The Counter-Reformation, Science, and Long-Term Growth

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Abstract

Is it true that the Catholic reaction to Protestantism—the Counter-Reformation—led to scientific and economic decline for hundreds of years? Introducing biography-based evidence, I show that Catholic and Protestant European cities long shared comparable trends of notable scientists per capita. Yet, after imposing intellectual control in response to the Reformation, Catholic cities experienced a dramatic scientific collapse that coincides with the Counter-Reformation's different timing and city-level intensity. Reassuringly, science began to recover after the Counter-Reformation was dismantled, but the recovery stagnated when Counter-Reformation-rooted institutions were revived centuries later against new ideological threats. Although it has largely vanished by now, the gap in science that emerged during the Counter-Reformation was enormous, lasted centuries, and helps explain Europe's unequal modern economic growth. Protestants, who also tried to impose their own intolerance, lacked sufficient coordination and authority. Had they been more effective, modern science and sustained economic growth might have never taken off.

Keywords: Science, Catholicism, Counter-Reformation, Inquisition, Spanish Empire, censorship, dictatorships, conservatism, political economy, causes of persistence, long-term economic growth.

JEL: N00, P00, N10, O11, O10, O30, O43, Z12, F50.

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> *How should we learn the modern discoveries of the exact sciences, which have produced the wealth of France, England, and other industrious nations thanks to the Enlightenment? . . . Only by violating the prohibitive laws of the Inquisition. But this is dangerous, and few dare to take the risk.*
>
> — Juan Antonio Llorente, 1817
> (former Spanish inquisitor)

1 Introduction

The rise of science in early modern Europe has long been considered a precondition for the takeoff of sustained economic growth.[1] However, little is known about the city-level distribution of early modern scientists and the causes and consequences of their emergence. How did science respond to intellectual persecution? Did science benefit from the gradual adoption of free-thought ideals? Did the Church's fragmentation in the 16th century pave the way for varying outcomes across the European continent? And did cities with more scientist grow faster once science-driven modern growth began? I address these questions by studying an event that has received little attention in economics, even though its impact on early modern science and subsequent long-term economic development was allegedly enormous: the Catholic reaction to Protestantism, the so-called Counter-Reformation.

Why, allegedly, did the Counter-Reformation affect science? Because to stop the spread of subversive Protestant ideas, Catholic leaders banned dangerous literature at unprecedented scale, restricted studying and teaching at foreign universities, and enforced strict conformity to a fixed philosophical dogma—all in concerted fashion, thanks to the unity of the Church, the geopolitical might of imperial Spain, and the power of inquisitorial systems. It worked: the expansion of Protestantism was stopped, even reversed. But also "the diffusion of new ideas to society at large slowed to a trickle," and "the pursuit of the strange and potentially heretical" was warned off (Landes, 1998, pp. 179–80). The outcome: southern Europe—which "before the Reformation [was] a center of learning and intellectual inquiry"—"missed the train of the so-called scientific revolution." This would cost "more than three centuries of backwardness . . . in income and achievement," with effects "not wear[ing] off until the twentieth century" (p. 250).

If true, this interpretation would not only be key to understanding Europe's history. It would also demonstrate the critical role of intellectual freedom in scientific progress, addressing current debates on the importance of tolerance and freedom of information.

But is this true? Did the Counter-Reformation depress science dramatically and enduringly, reducing long-term growth? Today's historiography is overwhelmingly skeptical and tends to dismiss this view as nothing but the echo of old anti-Catholic propaganda, the continuation of the so-called Black Legend (e.g., Kamen, 2014).[2] This paper, on the contrary, presents ample evidence that confirms: (i)

[1] Kuznets (1960), for example, argued that "modern science" was not just the "the major source of economic growth in the developed countries," but the "epochal innovation" that brought about the modern growth regime. For brief expositions of this interpretation, see Rosenberg and Birdzell (1990), Mokyr (2005), and Cohen (2009).

[2] While religious dogmatism and the Counter-Reformation in particular were seen by 19th-century historians such as Lea (1890), White (1898) and Draper (1875) as in "conflict" with science, scholars now largely agree that "it is a

a sharp decline of science that correlates with the Counter-Reformation's intensity, (ii) a remarkable persistence of this decline—largely explained by revivals, centuries later, of institutional legacies of the Counter-Reformation—and (iii) long-term economic consequences that seem indeed to stretch even into the 20th century.

The paper is divided chronologically into two parts. In the first one, I study science during the Counter-Reformation period itself (ca. 1550–1700). Using scientific biographies gathered from Wikidata, I find that the number of notable scientists per capita at the city level declined when and where the Counter-Reformation was implemented—and especially where and when the implementation was more intense. The magnitude of these results is so large that it can be easily recognized in the aggregate data, as can be seen in figures 1 and 2. They show that the number of notable scientists declined in Catholic relative to non-Catholic cities (figure 1a) and that this decline was steeper among scientists of higher quality (figure 2a). They also show that the decline was particularly dramatic within the leading bastions of the Counter-Reformation—Spain, Italy, Belgium, and Portugal—where the number of notable scientists per capita fell to levels not seen in centuries (figures 1b and 2b).[3]

While these overall trends across European countries are to some extent known (e.g., Anderson, 2015), I show that they also apply to contiguous and comparable cities. For example, within German-speaking or Dutch-speaking religious borderlands, Catholic and Protestant cities shared parallel trends in notable scientists per capita for decades or centuries, but Catholic cities began to underperform precisely when the Counter-Reformation was implemented. Identification follows not just from comparing contiguous and comparable cities—it becomes evident from the variance in the timing of treatment, which began as early as 1521 or as late as the 17th century, depending largely on the military outcomes that shaped the Counter-Reformation map across Europe. A revealing example is that of the Dutch-speaking Low Countries, which revolted against Spain in 1566. While the Calvinist-led revolt spread across the whole territory (reflecting cultural homogeneity), geographical accidents and contingent events led to the partition of this homogeneous territory into a Protestant-controlled north and a Spanish-controlled south, where the Counter-Reformation was successfully enforced. Along this highly randomized border, a sharp discontinuity emerged not only in religion but also in science (figure 4). Interestingly, this quasi-natural experiment delivered an outcome comparable to that seen in the Iberian and Italian peninsulas, yet occurring north of the Alps and generations later.

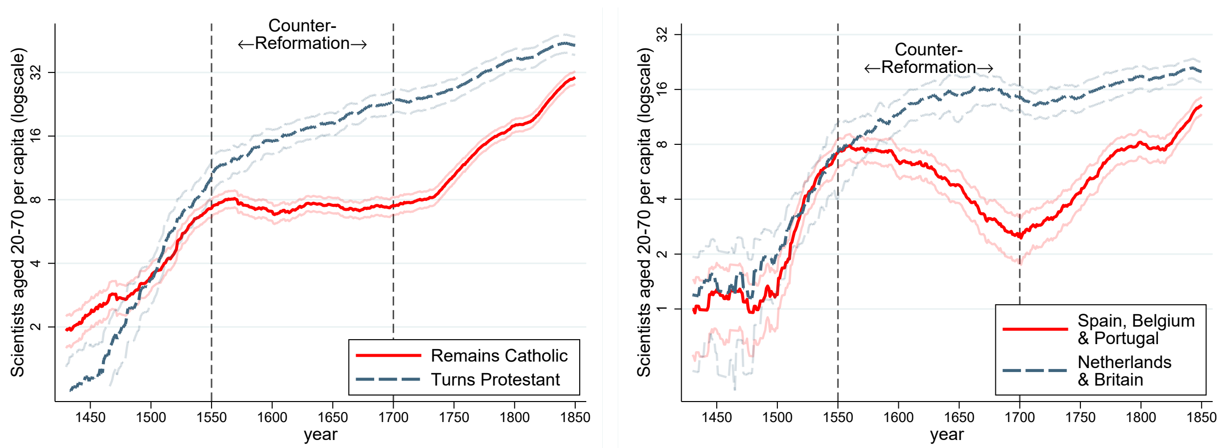
Similar discontinuities emerged elsewhere, again reflecting the specific timing of the Counter-Reformation (figure 6). And case-by-case studies reveal that the magnitude of the decline is consistent with the severity of the measures implemented. Meanwhile, when the treatment was weakened—for example, when inquisitorial activity receded or when Protestantism was tolerated—the number of scientists recovered systematically. Econometric exercises confirm that treatment intensity mattered:

