0.83)
[1400, 1500)	-1.88***	-2.26***	-4.67***	-4.90***	-2.20***	-2.44***	-0.78***	-0.88***
	(0.30)	(0.35)	(0.76)	(0.95)	(0.34)	(0.42)	(0.15)	(0.25)
Constant	3.56***	3.94***	6.92***	7.15***	3.28***	3.52***	0.78***	0.88***
	(0.20)	(0.26)	(0.58)	(0.82)	(0.29)	(0.37)	(0.15)	(0.25)
N	31,888	31,888	8,662	8,662	16,598	16,598	6,628	6,628
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Notes: standard errors clustered by decade in parentheses, coefficients multiplied by one-hundred. Dependent variable is equal to one if an author was a scientist. Coefficients estimated on authors in the entire sample who died between 800 an 1500 in columns 1 and 2. Columns 3 and 4 presents the results estimated on the VIAF data, 5 and 6 the biographical dictionary data and 7 and 8 the *Prosopografía de los Ulemas de al-Andalus* data. The row p-value provides the p-values corresponding to the null hypothesis that the reported century coefficients are jointly equal to zero.

point estimates suggest that by the fifteenth century the proportion of scientists had fallen by over half when compared to the omitted period.

Selection is a central concern when interpreting these results.[17] For example, authors in the data may not be randomly selected from the underlying population. More worryingly, it is possible that western scholarship has systematically ignored the works of later scientists (Saliba, 2007). Such time-varying selection could generate a spurious downward trend in scientific production.

There are a few ways to address this concern. One could —in the spirit of Altonji et al. (2005)— examine how much selection is needed to explain away the results. I discuss and implement this strategy in the Appendix. Here I note that selection will not affect the sign of the century point estimates as long as the

[17]Measurement error, while always a potential issue when using historical data, is less likely to lead to spurious conclusions in this context. See the Appendix for a detailed discussion.

selection process does not significantly vary over time.

This observation suggests an additional robustness check. Because each dataset has different sources —many of which were composed in the Islamic world centuries ago— they are unlikely to suffer from time-varying selection in the same way. In other words, if the decline is due to western-induced selection it should not appear in historical Islamic sources.

Columns 3-6 implement this idea, demonstrating that the VIAF-based results are qualitatively similar to those obtained using historic biographical dictionaries. In fact, results in columns 5 and 6 show that the estimated decline in scientific activity becomes statistically significant in historical Islamic sources earlier than in the VIAF data.

This result weighs against the time-varying selection hypothesis, although the differences in the estimated coefficients are consistent with the claim that VIAF oversamples scientists, magnifying the magnitude of the decline. For example, the estimated decline of approximately 5 percentage points in the VIAF data between 1400 and [800,1000) is roughly double that in the biographical sources. Nevertheless, both sets of point estimates imply that scientific output in 1400 was around 30% its [800,1000) level. This result is consistent with the idea that selection, while differing across datasets, is roughly stable within datasets across time.[18] So while caution is required when interpreting coefficient magnitudes, less is needed when discussing

[18]See the Appendix for a detailed discussion of this point.

Table 3: **The Decline of Islamic Science (Books)**

	Dependent Variable Equal to One if Book:							
	Medicine, Mathematics		Broad Science		Commentary (1)		Commentary (2)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
[1000, 1100)		0.11		-0.35		5.77***		6.21***
		(0.30)		(1.27)		(2.03)		(2.19)
[1100, 1200)	-0.98	-0.95	0.21	0.10	6.52***	9.09***	7.50***	10.27***
	(0.78)	(0.85)	(2.29)	(2.32)	(2.26)	(2.36)	(2.29)	(2.41)
[1200, 1300)	0.26	0.29	0.17	0.05	14.73***	17.29***	17.06***	19.83***
	(0.73)	(0.78)	(0.92)	(1.01)	(2.41)	(2.51)	(2.40)	(2.52)
[1300, 1400)	-1.89***	-1.86***	-2.96***	-3.08***	22.90***	25.47***	26.02***	28.78***
	(0.53)	(0.58)	(0.62)	(0.72)	(1.86)	(1.98)	(2.01)	(2.15)
[1400, 1500)	-1.25**	-1.22**	-1.73**	-1.85**	23.81***	26.37***	31.13***	33.90***
	(0.55)	(0.60)	(0.69)	(0.77)	(2.31)	(2.41)	(1.91)	(2.06)
Constant	3.17***	3.14***	4.74***	4.86***	9.82***	7.25***	11.03***	8.27***
	(0.49)	(0.55)	(0.59)	(0.69)	(1.07)	(1.27)	(1.15)	(1.38)
N	196,173	196,173	196,173	196,173	8,402	8,402	8,402	8,402
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Notes: standard errors clustered by decade in parentheses, coefficients multiplied by one-hundred. Dependent variable in columns 1 and 2 is equal to one if a book is on mathematics or medicine. In columns 3 an 4 it is equal to one if a book is on scientific topics more broadly. In columns 5 and 6 the dependent variable is equal to one if the books is a commentary. Columns 7 and 8 provide results from a similar specification with a broader definition of commentary. Columns 1-4 are run on the sample of books in WorldCat written by authors in the VIAF data. Columns 5-8 are estimated on the Hajji Khalifa dataset. The row presents p-values corresponding to the null hypothesis that the reported century coefficients are jointly equal to zero. See the Appendix for more detailed definitions and sources.

a coefficient's sign.