very long time since these attitudes have been held by historians of science" (Shapin, 1998, p. 195). This new dominant view in historiography, which either doubts or denies any negative effect the Counter-Reformation on science, is found in Harris (2000), Ferngren (2002), Feingold (2003a), Olson (2004), Numbers (2009), Grendler (2011), Kamen (2014), Harrison (2015), Malta Romeiras (2020), Leitão (2020), and Gorman (2020), among many others. See also this paper's section 2 and footnotes 21, 22, and 68.

[3]Notice the similarity of pre-1550 trends in figure 1b: excluding Italy, whose exceptionally high number of famous scientists before 1550 precludes comparison, the remaining bastions of the Counter-Reformation shared common trends with comparable non-Counter-Reformation countries up to around 1550.

Figure 1: The Counter-Reformation and persistent scientific decline

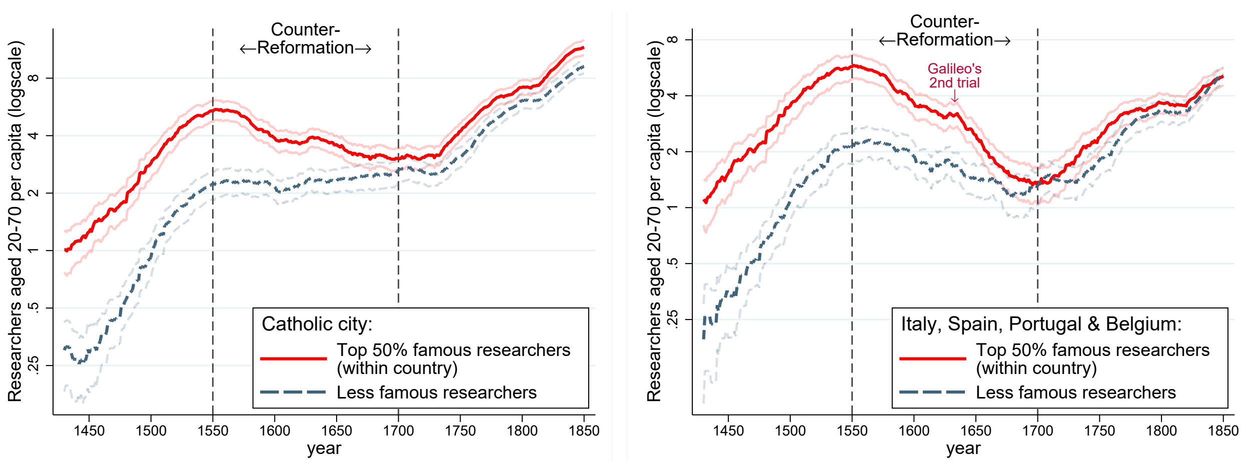
(a) Cities across Europe (b) CR-bastions vs. comparable group



Notes: The figures show that the Counter-Reformation is associated with a dramatic and persistent decline of famous scientists per capita in Catholic cities relative to Protestant ones. This is observed in Catholic Europe as a whole (1a) and especially in the most heavily treated territories, such as Iberia and Belgium (1b), where the decline is not just relative to comparable Protestant regions but also absolute. Plotted are means across cities ± 2 standard deviations. Number of scientists is based on biographies retrieved from Wikidata (see section 3) and city population, in thousands, is computed as described in the data appendix (section D.2.1).

Figure 2: Quality decline of science

(a) Catholic cities (b) Heavily treated regions



Notes: By distinguishing between high and low quality researchers (measured by the degree of visibility of their biographies), the figures show that the quality of science fell during the Counter-Reformation, especially in the most-heavily treated territories (and there, especially after the restrictive Spanish censorship index of 1630 and Galileo's condemnation in Italy in 1633). Top and bottom 50% visibility corresponds to the within-country rank, based on five criteria, as computed by Laouenan et al. (2022): the number of Wikipedia editions, non-missing biographic information in Wikidata, length of Wikipedia pages, hits of pages, and the number of external links. "Researchers" are those categorized as "Science/Discovery" by the authors. Plotted are means across cities ± 2 standard deviations. City population computed as described in the data appendix (section D.2.1).

among Catholics, science declined especially in realms that enforced Catholicism more strictly (such as the Spanish Empire); and, within these realms, science declined more in cities hosting inquisitorial tribunals or universities (which being at higher risk of Protestant contagion, faced a stricter uprooting of heresy). In short, the decline of scientists coincides with the intensity of the Counter-Reformation in both time and space. The results hold across various samples: in Europe as a whole, in cities close to confessional borders, and when restricting the sample to Catholic cities that are close to each other, differentiating them by treatment intensity. Accounting for alternative explanations—sampling biases, economic decline, devastation by wars and plagues, changes in literacy, political institutions, or or Protestantism (the reverse of the treatment)—does not affect the results.

Through which mechanism did science decline? The measures implemented to curb the spread of Protestantism were many and were often implemented simultaneously. While this poses an identification problem, the data suggest some interesting conclusions regarding the mechanisms. For example, it can be shown that brain drains (scientists moving out of Catholic territory) were significant but the effects of these brain drains on subsequent science were negligible; it can be shown that Catholic and Protestant universities continued to employ scientists at comparable rates, but the proxied quality of Catholics research declined; and it can be shown that pluralism is associated with better scientific outcomes—this being not so much because of multicultural ferment but rather because pluralism undermined effective repression. Overall, it appears that the crucial factor that made the measures effective was the degree of logistic capability. Factors such as clerical presence or resources, which had previously been beneficial for science, came to explain a larger decline.

The second part of the paper deals with the subsequent period: from 1700 to the present. Did the shock endure, as some historians have claimed? As hinted by figure 1, the data support the narrative once more. Multiple proxies for the Counter-Reformation (Catholicism, historical inquisitorial presence, Spanish control by 1600) are associated with depressed science until the late 18th century, lending support to the claim that "the Counter-Reformation ... slowed down the diffusion of the *nuova scienzia* innovations and the rise of the Enlightenment" (Mokyr, 2016, p. 165). By some metrics, the persistence remains also significant until the 19th century (or even longer), and it holds after controlling for plausible confounding factors, including economic and educational development, spatial proximity, languages, natural endowments, states, and institutions. Importantly, these results imply that science was *predetermined* by the Counter-Reformation at the time when modern economic growth—i.e. "science-based" growth (Kuznets, 1960, pp. 1–16)—found its way throughout the Continent.