Does the timing of the decline vary geographically? Columns 7 and 8 provide preliminary analysis of this question using the *Prosopografía de los Ulemas de al-Andalus* data. The proportion of scientists in this dataset, which concentrates on authors working in Islamic Iberia, appears to evolve differently than in the other two datasets. For example, consistent with the historical record, the decline in the proportion of scientists does not become statistically significant until the fifteenth century.

2.1 Book Level Analysis

To further investigate the robustness of these results, Table 3 —which has a similar format to Table 2— estimates equation 1 at the book level. Conceptually, book-level regressions are arguably the cleanest way to measure the evolution of intellectual output over time. Practically, these regressions are limited

by the fact that information on authors has often outlived their works. This limits the analysis to modern library holdings or to isolated historical sources containing detailed information on individual books.

In Table 3, the first four columns present results obtained using all books held in modern libraries by VIAF authors. Columns 1 and 2 present estimates in which the dependent variable is one if a book is on Medicine or Mathematics and zero otherwise. The following two columns perform the same exercise using a broader definition of science (in which I add subjects such as Astronomy and Optics to Medicine and Mathematics). Similar to the results calculated using the VIAF data in Table 2, the decline in the proportion of books on Medicine or Mathematics becomes statistically significant in the fourteenth century.

The last four columns of Table 3 provide results obtained from data contained in a historical bibliographic encyclopedia. This encyclopedia, composed in seventeenth-century Anatolia, is widely recognized as an important source for the intellectual history of the Islamic world. It contains time-referenced information on over 10,000 works and whether they are commentaries on previous works.

This information provides an opportunity to investigate the empirical relevance of an influential body of scholarship that links an increase in commentaries to the same forces that drove the decline in scientific activity. Conceptually, this literature argues that increasingly influential religious leaders channeled intellec-

tual production towards reproducing approved knowledge and away from innovative, and potentially subversive, intellectual activity (for a concise but critical overview of this argument see Saliba (2007, p. 241)).

Results in columns 5 and 6 are consistent with this view in the sense that the rise in the proportion of works dedicated to commentaries mirrors the decline in scientific production. For example, results in columns 5 and 6 using a more restrictive definition of commentaries shows that this proportion rises from under 10% of works prior to 1000 to over 30% in the fifteenth century. Results in columns 7 and 8, which use a broader definition, lead to qualitatively similar conclusions.

Overall, the results are consistent with the claim that scientific production declined in the medieval period. While any individual point estimate should be treated with caution, the general patterns —common to a wide variety of datasets— weigh against the possibility that the measured decline is spurious.

3 Theories and Explanations

Why did the decline begin in the eleventh century? And was it related to an increase in the political power of conservative religious leaders? The gradual nature of the Revival's institutional changes, coupled with the data limitations, make clean identification of the channels through which the Revival affected scientific production impossible. Faced with this limitation, I

investigate the extent to which the data are consistent with the historical evidence presented in the first section and are opposed to plausible competing explanations for the results.

The central implication of the Revival hypothesis is that the decline in scientific activity coincided with an increase in the political power of religious leaders. Columns 1-6 of Table 4 provide evidence consistent with this prediction.

Columns 1 and 2 document the rise in *madrasa* affiliation over time. Because the *madrasa* was the "chief means by which [religious elites] were coopted by the ruling elites" (Hallaq, 2009, p. 135), this result suggests increased resource transfers to religious leaders and, by definition, an increase in their political power.

Although rising *madrasa* affiliation is probably the best documented proxy for the increase in the political power of religious authorities during this period, this proxy may reflect the empowerment of religious leaders with a lag due to logistical delays in the construction and staffing of *madrasa*s.

Columns 3-6 investigate the robustness of the results using two additional proxies for the political power of religious leaders. In columns 3 and 4, I document the evolution of the proportion of authors with titles emphasizing religious authority (e.g. *burhan al-din*). Columns 5 and 6, in turn, examine the proportion of authors with mentioned Islamic law school affiliations. These affiliations are a useful marker of the political power of religious leaders because law school affiliation is believed to

have become more important as religious elites gained societal influence (e.g. Lapidus, 2014, pp. 133-134). The results are reassuring: because different proxies display similar trends, they increase confidence in the conclusion that religious elites became increasingly powerful as science declined.

My reading of the historical evidence implies that this increase in political power led to a decrease in the societal influence of competing interpretations of Islam. Conceptually, this hypothesized relationship is rooted in the idea that empowered religious leaders exploited their newfound influence to limit alternative ideologies that threatened their societal control. Although empirically substantiating the motives of religious elites is difficult, columns 7 and 8 provide evidence consistent with this claim.

Column 7 shows that the proportion of authors adhering to "deviant" interpretations of Islam (including rational Islam) declines from approximately 4% in the omitted period of [800,1100) to zero by the fifteenth century. Column 8 shows that this decline is robust to varying the omitted period. These results, at the very least, are consistent with the idea that Muslim minorities were increasingly excluded from intellectual life after the Revival. To the extent that an author's religious affiliation mirrors that of society, these results provide evidence that the societal influence of these minority interpretations declined after the eleventh century.