But why did the shock persist for so long? I find that, while part of this persistence can be linked to a permanent Counter-Reformation-driven increase in clerical power (a predictor of less science in both Catholic and Protestant samples), the crucial factor was the revival of legacies of the Counter-Reformation (including censorship laws and religiously legitimized politics) during episodes of reactive conservatism. For example, when conservative regimes emerged all over Europe in reaction to the French Revolution (1789), it is among Catholics, and especially among cities with a strong Counter-Reformation past, that we observe a slowdown of science. Spain, in particular, revived its Inquisition to counter revolutionary thought, and science collapsed more than elsewhere, especially in cities hosting inquisitorial tribunals. Similarly, when Fascism proliferated across the West in reaction to Bolshevism after 1917 (e.g., Acemoglu et al., 2022), scientific growth declined where the Counter-Reformation had once been strongest. Even until the recent past, conservatism and dictatorships are associated with depressed science in cities or countries *conditional* on once having been subject to a strong Counter-Reformation.[4]

Finally, I ask what, if any, were the long-term economic consequences of the scientific decline that originated during the Counter-Reformation. I find that proxies for the Counter-Reformation and its intensity are indeed correlated with lower city growth during the initial phases of Europe's modern economic growth, from 1800 to 1939. I also confirm that this lower growth in treated cities can be largely attributed to having fewer scientists. However, some evidence suggests that there might have been additional Counter-Reformation-related mechanisms at play.

Recent years have seen the emergence of a vast and vibrant literature on the economics of religion and on the early modern roots of economic development.[5] Yet "the Counter-Reformation has seen relatively little study"—note Becker, Rubin, and Woessmann (2021)—"even though its long-run impact on European history and economic history is immense." Notable exceptions are Anderson (2015)—who, however, exploits only cross-country variance and attributes solely to the Inquisition what I identify as being the Counter-Reformation more broadly——and the very recent studies by de la Croix and Morault (2020), Drelichman, Vidal-Robert, and Voth (2021), Blasutto and de la Croix (2021), Becker, Pino, and Vidal-Robert (2021), Dewitte et al. (2022), and Buri (2024), which provide supporting evidence on the Counter-Reformation's negative effects on science or growth found in this paper. Further support, albeit indirect, comes from recent studies finding that science and innovation relate positively to conditions that the Counter-Reformation tried to impede—such as freer access to knowledge (Dittmar, 2019; Buonanno et al., 2023) and greater religious diversity (Cinnirella and Streb, 2017; Cabello, 2024a)—but relate negatively to conditions fostered by the Counter-Reformation—such as increased religiosity (Andersen and Bentzen, 2022; Lecce, Ogliari, and Squicciarini, 2021; Bénabou, Ticchi, and Vindigni, 2015, 2021; Cabello, 2024b), ideological persecution (Moser and Parsa, 2023), isolation (Iaria, Schwarz, and Waldinger, 2018), and increased clerical power (Chaney, 2023).[6]

That said, many studies offer alternative explanations for the observed scientific and economic decline. All these explanations are either controlled for or rejected in this paper. One is the decline of parliamentary representation, which, as shown by van Zanden, Buringh, and Bosker (2012), roughly coincides in time and space with the Counter-Reformation. Adding relevance to this confounder, recent studies have found a positive relationship between intellectual creativity and institutional variables such as self-governance (Serafinelli and Tabellini, 2022) and post-Reformation laws (Dittmar and Meisenzahl, 2020). However, controlling for these and other institutional variables does not affect the

[4]Besides providing a rationale for the shock's persistence, this perspective—studying the Counter-Reformation long after it occurred—allows to test the relevance of the original shock in alternative settings, overcoming issues specific to the 16th and 17th centuries, such as data shortages or confounding factors, thereby strengthening identification. Importantly, conditioning persistence on the political reaction explains why persistence is observed in some countries but not others.

[5]Seminal studies include Iannaccone (1998), Barro and McCleary (2003), and Becker and Woessmann (2009).

[6]For the many analogies between the event in medieval Islam studied by Chaney (2023) and the Counter-Reformation, see footnote 76.

results.[7]

Another popular alternative explanation is that differences in science between Catholics and Protestants arose not because of negative effects of the Counter-Reformation but instead because of alleged *positive* effects of Protestant asceticism (e.g., Merton, 1936). However, as figure 1a already reveals, the emergence of Protestantism (ca. 1517–1600) is not associated with an acceleration of the growth of scientist; and I show that neither is an intensification of Protestantism in time or space. Instead, I find that when and where it gained sufficient strength, Protestantism was *harmful* to science—although less harmful than the Catholic reaction to it. Both confessions *tried* to isolate themselves and enforce their dogma.[8] But Catholics did it more effectively, I conclude, because of their logistic advantages (especially religious unity and political coordination).[9] Had Protestantism been a more unified faith, capable of controlling philosophical debate as Luther or Calvin would have liked, it seems possible that modern science may have not risen at all.

This paper relates to the so-called persistence studies but differs from most of them by tracking the shock *continuously* from its inception to the present day.[10] Not only does this allow to show that the shock persisted indeed, but it allows a much better identification of the mechanisms driving persistence.[11] Another strand of related literature is the vast body of revisionist history of science, which emphasizes that many popular notions surrounding the alleged bloodiness of the Inquisition or the supposed lack of intellectual sophistication of the Counter-Reformation leaders (Jesuits, the Habsburgs, and popes) are false and grounded in propaganda.[12] While at times this literature acknowledges scientific decline during the Counter-Reformation, it tends to do so by pointing at confounding drivers (for example economic conditions) specific to the studied cases. In contrast to such case studies, this paper provides more extensive time and space coverage, a big-picture perspective that allows to distinguish better between systematic causal factors and those that may matter specifically at most. Lastly, the paper also connects to the centuries-old debates on possible negative consequences associated with censorship and intolerance, and how such repression is rooted in political power and fueled by geopolitical instability.[13]

[7] Neither does controlling for other popular confounders such as printing (Boerner, Rubin, and Severgnini, 2021), literacy (Becker and Woessmann, 2009), or economic variables such as proximity to the Atlantic, soil quality, or transport routes.

[8] As Elliott (1970) puts it: “Europe was now divided within itself, each half barricading itself against the beliefs of the other.”

[9] Others in the past have pointed in this direction too, such as Reusch (1883) and Putnam (1906), as I discuss below. On the relationship between fragmentation (which in religious terms was obviously greater among Protestants), persecution effectiveness, and intellectual development, see Mokyr (2007) and Mokyr (2016), chapters 9–12.

[10] For a review of persistence studies and the concerns associated with them, see Kelly (2019) and Voth (2021).

[11] My finding of persistence being strengthened during episodes of reactionary conservatism relates to the study of reactive fascism by Acemoglu et al. (2022), to the studies of enduring religiously-legitimized regimes by Rubin (2017) and Bentzen and Gokmen (2023), and to the studies of persistent political sentiments by Voigtländer and Voth (2012) and Cantoni, Hagemeister, and Westcott (2020), among others. Yet I am not aware of any study, other than this one, linking persistence to reactive conservatism systematically.

[12] See literature cited in footnotes 2, 21, 22, and 68.

[13] The notion that freedom of expression is a desirable, if not necessary, condition for progress has featured prominently in Western society ever since the Enlightenment. It is worth pointing that some writers of the Enlightenment, such as Voltaire or Nicolas Masson de Morvilliers, saw in Counter-Reformation Europe an example of the alleged dismal consequences of intellectual repression (see, e.g., Goodman, 2005). Academic interest in the consequences of censorship and intolerance has recently reemerged, addressing current issues such as internet censorship (e.g., Chen and Yang, 2019) and the so-called “cancel culture” (e.g., Norris, 2023).