The final two columns of Table 4 investigate whether, as pre-

Table 4: **Empowerment of Religious Elites and the Decline**

	Dependent Variable equal to One if:									
	Madrasa		Religious Authority		Law Affiliation		"Deviant" Islam		Bureaucrat	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
[1000, 1100)		0.20**		0.42**		-1.74***		0.31		3.82***
		(0.08)		(0.18)		(0.38)		(0.32)		(0.41)
[1100, 1200)	1.40***	1.49***	7.37***	7.56***	2.40***	1.63***	-1.24***	-1.11***	-0.17	1.53***
	(0.18)	(0.18)	(0.40)	(0.40)	(0.42)	(0.46)	(0.27)	(0.31)	(0.38)	(0.39)
[1200, 1300)	2.68***	2.77***	32.13***	32.32***	7.08***	6.30***	-3.64***	-3.50***	-3.36***	-1.66***
	(0.23)	(0.23)	(0.65)	(0.65)	(0.49)	(0.53)	(0.17)	(0.22)	(0.29)	(0.31)
[1300, 1400)	7.58***	7.67***	41.66***	41.85***	19.34***	18.57***	-3.73***	-3.60***	-4.75***	-3.05***
	(0.44)	(0.44)	(0.82)	(0.82)	(0.73)	(0.76)	(0.17)	(0.22)	(0.27)	(0.29)
[1400, 1500)	6.99***	7.08***	44.89***	45.08***	23.08***	22.30***	-3.82***	-3.69***	-5.41***	-3.71***
	(0.49)	(0.49)	(0.95)	(0.95)	(0.88)	(0.90)	(0.17)	(0.22)	(0.24)	(0.27)
Constant	0.22***	0.14***	1.16***	0.97***	5.61***	6.39***	3.90***	3.76***	5.99***	4.29***
	(0.04)	(0.04)	(0.09)	(0.11)	(0.19)	(0.27)	(0.16)	(0.21)	(0.20)	(0.22)
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.07]	[0.07]	[0.00]	[0.00]	[0.00]	[0.00]
N	31,888	31,888	31,888	31,888	31,888	31,888	31,888	31,888	31,888	31,888

Notes: standard errors clustered by decade in parentheses, coefficients multiplied by one-hundred. Dependent variable in columns 1 and 2 is an indicator equal to one if an author was affiliated with a *madrasa*. In columns 3 and 4, it is an indicator equal to one if an author had a title indicating religious authority. The dependent variable in columns 5 and 6 is equal to one if there is information that an author was affiliated with one of the four major Islamic law schools. The dependent variable in columns 7 and 8 is equal to one if an author adhered to "deviant" Islam (as defined by conservative religious elites). In columns 9 and 10 it is equal to one if an author was affiliated with the bureaucracy. The row presents p-values corresponding to the null hypothesis that the reported century coefficients are jointly equal to zero.

dicted by the historical evidence, the proportion of authors employed in bureaucratic positions falls as religious authorities are empowered.[19] Creating a measure of bureaucratic affiliation is challenging, in part, because the primary Arabic word for bureaucrat secretary (*katib*) has alternative meanings used for both religious and other occupations. Notwithstanding this source of measurement error, the results show that by the fifteenth century the proportion of bureaucracy-affiliated authors had sharply dropped when compared to the omitted period. Empirically, the relatively lagged drop in bureaucratic affiliation is driven by the fact, illustrated in Table 1, that the proportion of bureaucrats was increasing prior to 1100. This fact, which may represent a host of factors including the growing importance of bureaucratic structures in intellectual production or measurement error, implies that the regression results

[19]This proxy for secular state capacity follows (Acemoglu et al., 2015, p. 2365) who conceptualize state capacity as the "presence of state functionaries and agencies."

understate the decline in the proportion of bureaucratic authors when compared to immediately before the Revival. For example, if one examines the trend in bureaucratic affiliation, it begins to reverse around the time science begins to decline.

In general, the data are consistent with historical evidence that between 1100 and 1400 the political power of religious leaders increased at the expense of secular bureaucratic structures. A drop in the proportion of authors adhering to non-conservative interpretations of Islam accompanied this shift, providing empirical support to the idea that empowered religious leaders worked to eliminate competing interpretations of Islam.

3.1 The Geography of the Decline

To further investigate the empirical relevance of the Revival hypothesis, Table 5 documents how the decline varies across time and space using the sample of geo-referenced authors. Because variation in the original data is at the author level I continue to report regression results at this level of disaggregation. Although it is possible to create a city-level panel of scientific production, these regressions have the disadvantage of dropping observations that are not geo-referenced to a city but are linked to a broader region (e.g. Sijistan). Moreover, the author-weighted point estimates using such a panel are identical to those obtained from the corresponding author-level regressions.

In column 1, I reproduce the results from regression 1 on the

geo-referenced sample for comparison. The smaller sample size translates into less precise estimates although the qualitative implications that scientific activity declined remains unchanged.

To investigate how the decline varies across space, column 2 presents results from the regression:

$$Science_i = \gamma_r + \sum_r \sum_{h \geq 1000} \delta_{rh} D_h \cdot D_r + \epsilon_i \qquad (2)$$

where the variables are as in equation 1, r indexes geographical regions (West and East) and D_r is an indicator equal to one if an author died in region r.[20] Note that in this regression there is not an omitted category so the point estimates are identical to those obtained estimating equation 1 by region. The use of these broad geographic regions is entirely driven by statistical power: analysis using finer levels of geographic disaggregation is generally too noisy to be informative.