The remainder of this paper begins with a brief introduction to the Counter-Reformation in section 2, including the controversies surrounding its alleged effects on science. Section 3 introduces the biographical data on scientists and intellectuals. Section 4 shows how the Counter-Reformation is associated with scientific decline from the 16th to the 17th century. Section 5 shows that the scientific geography produced by this decline persisted into the 19th century, identifies forces driving this persistence, and shows how it relates to city growth after 1800. Section 6 concludes. The paper also contains several appendices. Appendix A provides details about the Counter-Reformation policies that seem to have affected science. Appendix B rejects alternative explanations for the scientific decline. Appendix C studies persistence in more detail, covering echoes of the Counter-Reformation during dictatorships and waves of international reactionary conservatism. Appendix D provides details on the data and appendix E contains supporting maps.

2 History and controversies

2.1 The Counter-Reformation: when and where

As traditionally defined, the Counter-Reformation refers to the Catholic establishment's reaction to the spread of Protestantism.[14] In regions where Catholicism remained dominant, the reactive measures of the Counter-Reformation were protective, including censorship and the setup of inquisitorial systems aimed at controlling religious compliance. By contrast, in territories where Protestantism was already widespread, measures were offensive, ranging from peaceful educational missions to military-imposed persecution and forced recatholicization.

The timing of the Counter-Reformation's implementation and intensity varied geographically (see, e.g., the timing of heresy executions in figure A9). It peaked early on in Germany (in the 1520s, right after Luther's condemnation), after the 1550s in Italy and Iberia (in immediate reaction to cases of Protestant "infection"), but only in the 17th century in other parts of Europe, usually after Catholic military conquests.[15] Important in this chronology was the Council of Trent (1545-63), during which the doctrinal distinctions between Catholicism and Protestantism were established, and after which the coordination, intensity, and effectiveness of Counter-Reformation measures increased significantly (especially after the late 1550s, see appendix A).

Geographically, the Counter-Reformation was implemented all across Catholic Europe but with different degrees of intensity. Civil war-weakened France, for example, allowed Protestant worship

[14] For a definition of the term and a distinction to the related concepts "Catholic Reform," "Catholic Reformation," and "Early Modern Catholicism" see Bireley (2004) and Mullett (2010, pp. 118–20). For a comprehensive treatment, see O'Connell (1974), Wright (2017), Bamji, Janssen, and Laven (2013), and Trevor-Roper (2001). For a treatment of the Tridentine reforms, see O'Malley (2013). For an economic perspective on these reforms, modeled as a defensive strategy of an incumbent-firm monopoly, see Ekelund, Hebert, and Tollison (2004).

[15] Some landmark episodes are the prohibition of Lutheranism in the Holy Roman Empire through the Edict of Worms in 1521, the establishment of the Roman Inquisition in 1542, "in order to combat the spread of Protestant ideas into Italy, evident in the discovery of a Protestant cell in the city of Lucca" (Mullett, 2010, p. 263), the publication of the first comprehensive Spanish and Roman indexes of prohibited books of 1558-64, the Spanish death penalty for possessing prohibited books after 1558, the ban to visit foreign universities imposed to Spanish subjects in 1559 and in 1568, the military-imposed recatholicization of several territories between the late 16th and early 17th centuries, usually through Spanish military interventions (Belgium, Bohemia, the Rhineland), and the reversal of tolerance arrangements later in the century (Poland, Hungary, France).

for nearly ninety years, between the Edict of Nantes of 1598 and its revocation in 1685. Similar compromises were reached at times in parts of Austria where state power was weak (especially in Hungary, see Péter, 1996). And in Poland-Lithuania tolerance remained comparatively high (Mullett, 2010, pp. 378, 449; Butterfield, 1977).

By contrast, the Counter-Reformation took a particularly intolerant and intense form in localities subject to the Spanish, Portuguese, and Roman inquisitorial systems (figure A6) and in the vast European territories controlled by imperial Spain (appendix map E1), which, besides ruling over nearly 45% of the Western European urban population around 1600 (including Spain, Portugal, southern Italy, Milan, and Belgium), acted as political, financial, and military spearhead of the Counter-Reformation (e.g., Nexon, 2009; Schilling, 2007). Thanks to a few accidents—four unexpected inheritances and the subsequent conquest of the Americas—the Spanish Habsburgs had become the most powerful European rulers in a millennium (Maltby, 2002; Parker, 2021). Yet the legitimacy of their titles rested largely on the traditional order associated with a united Catholic church.[16] Habsburg political interests, combined with formidable military and financial power, made Spain and the Counter-Reformation almost inseparable. This is relevant for causal inference: Spain's unpredictable military victories and defeats reflected in the reach and intensity of the Counter-Reformation, thereby providing useful quasi-random variance in both time and space.

It is only after the defeat of Spain's hegemonic ambitions in 1648 (the end of the Thirty Years War) that the Counter-Reformation began to slowly fade off (especially after 1700 with the rise of Enlightenment ideals and despots implementing them).[17] In Italy, the majority of the tribunals of the Inquisition were abolished in the course of the 18th century, whereas in Portugal and Spain the Inquisition was weakened as well during the 18th century but not abolished definitively until 1821 and 1834 respectively (Bethencourt, 2009, p. 116).

[16] Charles V and his Spanish Habsburg descendants had a number of strong reasons to defend a united Catholic Church. To begin with, in 1517—the very year Luther sparked the Reformation from Wittenberg—the pope had already granted Charles the title "Catholic King," inherited from Ferdinand and Isabella, who had expelled the last Muslim rulers from the Iberian Peninsula. This religious legitimacy associated with Rome was further strengthened by his Holy Roman imperial title, especially after the pope crowned Charles in 1530 in a ceremony echoing Charlemagne's crowning in 800. Breaking with Rome might have enhanced Charles' legitimacy in parts of Germany, but it would have severely undermined it elsewhere, especially in his most important realm: Spain. The Spanish Church had already undergone significant reforms—indulgence abuses were curtailed, clerical celibacy was enforced, and corruption reduced—thereby addressing many grievances that fueled the Protestant outcry in Germany, limiting its appeal in Spain (MacKenney, 1993). Furthermore, Spain's centuries-long history of conquest over non-Christian communities made religious unification a pressing priority; and the papacy, which had funded around three-quarters of the fight against Granada" (Rubin, 2017, p. 173), symbolized the unity of the Iberian kingdoms during their campaign against the Moors. More important still, the Church in Spain was already firmly under royal control (in contrast to England, Germany, and Scandinavia). Lastly, even Rome itself had become increasingly a Habsburg client as an outcome of the Italian Wars (Philip II, for example, blackmailed Rome frequently; see, e.g., Parker, 2014, pp. 89, 142, 164, 203). For all these reasons, the Habsburg ideal had been to unify all of Europe—Lutherans included—under a single Catholic Church during the Council of Trent. However, when efforts to co-opt the Reformation failed, the only remaining strategy was to counter it.

[17] In Spain, the multitudinous and pompous public sentences by the Inquisition ended with the extinction of the Habsburg dynasty in 1700. The takeover by the French Bourbons is often associated with the rise of Spanish Enlightenment. A similar shift towards the Enlightenment occurred in Portugal with the takeover by the Marquês de Pombal in 1755.