The results in column 2 confirm the preliminary analysis in Table 2: the decline in scientific production begins earlier in the Eastern Islamic world. The row p-value, which reports the p-value corresponding to the null hypothesis that the differences between the century coefficients are jointly equal to zero, shows that the data reject the hypothesis that science evolved identically in the Eastern and Western Islamic world at the 10% level. The differences between the East and West intercepts, which measure the proportion of scientists prior to 1000, may repre-

[20]The eastern region includes all cities to the east of Alexandria, Egypt (inclusive).

Table 5: **The Geography of the Decline**

	Dependent Variable:							
	Scientist		Madrasa Affiliation		Religious Authority		Law Affiliation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$[1000, 1100)$	-0.73*		0.22*		0.41		-1.53*	
	(0.43)		(0.12)		(0.27)		(0.86)	
$[1100, 1200)$	-1.16***		1.64***		7.78***		1.75**	
	(0.40)		(0.27)		(0.88)		(0.84)	
$[1200, 1300)$	-0.99**		3.33***		31.41***		7.85***	
	(0.49)		(0.47)		(4.14)		(1.44)	
$[1300, 1400)$	-1.40***		9.18***		44.89***		23.12***	
	(0.50)		(1.86)		(3.01)		(3.90)	
$[1400, 1500)$	-2.16***		9.40***		50.98***		29.67***	
	(0.41)		(1.54)		(2.52)		(1.57)	
$[1000, 1100) \cdot EAST$		-1.44**		0.42*		1.08**		-1.22
		(0.64)		(0.22)		(0.53)		(1.35)
$[1100, 1200) \cdot EAST$		-1.12**		3.31***		15.87***		6.05***
		(0.50)		(0.50)		(1.56)		(0.61)
$[1200, 1300) \cdot EAST$		-1.27**		5.32***		48.21***		13.08***
		(0.64)		(0.49)		(3.92)		(1.90)
$[1300, 1400) \cdot EAST$		-2.46***		12.01***		57.86***		27.93***
		(0.49)		(2.24)		(3.22)		(4.10)
$[1400, 1500) \cdot EAST$		-2.83***		10.39***		55.25***		30.96***
		(0.51)		(1.72)		(2.60)		(1.81)
$[1000, 1100) \cdot WEST$		0.39		0.04		-0.12		-1.28*
		(0.94)		(0.07)		(0.10)		(0.68)
$[1100, 1200) \cdot WEST$		-0.76		0.05		0.16		-1.68***
		(0.65)		(0.11)		(0.12)		(0.60)
$[1200, 1300) \cdot WEST$		-0.68		-0.01		3.10***		-1.18**
		(0.61)		(0.08)		(1.11)		(0.52)
$[1300, 1400) \cdot WEST$		0.48		0.76*		6.07***		6.97**
		(1.06)		(0.40)		(1.64)		(2.90)
$[1400, 1500) \cdot WEST$		-2.38***		0.42		10.77***		8.04***
		(0.68)		(0.50)		(2.60)		(0.77)
Constant	4.14***		0.18***		0.97***		6.79***	
	(0.27)		(0.06)		(0.12)		(0.55)	
EAST		4.98***		0.23		1.45***		8.04***
		(0.39)		(0.09)		(0.25)		(0.77)
WEST		2.88***		0.08		0.23***		4.52***
		(0.47)		(0.05)		(0.07)		(0.40)
$p - value$		[0.07]		[0.00]		[0.00]		[0.00]
N	25,176	25,176	25,176	25,176	25,176	25,176	25,176	25,176

Notes: standard errors clustered by decade in parentheses, coefficients multiplied by one-hundred. Dependent variable in columns 1 and 2 is an indicator equal to one if author was a scientist. In columns 3 and 4, it is an indicator equal to one if there is information that an author was employed in a *madrasa*. The dependent variable in columns 5 and 6 is an indicator equal to one if an author has a title indicating religious authority. In columns 7 and 8 it is an indicator equal to one if an author was affiliated with one of the four major Islamic law schools. The row presents p-values corresponding to the null hypothesis that the difference between the East and West interactions by century are jointly equal to zero.

sent greater scientific intensity in the Eastern Islamic world. Alternatively, it may reflect differing focus in the sources.

Do the proxies for the political power of religious leaders follow a similar pattern? Columns 3-8 present results investigating this question. These columns report results from equation 2 and follow the format of columns 1 and 2. They are broadly consistent with the idea that the institutional changes of the Revival that empowered religious elites moved from East to West.

Columns 3 and 4, for example, show that the increase in the proportion of *madrasa*-affiliated authors begins earlier and is more pronounced in the Eastern Islamic world.[21] Similarly, columns 5-8 illustrate that additional proxies for the political power of religious leaders follow broadly comparable trends.[22]

These results, while somewhat limited due to data constraints, weigh against the possibility that the decline was the result of pan-Islamic shocks. Similarly, they are not consistent with theories attributing the overall decline to region-specific external shocks such as the Crusades or the Mongol invasions. In particular, the western Islamic world was subject to significant Christian military pressure after 1100, yet scientific output did not decline until after the arrival of Revival institutions. Like-

[21]The relatively weak upward trend of *madrasa*s in the western Islamic world likely reflects both the noisy nature of this proxy and the concentration of Iberian authors in the Western data where the *madrasa* arrived comparatively late.

[22]The drop in law affiliation in the Western Islamic world from the eleventh through thirteenth century may reflect, at least in part, the impact of Almoravid and Almohad rule.

wise, the Eastern Islamic world suffered the direct impact of the Mongol invasions, yet the decline pre-dates these invasions by over a century.[23]

Although city-level variation is too noisy to pin down the channels through which the Revival affected scientific activity for any individual city or subset of cities with any further degree of certainty, in the aggregate, city-level data allows one further test of the idea that the political empowerment of religious leaders contributed to the decline in Islamic science. One can examine how the aggregate proportions of both scientists and *madrasa*-affiliated authors vary with respect to the time elapsed from the first *madrasa* construction in a city. This is a useful check on the results, because any decline significantly prior to the construction of the first *madrasa* would cast doubt on the idea that these institutional changes caused the decline.[24]

Figure 2 implements this strategy by plotting the one-hundred year moving average of the proportion of scientists and *madrasa*-affiliated authors against time since first *madrasa* construction. This figure provides additional confirmation that the decline of science and the empowerment of religious leaders were closely linked and weighs against the idea that the decline in scientific

[23]Chaney (2023) presents evidence consistent with the idea that Mongol invasions had a long-lasting and negative economic impact. In this sense, the Mongol invasions may have contributed to or exacerbated the decline in scientific output. In the Appendix I provide additional evidence that the areas most affected by the Crusades did not drive the decline.

[24]The analysis is limited to the 80 cities which remained in the Islamic world more or less continuously between 800 and 1500 and for which I was able to obtain an approximate date the first *madrasa* was constructed. See the Appendix for details.

activity reflects pre-Revival trends.[25]

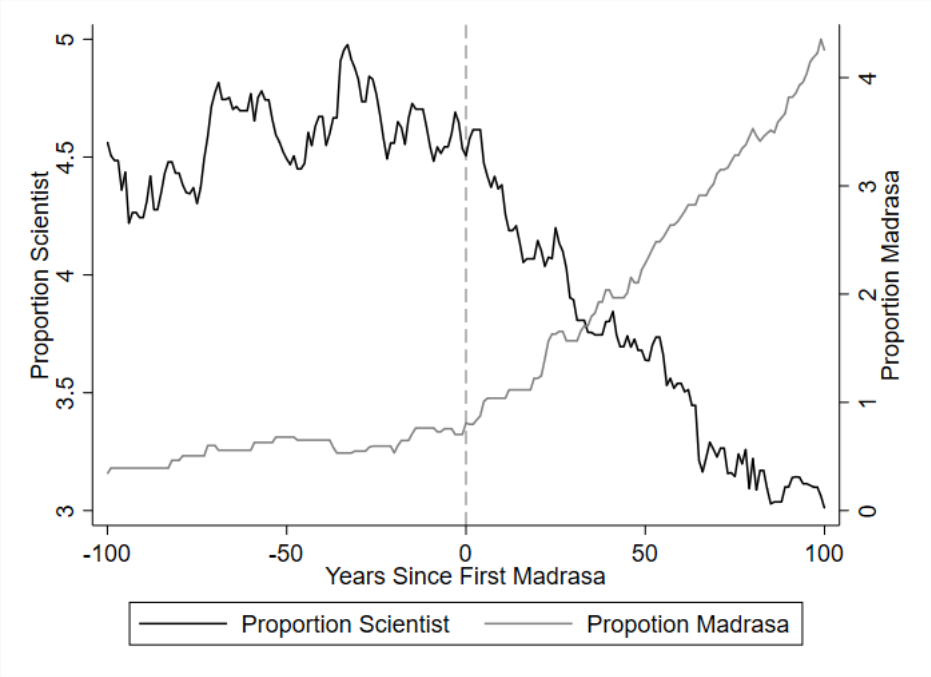

Figure 2: **Proportion Scientist and Madrasa-Affiliated by Time Since First Madrasa**

3.2 Other Causal Channels

The weight of the evidence supports the idea that the Sunni Revival's institutional changes contributed to the decline of Islamic science starting in the eleventh century. An increase in the relative political power of religious leaders is not the only channel, however, through which the Revival may have affected scientific output. Table 6, which has a similar format to Table 1, investigates the empirical relevance of a few of these alter-

[25]For example, in the regression of the proportion scientist (and proportion *madrasa*-affiliated) on decade indicators corresponding to Figure 2 (omitting the decade prior to the construction of the first madrasa) the p-value on the pre indicators is not statistically significant whereas the p-value corresponding to the post indicators is.

native channels.[26]

First, columns 1-4 investigate the possibility that overall religiosity changed following the Revival. If the population became more religious during this period, then increased demand for religious works could have crowded out scientific activity. Columns one and two examine the empirical relevance of this hypothesis by exploiting information on the religious qualities of individuals present in many biographical dictionaries. In these regressions, the dependent variable is equal to one if a biography notes that an author was abnormally religious. While this decline in author religiosity does not necessarily imply a decline in the religiosity of the population it provides additional support for an increase in the political power of religious leaders. In particular, it is consistent with the claim that the professionalization of religious scholarship led to the entry of less religious individuals (e.g. Hallaq, 2009, p. 154) and weighs against broad-based societal increases in religiosity during this period.