2.2 Effects on science. . . or nothing but the Black Legend?

Besides military-imposed recatholicization and reforms addressing doctrinal ambiguities and lack of discipline, central to the Counter-Reformation were measures aimed at *isolating* Catholic Europe from "infection" with the dangerous ideas of Protestantism.[18] While not antiscientific per se, these measures—which include coordinated censorship and restricted academic mobility—significantly raised the costs of scientific communication as a side effect (details in appendix A). Similarly, the reformed Catholic dogma produced during the Council of Trent, while not antiscientific in itself, likely entrenched dogmatism and intellectual conservatism: teachings by Aristotle, Galen, and Ptolemy, for example, which had been made compatible with Catholic thought, were not to be questioned, "for to discard one part of the interlocking system of ideas was to threaten the rest of it" (O'Connell, 1974, p. 339).

Galileo was famously condemned by the Roman Inquisition in 1633 (for claiming, based on his astronomic observations, that Earth revolved around the sun), and his work was banned in the Roman Index of Prohibited Literature.[19] Similar cases of direct clashes between science and the Counter-Reformation's dogma, however, are rare (see, e.g., Olson, 2004). That said, we know for a fact that: (i) book censorship to counter Protestantism was so extensive that scores of *scientific* books were censored indeed (figure A1); (ii) international academic mobility fell—especially in Spain (figure A3), where harsh prohibitions on visiting foreign universities were imposed to avoid Protestant infection—; and (iii) self-censorship occurred, such as that of René Descartes, who, "though living in the Dutch Republic, far beyond the reach of the Inquisition, was 'so astonished' by Galileo's fate 'that [he] almost [took] the decision to burn all [his] papers, or at least to let no-one see them'" (Parker, 2013, p. 654). Further, available evidence on contemporary impressions suggest that Iberians in particular went from being "those bright lampes of learning" (Hakluyt, 1599), who "confidently saw themselves as the first 'moderns,' superseding the ancients" (Cañizares-Esguerra, 2004), to becoming—as the Spanish physician Juan de Cabriada wrote in 1687—both intellectual *conservatives* ("[sticking to] outdated doctrines . . . idolized to the detriment of the truth") and intellectual *isolates* ("the last to receive [knowledge] spread across Europe, as if we were Indians").[20] Such evidence has long motivated the idea that the Counter-Reformation "sealed the fate of southern Europe for the next three hundred years" (Landes, 1998, p. 181).

Yet the theory linking the Counter-Reformation with scientific (and eventually economic) decline is far from being consensus. Instead, and contrary to traditional historiography, today's leading historians tend to question or outright reject this interpretation.[21] This reassessment largely arises from

[18] The sense of "infection" was explicit and common at the time. "[I]f one of the arms of my body was infected with this corruption," France's king Francis I declared in 1535, "I would cut it off, and if my children were tainted with it, I would myself offer them in sacrifice." (Kaplan, 2006, p. 486). Contagion was a particularly serious concern in Spain, which had its soldiers fighting all across Europe at risk of being infected and become, as a Spanish monk residing in Brussels put it by 1600, "sparks of heresy that may fly from Flanders to Spain" (Thomas, 2014).

[19] "In denying the geocentric and geostatic system of Ptolemy," Shapin (1998, p. 136) explains, "Galileo was taken as rejecting the truth of Scripture." There is considerable debate, however, regarding whether the ban was driven primarily by religious motivations or instead rooted in "personal conflict fueled by the insensitivity and arrogance on the part of Galileo" (Olson, 2004, p. 18).

[20] See López Piñero (1979, pp. 421–24).

[21] Leading science historian Steven Shapin, for example, asserts that "there is no longer any sustainable and interesting

the growing awareness that many popular notions about the Counter-Reformation, from the supposed bloodiness of the Inquisition to the supposed antiscientific stance of the Jesuits, are unfounded, often being the enduring echoes of early modern anti-Catholic propaganda—a bias commonly referred to as the Black Legend.[22]

Given that old historiographical biases are undeniable, may the very notion that the Counter-Reformation harmed science be *nothing* but the enduring echo of propaganda? Or is it true that "the prohibitive laws of the Inquisition" were in 1817 still an impediment to "learn[ing] the discoveries of the exact sciences," as complained by former Spanish inquisitor Juan Antonio Llorente (1822)? Two hundred years later, his statement remains controversial—and so does the role of the Counter-Reformation as a whole.

3 Biographical data

To investigate whether science was affected by the Counter-Reformation, this paper proxies scientific activity by the number of "scientist per capita" (to be defined below) at the city-year level, based on biographical data gathered from Wikidata (`wikidata.org`), a repository of encyclopedic metadata which draws information from several biographical dictionaries (e.g., *Neue Deutsche Biographie*), from authority files of national libraries (e.g., the *Bibliothèque nationale de France*) and from encyclopedias (e.g., *Britannica* or *Wikipedia* in different languages). Following the usual practice in dealing with the early modern period, this paper defines a "scientist" as somebody engaging in what we broadly call science today (including non-experimental fields like mathematics and historiography) or engaging in philosophy or branches of protoscience such as alchemy and astrology.[23] Additionally, either for robustness purposes or in order to augment the number of observations, I sometimes use the more

sense in which it can be said that the Catholic Church was 'antiscientific' or even unambiguously opposed to the new science" (Shapin, 1998, p. 198), while Henry Kamen, a leading historian of early modern Spain, asserts that the Inquisition "was never in a position to affect or dictate the cultural evolution of Spain" (Kamen, 2014, p. 149). For a list of titles containing comparable assertions, recall footnote 2.

[22] As explained by Maltby (2009, p. 118),

> hundreds of anti-Spanish publications appeared in English, Dutch, French, and German in the sixteenth century[, and then again] in the Thirty Years' War and on other occasions when it seemed useful to stir up anti-Spanish sentiment. Given the pervasiveness of such material, it is not surprising that the authors of scholarly histories absorbed anti-hispanism and transmitted it to later generations.

The term Black Legend has been used among historians to describe not just the anti-Spanish bias of historiography, but the broader anti-inquisitorial, anti-Catholic, and anti-religious bias present in traditional historiography. Historians have been uncovering these biases since decades. It has been noted that, considering the common practices of repression across Europe in early modern times, neither the Roman, nor the Spanish or Portuguese Inquisitions were as repressive as it is commonly believed (e.g., Monter, 2004, Tarrant, 2014, and Kamen, 2014). The famous trial of Galileo by the Inquisition is seen as an exception to an otherwise constructive relation between the Church and early modern science (Shapin, 1998, Hannam, 2011, and Ferngren, 2002, among others). Jesuits—a key force of the Counter-Reformation—were "men of letters" including figures like Athanasius Kircher and Christopher Clavius, they educated the likes of Descartes, Voltaire, and Diderot (see, e.g., Feingold, 2003a), and spread science education through their missions (Ma, 2021; Valencia Caicedo, 2019) or the founding of universities (Frijhoff, 1996). For such reasons, many historians (and historians of science in particular) are now reluctant to confirm a negative impact of the Counter-Reformation on science. Instead, they prefer to highlight how the narrative is known to have been affected by propaganda (e.g., Malta Romeiras, 2020).

[23] Explorers are *excluded* in order to avoid a spurious pre-Counter-Reformation spike in Iberia driven by a unique contingency—the discovery and exploration of the Americas. Including them would only strengthen the results.

broadly defined metric "intellectuals," including thinkers, theologians, and other influential nonfiction writers in addition to scientists. Even though we usually have twice the number of biographies when considering intellectuals instead of scientists, the behavior of the time series is remarkably similar (see appendix figures D1-D2).