A more sophisticated version of the religiosity hypothesis links the decline of science to the rise of *Sufism* (mystical Islam). *Sufism* is believed to have undercut scientific production by

[26]The actions of the military is one additional channel that I am unable to empirically address. This channel views the actions of religious elites as downstream from the desires of military leaders to maintain order through ideological conformity. Such hypotheses, however, face the difficulty that the religious elites that controlled educational institutions operated relatively independently from military elites in this period of reduced state capacity. In other words, it seems unlikely that military leaders could have single-handedly engineered the decline had these changes not been in the interest of religious leaders.

undermining the use of reason and encouraging the rejection of causality (e.g. Huff, 2003, p. 113). Columns 3 and 4 investigate the empirical relevance of this view, documenting that the proportion of authors adhering to mystical interpretations of Islam increased over time. While an increase in adherence to mystical Islam did coincide with the decline, this result is also consistent with the argument that conservative religious elites drove the decline. For example, it has been hypothesized that the rise of Sufism itself was a manifestation of the political empowerment of conservative religious elites and a tool with which to address skepticism (Makdisi, 1973; Crone, 2006).[27]

A third alternative hypothesis stresses the centrality of non-Muslims in the Islamic world's scientific development (e.g. Saunders, 1962, p. 704). For example, non-Muslims may have faced fewer religious impediments to scientific activity or encouraged scientific activity through other channels. If the activity of non-Muslims in the science, rather than the ascendancy of conservative elites, drove the decline a drop in non-Muslim affiliation from a sizeable base should coincide with the decline of scientific activity. Columns 5 and 6 explore the empirical relevance of this view by documenting the evolution of the proportion of non-Muslim authors over time. Although the proportion of non-Muslim authors declines in the centuries following the Revival this drop is often not statistically significant. Moreover,

[27]In this sense, it is consistent with Dallal (2010, p. 154) who argues that the rise of *Sufism* during this period should be viewed as a symptom of the decline of science and not its root cause.

the proportion of non-Muslims authors prior to the Revival is under one percent, casting doubt on the centrality of this group for Islamic scientific production.[28]

Fourthly, the Revival as a "critical juncture" in Islamic institutions, may have altered economic performance. Did the Revival lead to an economic downturn, which in turn drove the decline in scientific activity? Although testing this hypothesis is empirically challenging due to data constraints, columns 7-10 provide some evidence against its relevance by documenting the evolution of the average number of author deaths by year. This analysis is rooted in evidence that variation in this quantity proxies for economic activity. In particular, Chaney (2023) documents that increased author deaths are strongly correlated with increased urbanization.

Columns 7 and 8 examine the evolution of the number of authors using the entire sample and those in columns 9 and 10 exclude the Western Islamic world, which was contracting during this period due to the Christian conquest of Islamic Iberia.[29] Aside from documenting the relative decline of the Western Islamic world during this period, these results are not consistent with the idea that the Revival led to widespread economic decline.[30]

[28]I do document in the Appendix, however, that in the sample of authors non-Muslims are more likely to be classified as scientists.

[29]In the Appendix I use the framework developed in Chaney (2023) to examine the evolution of economic activity around the Revival more formally. The qualitative implications of this analysis are similar to the more simple approach employed here.

[30]The absence of economic decline may be rooted, at least in part, in the fact that the "decreased institutional complexity of the bureaucracy" was balanced by the actions of empowered religious leaders (Gilbert, 1980, p. 133). Alternatively, it could be that

Table 6: **Alternative Channels**

	Dependent Variable:											
	Religious		Sufi		Non-Muslims		Authors (All)		Authors (No West)		R. Elite and Scientist	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
[1000, 1100)		-1.77**		0.01		-0.39**		24.69***		12.30*		1.11
		(0.73)		(0.15)		(0.19)		(8.24)		(6.59)		(2.72)
[1100, 1200)	-0.79*	-0.57***	0.14	0.14	0.13	-0.04	3.48	11.71***	-2.06	2.04	23.80***	24.23***
	(1.41)	(0.41)	(0.19)	(0.21)	(0.18)	(0.20)	(6.89)	(6.72)	(5.02)	(4.95)	(2.95)	(3.15)
[1200, 1300)	0.00	-0.78**	1.80***	1.81***	-0.03	-0.20	5.43	13.66**	6.64	10.74**	51.11***	51.53***
	(0.42)	(0.35)	(0.36)	(0.37)	(0.18)	(0.20)	(6.49)	(6.34)	(4.65)	(4.63)	(7.32)	(7.40)
[1300, 1400)	-0.19	-0.35**	1.33***	1.34***	-0.18	-0.98	-11.67**	-3.45	-1.74	2.36	53.90***	54.32***
	(0.65)	(0.61)	(0.39)	(0.40)	(0.15)	(0.17)	(5.37)	(5.18)	(4.32)	(4.29)	(6.34)	(6.43)
[1400, 1500)	-1.92***	-2.71***	1.78***	1.79***	-0.33**	-0.50***	-20.95***	-12.73**	-5.77	-1.67	52.29***	52.71***
	(0.43)	(0.36)	(0.45)	(0.46)	(0.16)	(0.19)	(5.68)	(5.50)	(4.86)	(4.84)	(7.54)	(7.63)
Constant	2.85***	3.64***	0.68***	0.68***	0.69***	0.86***	48.94***	40.72***	32.00***	27.90***	7.28***	6.85***
	(0.36)	(0.28)	(0.08)	(0.12)	(0.10)	(0.14)	(3.99)	(3.72)	(2.89)	(2.85)	(1.34)	(1.73)
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.13]	[0.06]	[0.00]	[0.00]	[0.17]	[0.08]	[0.00]	[0.00]
N	31,888	31,888	31,888	31,888	31,888	31,888	700	700	700	700	963	963

Notes: standard errors clustered by decade in parentheses, coefficients multiplied by one-hundred. Dependent variable in columns 1 and 2 is equal to one if there is information an author was abnormally religious. In columns 3 and 4 the dependent variable is equal to one if there is information an author adhered to Sufism. The dependent variable in columns 5 and 6 is one if an author is identified as non-Muslim. In columns 7-10 the dependent variable is the number of authors dying in a given year. The dependent variable in columns 11 and 12 is equal to 100 if an author is recorded as being both a religious authority and scientist. Regressions are estiamted on the entire sample with the exception of those in columns 9 and 10 (in which the Western Islamic world is excluded) and 11 and 12 (which is limited to scientists). The row presents p-values corresponding to the null hypothesis that the reported century coefficients are jointly equal to zero.

Finally, I examine whether measurement error can explain the decline. In recent years, scholars have noted that many religious leaders also engaged in scientific activity (e.g. Saliba, 2007, p. 243). This raises the possibility that scientific production remained constant, but the proportion of scholars classified as scientists in the sources declined as they increasingly were also employed in religious activities.

Although this hypothesis faces conceptual challenges (e.g. hybrid scholars would have struggled to resist the crowding out of scientific activities) and is also not consistent with the book level results, columns 11 and 12 further investigate its empirical relevance. In these columns, I restrict analysis to the 963 scientists in the sample and set the dependent variable equal to one if there is information that the scientist was also a religious elite. The proportion of dual religious elite-scientist authors increases

during this period secular bureaucratic structures were less important for economic outcomes.

with the decline, demonstrating that the sources do note the existence of these hybrid scholars. This provides some evidence against the idea that classification changes drive the observed decline. In fact, the growing importance of hybrid scientists over time is consistent with the hypothesis that scientific activity was increasingly restricted to religiously-sanctioned ends.[31]

More generally, while it is impossible to completely rule out the existence of time-varying measurement error, it is unlikely that measurement error could explain the broad-based empirical patterns documented in this paper.

4 Conclusion

Starting in the eleventh century, scientific activity began to decline in the Islamic world. This previously empirically undocumented fact is central to understanding scientific and technological development over the past millennium and has implications for theories relating Islam and human capital development as well as for understanding the Great Divergence.

I argued that a series of institutional changes known as the Sunni Revival contributed to the decline of Islamic science through the empowerment of conservative religious leaders. Arguments that science did not decline or competing channels for the decline such as negative economic shocks contradict the available

[31]This result is also consistent with the claim that the author-based results may understate the decline in scientific activity, as scientists after the Revival dedicated a smaller proportion of their time to scientific endeavors.

data.

The data patterns do not support the essentialist idea that Islam and science are incompatible. Rather, the results suggest that the political empowerment of religious leaders negatively impacted scientific development. Newly empowered elites restricted intellectual production and discouraged interpretations of Islam that undermined their authority. These actions decreased the incentives to engage in scientific activity and helped drive the decline.

The root causes of the Revival remain poorly understood. Elsewhere, I have hypothesized that the Revival represented the culmination of long-run processes rooted in the tribalization of civil society (Chaney, 2020). Although such hypotheses await systematic empirical investigation, this paper has highlighted the contribution of religious elites to the decline of one of history's most scientifically advanced societies. I hope that it will encourage further research examining the role of cultural elites —religious and non-religious— in scientific and technological development in the Islamic world and beyond.

References

Acemoglu, D. and J. A. Robinson, "Political Losers as a Barrier to Economic Development," *American Economic Review*, 2000, *90* (2), 126–130.

_ **and** _ , *Economic Origins of Dictatorship and Democracy*, Cambridge University Press, 2006.

_ **, C. Garcia-Jimeno, and J. Robinson**, "State Capacity and Economic Development: A Network Approach," *American Economic Review*, 2015, *105* (8), 2364–2409.

al-Ghazali, *Deliverance from Error*, Louisville: Fons Vitae, 1980.

Altonji, J., T. Elder, and C. Taber, "Selection on Observed and Unobserved Variables: Assessing the Effectiveness of Catholic Schools," *Journal of Political Economy*, 2005, *113* (1), 151–184.

Andalusi, A., *Jadwa al-Muqtabas fi Dhikr Walat al-Andalus*, Beirut: Dar al-Kutub al-Ilmiyya, 1997.

Athamina, K., "The Ulama in the Opposition: the Stick and Carrot Policy in Early Islam," *The Islamic Quarterly*, 1992, *36* (3), 153–178.

Baumol, W., "Entrepreneurship: Productive, Unproductive, and Destructive," *The Journal of Political Economy*, 1990, *98* (5), 893–921.

Benabou, R., D. Ticchi, and A. Vindigni, "Forbidden Fruits: The Political Economy of Science, Religion, and Growth," *Review of Economic Studies*, 2022, *89*, 1785–1832.

Bennison, Amira K., *The Almoravid and Almohad Empires*, Edinburgh: Edinburgh University Press, 2016.

Berkey, J., *The Formation of Islam*, New York: Cambridge University Press, 2003.

Brentjes, S., *Teaching and Learning the Sciences in Islamicate Societies (800-1700)*, Turnhout: Brepols, 2018.