I use the incidence of such biographies to proxy scientific and intellectual activity across time and space. How exactly? Since data on actual activity are scarce, I proxy activity over time using a researcher's age combined with the empirically-observed distribution of the age of scientific genius during the analyzed period (Hongzhou and Guohua, 1985; López Piñero, 1979; Li-Ming et al., 1996; Wray, 2009; Jones, 2010; Jones, Reedy, and Weinberg, 2014).[24] With regard to activity locations, I proxy them using birth and death places (each adding to the sum of scientists or intellectuals in a city).[25] This approximation will be inaccurate for superstars, many of whom traveled greatly around the Continent. However, for the median 16th-century scientist, for example, birth and death locations coincide but for 10 kilometers (or 0 kilometers in the case of intellectuals), suggesting that mobility was low (see table D2).

Unless stated otherwise, "per capita" means "per city's population" (based primarily on Bairoch, Batou, and Chevre, 1988 and within-century observations from de Vries, 1984, Lees and Hohenberg, 1989, and Biraben and Blanchet, 1999), where population has been log-linearly interpolated to create yearly time series (details in appendix section D.2.1).[26]

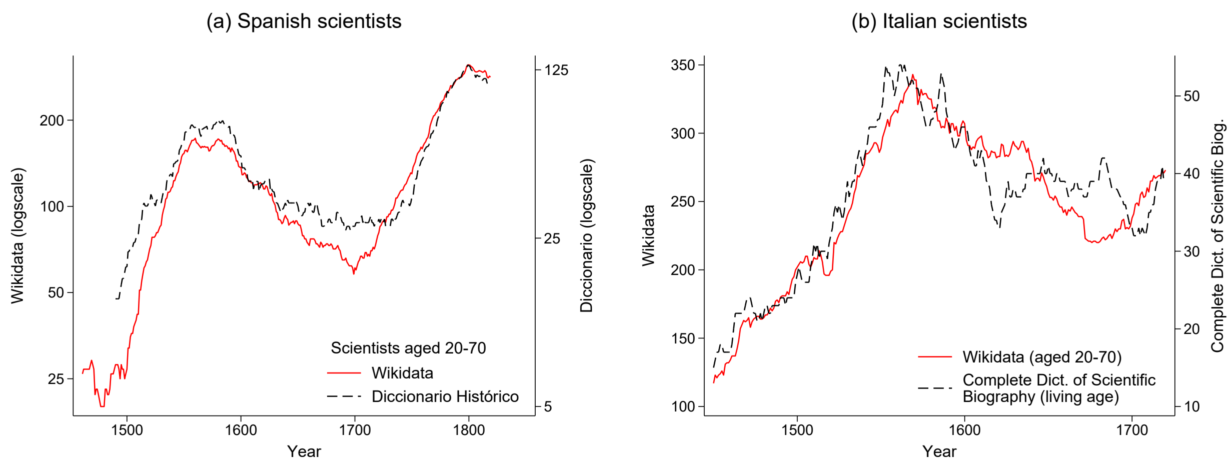
Are the data used in this paper consistent with other scientometric studies? Yes. For example, figure 3 compares time series of Spanish and Italian scientists based on Wikidata with those based on the *Diccionario histórico de la ciencia moderna en España* (López Piñero et al., 1983) and the *Complete Dictionary of Scientific Biography* (as coded by Anderson, 2015), confirming similar dynamics. The same can be said about Belgian scientists (figure 6c), which peaked around 1600, then declined until 1700, and recovered vigorously in the 18th century, precisely as drawn by Quételet (1864, p. 374) in his account of Belgian mathematicians and physicists since 800—a shape later confirmed by Pelseneer (1941), with data from the *Biographie nationale*, not just for mathematicians and physicists but for people in other fields of intellectual activity. In general, the overall trends in the data find support in comparable biography-based scientometric country-year panels, such as Gascoigne (1992), Murray (2003) and Anderson (2015); and, albeit less precisely, in Darmstaedter's (1908) count of notable discoveries and inventions (appendix figure B7). Since this paper was first written, recent datasets

[24] Taken together, these studies suggest that, from 1400 to 1900, scientific activity occurs roughly between ages 20–70, with higher densities around ages 25–50. While smoothing is stronger using a wider interval, switching between age intervals 25–50 and 20–70 has no big impact on the timing of structural changes: see appendix figures D1-D2.

[25] For example, a scientists who is born and dies in the same city will count twice, whereas one dying in a different city will count once in each city. This procedure augments the number of cities but, because of low average mobility, the results are essentially equivalent to those based on locations of birth or death only.

[26] For robustness purposes, I will at times divide the number of researchers not by urban population but by the quantity of all "notables"—i.e. all persons with biographies in Wikidata. Using the number of famous people as denominator is desirable *if* both the numerator and denominator share comparable time-space sampling biases. However, this approach is subject to much higher variance overall and also to marked distortions over time, which are the result of important periods (great wars, for example) being associated with more biographies and hence with an artificially depressed density of scientists. For example, even though science was thriving in 18th century France (as the "per urban citizen" ratio correctly shows), the share of French scientists among famous Frenchmen *declines* abruptly during the 18th century and especially during French Revolution, given the abnormally high number of non-scientific biographies we have during those years.

Figure 3: Different sources, similar dynamics: Italian and Spanish scientists



Notes: The figure shows similarities between time series based on Wikidata and those based on (a) the *Diccionario histórico de la ciencia moderna en España* (López Piñero et al., 1983) and (b) the *Complete Dictionary of Scientific Biography* (as coded by Anderson, 2015).

have been providing further support. One is the quality index of university scholars of de la Croix et al. (2023) (appendix figure A4) and the Wikipedia-based data of Laouenan et al. (2022), (specifically their science/discovery category, which I introduce for quality-weighting exercises in the present paper). Further confirmations have been made by Dewitte et al. (2024) for Italy and by Buri (2024) for Spain.

It must be stressed that scientists and intellectuals in the data are famous ones. For the sake of brevity, I henceforth use the shortcut "science" when referring to the "observed number of famous scientists per capita." Further details on queries, the definitions of "scientists" and "intellectuals," summary statistics, and other details can be found in the data appendix.

4 The Counter-Reformation and scientific decline

We will now see that the number of notable scientists per capita fell when the *intensity* of the Counter-Reformation was greater, either in space (section 4.1) or in time (section 4.2).

4.1 The geography of scientific decline

Table 1 presents city-level OLS estimates of

$$\ln\left(\frac{\text{Scientists born C17}_i}{\text{Population in 1700}_i}\right) - \ln\left(\frac{\text{Scientists born C15 \& C16}_i}{\text{Pop. in 1500 \& 1600}_i}\right) = \alpha \cdot \text{CR-proxy-vector}_i + \text{controls}_i + \text{error}_i, \quad (1)$$

where α captures how the Counter-Reformation treatment (of varying intensity) correlates with the growth of notable scientists per capita in city i from the start of the Counter-Reformation (measured as the 15th- to 16th-century average) to its apogee in the 17th century. Controls include distances to the Atlantic and to the Mediterranean, initial scientists per capita, early printing output, urban development, institutional variables, and fixed effects for ethno-linguistic groups and fluvial catchment regions.[27]

Column 1 begins evaluating a simple proxy for the Counter-Reformation: a dummy for Catholic rule around 1600.[28] The resulting α indicates that the number of notable scientists per capita grew on average 59 logpoints less in Catholic-controlled cities. Column 2 then contrast Catholic cities to Protestant ones located withing 100 km from each other, confirming a similar relative decline. This relative decline of famous scientists in Catholic cities remains robust to changes in the distance to the border and alternative definition of Catholic rule (see appendix table B2).

While these comparisons are suggestive, the use of a Catholicism indicator as treatment proxy raises some issues. May a sampling bias, an under-representation of Catholics, explain the *observed* lower number scientists? More generally, could any other factors independent of the Counter-Reformation but associated with religion be correlated with the scientific outcome? May, for example, Protestantism instead of Catholicism explain the differences? A way to study the Counter-Reformation's effects avoiding these issues is to focus on intra-Catholic proxies of the Counter-Reformation's intensity. The remaining columns of table 1 thus study the graduation of the treatment through various Counter-Reformation proxies.

Column 3 begins introducing two indicators of the intensity of the Counter-Reformation. The first is a dummy indicating strictly Catholic rule—i.e, Catholic states that did not allow for Protestant minorities by 1600.[29] The estimated coefficient is negative, meaning that science declined more in Catholic states that were less tolerant. The second intensity proxy in column 3 is a dummy indicating if city i hosts a tribunal of the Roman, Spanish, or Portuguese inquisitorial systems. These systems played a key role in the design and enforcement of the Counter-Reformation (see appendix A for details), and while they attempted to impose control over all towns within their jurisdictions, their activities were presumably more concentrated in the cities where their tribunals were located. In line with this hypothesis, column 3 reports a negative association between the tribunal dummy and the growth of scientists. As a robustness test (given that these tribunals were not scattered homogeneously across Catholic Europe, but were almost exclusively located in southern Europe and especially in Italy's north), column 4 restricts the sample to Catholic cities within 100 km of the tribunals, confirming the negative result. A similar confirmation is found in columns 5 and 6 within the Iberian and Italian peninsulas respectively.[30] Notice that columns 4 to 6 are independent of any religious-denomination bias.[31] And notice that the university coefficient, which is positive and statisti-

[27]One role played by these controls is the absorption of plausible geographical biases in biographical sampling (say an underrepresentation of southern Europe). Interestingly, however, the estimated α is similar to the one we would obtain without controls, suggesting rather unbiased sampling (see figures B8, B9a, and B9b).

[28]This baseline Catholic-rule dummy indicates if a city was subject to Catholicism as state religion around 1600. German cities are coded as in Cantoni (2012) and cities of the Low countries according to the military situation described in Parker (1977). For the rest of Europe, see appendix D.

[29]Catholic domains that, on the contrary, did allow for religious minorities are France, Poland-Lithuania, the Hungarian territories at the Ottoman-Austrians borderlands, and some smaller states within the Holy Roman Empire. For details, see appendix D.2.3 and map E2.

[30]The estimate of column 5 is based on few observations. However, Buri (2024) has very recently confirmed the results within Spain.

[31]Thus, confession dependent arguments—such as the idea that Catholic celibacy may have reduced the pool of scientists (in a context where priests were an important share of scientists, and clerical celibacy would mean fewer

cally significant in column 1 to 3, is no longer so in columns 4 to 6, suggesting that universities within the reach of the Inquisition were scientifically underproductive relative to their potential. Overall, within Catholic Europe, comparable cities had a lower growth of notable scientists per capita when hosting inquisitorial tribunals.[32]

A quasi-natural experiment. While in southern Europe the Counter-Reformation was mostly a protective enterprise against heresy contagion, in the north, were heresy had already spread, the Counter-Reformation took a more aggressive form that involved military conquest and forced recatholicization. An interesting case of cities that went from being Protestant to being Catholic again is that of the Low Countries (roughly today's Belgium, Luxembourg and the Netherlands). Before forced recatholicization, the bulk of scientists in the Low Countries came from a largely *homogeneous* cultural area—a wealthy, densely-urbanized, and Dutch-speaking territory centered around Antwerp (its cultural capital), which spanned from Brussels to north Holland and from the English Channel to the German border (figure 4). Inherited by Charles V and then by his son Philip II (both kings of Spain and key leaders of the Counter-Reformation), these domains were subject to repressive but ineffective attempts to stop the proliferation of Protestantism, which eventually spread throughout the whole territory.[33] Partly in response to religious repression, multiple cities revolted against Spanish rule, beginning in 1566 with a wave of iconoclasm—that is, the destruction of Catholic images—that started in the southwestern Belgian towns of Steenvoorde, Poperinge, Ieper, and Menin and then spread to Antwerp, 's-Hertogenbosh, and further north, as shown in panel (a) of figure 4.[34] Yet, despite its southern origins, and mostly because of geographical accidents—the north enjoyed natural defenses and the military forces of Spain were sent from Italy through the Alps (Parker, 2004)—the rebellion succeeded in the north but was crushed by Spain in the south. We can thus think of a homogeneous population affected by a *geographically-determined* geopolitical shock, namely effective Spanish military control.[35] Protestantism, which had spread across the whole Dutch-speaking territory by 1560, was virtually eradicated by 1650 in the Spanish-controlled south.[36]

children growing up in an intellectual environment)—cannot explain the decline.

[32] Appendix table A4 shows that similar negative correlation with the inquisitorial tribunals emerges when the outcome the scientists' fame, proxied by the size of their Wikipedia articles.

[33] As explained below, repression backfired. See also footnote 46.

[34] Admittedly, the event of 1566 was not fully spontaneous: The iconoclastic fury was initiated by an "organized itinerant body of image-breakers who came over from England" (Parker, 1977, p. 77). That said, the widespread incidence of Protestantism in the south at the time is clearly evidenced by the proclamation of "Calvinist Republics" in Antwerp, Bruges, and Ghent.

[35] Spanish troops used a south-north corridor from Italy to Spain known as the Spanish Road (see figure E1). Thus logistics allowed Spain to control the south more effectively. Spaniards came close to reconquer the north too, but they abandoned their positions by 1590 in order to attend another conflict: the troops were sent to France, where they captured Paris to prevent the takeover of the French crown by the Protestant Henry of Navarre (see, e.g., Nexon, 2009 and Parker, 1977, ch. 6). This distraction permitted the construction of Dutch fortified defense lines and led to a long-standing stalemate. This boundary came to determine a geography of religious affiliation that last even until today.