Chaney, E., "Revolt on the Nile: Economic Shocks, Religion and Political Power," *Econometrica*, 2013, *81* (5), 2033–2053.

_ , "Islam and Political Structure in Historical Perspective," in M. Cammett and P. Jones, eds., *The Oxford Handbook of Politics in Muslim Societies*, Oxford: Oxford University Press, 2020, pp. 33–52.

_ , "Modern Library Holdings and Historic City Growth," *Working Paper*, 2023.

Crone, P., *Slaves on Horses*, Cambridge: Cambridge University Press, 1980.

_ , "Post-Colonialism in Tenth-Century Islam," *Der Islam*, 2006, *83* (1), 2–38.

Dallal, A., *Islam, Science, and the Challenge of History*, New Haven: Yale University Press, 2010.

Endress, G., "Le Projet d'Averroes," in J. Aertsen and G. Endress, eds., *J. Aertsen and G. Endress, eds.*, Vol. 31 of *Islamic Philosophy, Theology and Science. Texts and Studies*, Brill, 1999, pp. 3–31.

Fernández, Raquel, "Chapter 11 - Does Culture Matter?," in Jess Benhabib, Alberto Bisin, and Matthew O. Jackson, eds., *Jess Benhabib, Alberto Bisin, and Matthew O. Jackson, eds.*, Vol. 1 of *Handbook of Social Economics*, North-Holland, 2011, pp. 481–510.

Gibb, H.A.R., "An Interpretation of Islamic History II," *The Muslim World*, 1955, *45* (2), 121–133.

_ , "The Social Significance of the Shuubiya," in S. Shaw and W. Polk, eds., *Studies of the Civilization of Islam*, Princeton: Princeton University Press, 1982, pp. 62–73.

Gilbert, J., "Institutionaliztion of Muslim Scholarship and Professionalization of the Ulama in Medieval Damascus," *Studia Islamica*, 1980, *52*, 105–134.

Goitein, S.D., "The Rise of the Near-Eastern Bourgeoisie in Early Islamic Times," *Journal of World History*, 1957, *3* (3), 583–604.

Gutas, D., *Greek thought, Arabic culture: the Graeco-Arabic translation movement in Baghdad and early 'Abbāsid soceity*, New York: Routledge, 1998.

Hallaq, W., *The Origins and Evolution of Islamic Law*, Cambridge: Cambridge University Press, 2005.

_ , *Shari'a*, Cambridge: Cambridge University Press, 2009.

Huff, T., *The Rise of Early Modern Science: Islam, China and the West*, Cambridge: Cambridge University Press, 2003.

Israel, J., *Enlightenment Contested*, New York: Oxford University Press, 2006.

Jones, S., R. Catto, T. Kaden, and F. Elsdon-Baker, "'That's how Muslims are required to view the world': Race, culture and belief in non-Muslims' descriptions of Islam and science," *The Sociological Review*, 2019, *67* (1), 161–177.

Kraemer, J., *Humanism in the Renaissance of Islam*, Leiden: E.J. Brill, 1992.

Lambton, A.K.S., "The Internal Structure of the Saljuq Empire," in J.A. Boyle, ed., *The Cambridge History of Iran*, Cambridge: Cambridge University Press, 1968.

Lapidus, I., *A History of Islamic Societies*, New York: Cambridge University Press, 2014.

Makdisi, G., "Ash'ari and the Ash'arites in Islamic Religious History II," *Studia Islamica*, 1963, *18*, 19–39.

_ , "The Sunni Revival," in D.H. Richards, ed., *Islamic Civilization, 950-1150*, Oxford: Bruno Cassirer, 1973, pp. 155–168.

_ , *The Rise of Colleges*, Edinburgh: Edinburgh University Press, 1981.

_ , "Ethics in Islamic traditionalist doctrine," in R. Hovannisian, ed., *Ethics in Islam*, Malibu: Undena Publications, 1985.

Mokyr, J., "The Intellectual Origins of Modern Economic Growth," *Journal of Economic History*, 2005, *65* (2), 285–351.

Rubin, J., *Rulers, Religion, and Riches: Why the West Got Rich and the Middle East Did Not*, Cambridge: Cambridge University Press, 2017.

Sabra, A. I., "The Appropriation and Subsequent Naturalization of Greek Science in Medieval Islam: a Preliminary Statement," *History of Science*, 1987, *25*, 223–243.

Saliba, G., *Islamic Science and the Making of the European Renaissance*, Cambridge: The MIT Press, 2007.

Saunders, J.J., "The problem of islamic decadence," *Journal of World History*, 1962, *7* (1), 701–720.

Sellheim, R., D. Sourdel, B. Fragner, and R. Islam, "Katib," in P. Bearman, Th. Bianquis, C.E. Bosworth, E. van Donzel, and W.P. Heinrichs, eds., *P. Bearman, Th. Bianquis, C.E. Bosworth, E. van Donzel, and W.P. Heinrichs, eds.*, Encyclopaedia of Islam, Second Edition, Brill, 2012.

Squicciarini, M., "Devotion and Development: Religiosity, Education, and Economic Progress in Nineteenth-Century France," *American Economic Review*, 2020, *110* (11), 3454–3491.

Stroumsa, S., *Freethinkers of Medieval Islam*, Leiden: Brill, 1999.

Watt, W.M., *Islam and the Integration of Society*, Milton Park: Routledge, 2001.