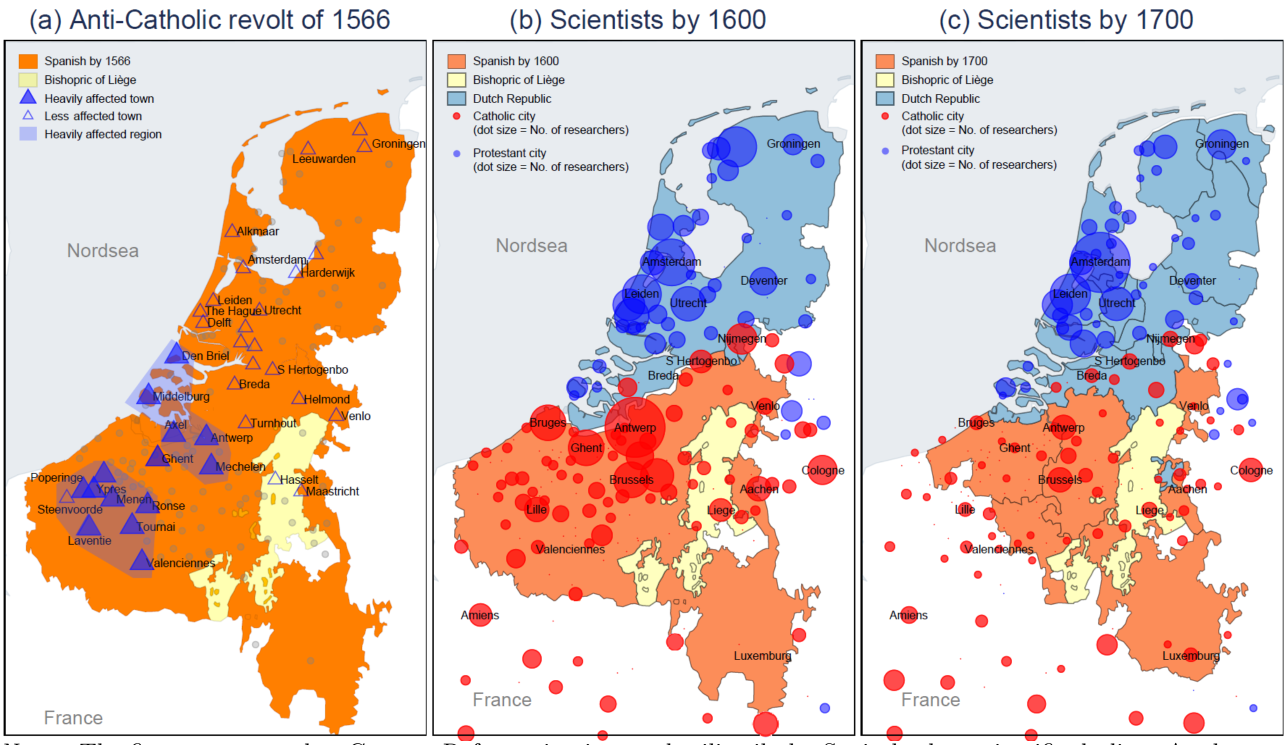
[36] So the Calvinist Republics of Antwerp, Bruges, and Ghent became Spanish and Catholic strongholds, while Amsterdam, originally loyal to Spain, became the capital of a Protestant majority country. Before the Spanish takeover, Protestantism may indeed have been stronger in the south. According to Parker (1977, p. 58), from the "only five Lutheran groups" in the Netherlands in the 1560s, three of them were in the south (Antwerp, Breda, and Mechelen), while Calvinism seems even more concentrated in the south: by 1561 "there was public worship only at Tournai and Valenciennes[,] synods [were] held at Antwerp [since] 1561" and there was massive cross-border French immigration of Calvinist after 1562, "[who] took refuge in the towns of the south Netherlands, where many magistrates were prepared to turn a blind eye to heresy." Recatholicization, while effective, took quite long: "Episcopal visitations reports . . . show

Table 1: Decline of science in Counter-Reformation cities by the 17th century

	Dependent variable: Change in scientists p.c. from 16th to 17th century									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	All cities	Religious border (100km)	All cities	Nearby Catholics (100km)	Iberia	Italy	All cities	Dutch border (100km)	All cities	All cities
Counter-Ref. intensity										
Catholic ruler 1600	-0.59***	-0.73***	-0.18				-0.24*		0.04	0.12
	(0.11)	(0.10)	(0.14)				(0.14)		(0.11)	(0.12)
Strictly Catholic regime			-0.48***				-0.33***		-0.32**	-0.31**
			(0.13)				(0.12)		(0.13)	(0.13)
Inquisitorial tribunal			-0.40***	-0.36***	-0.51*	-0.36***	-0.46***		-0.37***	-0.37***
			(0.12)	(0.12)	(0.30)	(0.12)	(0.13)		(0.12)	(0.13)
Spanish Empire 1600						-0.61***	-0.35***	-0.55***	-0.36***	-0.37***
						(0.12)	(0.13)	(0.18)	(0.13)	(0.14)
Catholic university 1700									-0.53***	-0.54***
									(0.13)	(0.16)
Catholic pop. share [0,1]									-0.44***	-0.51***
									(0.12)	(0.16)
Controls										
University in 1700	0.18**	0.35*	0.24***	-0.05	0.12	-0.07	0.25***	0.43***	0.58***	0.59***
	(0.09)	(0.20)	(0.09)	(0.12)	(0.30)	(0.09)	(0.09)	(0.15)	(0.12)	(0.15)
Prote. with 10%–50% Cath.										0.18***
										(0.06)
Some Calvinists (> 1%)										0.03
										(0.07)
Mostly Calvinists (> 50%)										-0.07
										(0.13)
Fully Calvinist (> 80%)										-0.29***
										(0.10)
Dist. to Atlantic	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dist. to Mediterranean	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Initial researchers p.c.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Printing volume (by 1500)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pop. growth 1600–1700	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pop. growth 1500–1700	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ethno-linguistic FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fluv. catchment region FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	649	172	649	171	43	105	649	75	641	641
R-squared	0.46	0.50	0.48	0.51	0.55	0.53	0.49	0.40	0.51	0.51

Notes: The table shows that cities affected by the Counter-Reformation experienced a decline of notable scientists per capita during the 17th century. The decline was larger in cities under less tolerant rule and in cities where the Counter-Reformation was logistically easier to enforce: those hosting tribunals of the Spanish, Portuguese, or Roman Inquisition, those within the Spanish Empire, those with universities, and those with larger shares of Catholics. The table suggests detrimental effects stemming from Protestant bigotry as well, since cities fully controlled by Calvinists are associated with scientific decline too (arguably because of effective social control). Meanwhile, Protestant cities hosting Catholic minorities correlate with more scientists, suggesting that tolerance had a positive effect. Estimates are cross sectional regressions across Western European cities. Fixed effects (FE) by ethno-linguistic groups listed in the appendix (map E8). FE by fluvial catchment region are dummies for the Atlantic, the North Sea, the Baltic, the Black Sea, and the Mediterranean based on Buringh (2021). Numbers of scientists and religious indicators are based on Wikidata (details in appendix D). University founding dates are from Verger (1991) and Frijhoff (1996). Locations of inquisitorial tribunals are from Bethencourt (2009). Spanish imperial limits as shown in figure E1. City population based on Bairoch, Batou, and Chevre (1988), extended as shown in appendix D. Early printing data based on the *Incunabula Short Title Catalogue* (ISTC, 1998). Institutional data based on van Zanden, Buringh, and Bosker (2012), Bosker, Buringh, and van Zanden (2013), and Henriques and Palma (2023). Constants omitted from the table. Spatial-autocorrelation-adjusted standard errors in parentheses, based on the procedure of Colella et al. (2019) within 200 km. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 4: Military logistics leading to a religious and scientific outcome



Notes: The figure suggests that Counter-Reformation imposed militarily by Spain lead to scientific decline. As shown in panel (a), the anti-Catholic, iconoclastic fury of 1566 that initiated the Dutch war of independence against Spain was more intense in the south. However, as shown in panel (b), it was also the south that was reconquered by Spain (because Spanish troops came from Italy), leading by 1600 to a military boundary within which all cities were recatholicized. Panel (b) also shows that Antwerp was the city with the most scientists and that cities such as Brussels, Bruges and Ghent were important centers of science too. However, panel (c) shows that over the course of the 17th century their positions declined precipitously compared to their northern counterparts in the Dutch Republic. Dot size is proportional to the number of scientists born in a city during the preceding 100 years.

As shown in figure 4, Spanish occupation is not just evidently related to a city's eventual religious affiliation but also to the change in the number of notable scientists born in a city. Antwerp, for example, went from being the most common birthplace of scientists in the region in the 16th century (the largest bubble in subfigure b) to being a modest player in the 17th century (subfigure c). The other important birthplaces (Brussels, Bruges, Ghent, Leuven, Mechelen) fell behind as well, suggesting an important negative effect of Spanish occupation.[37]

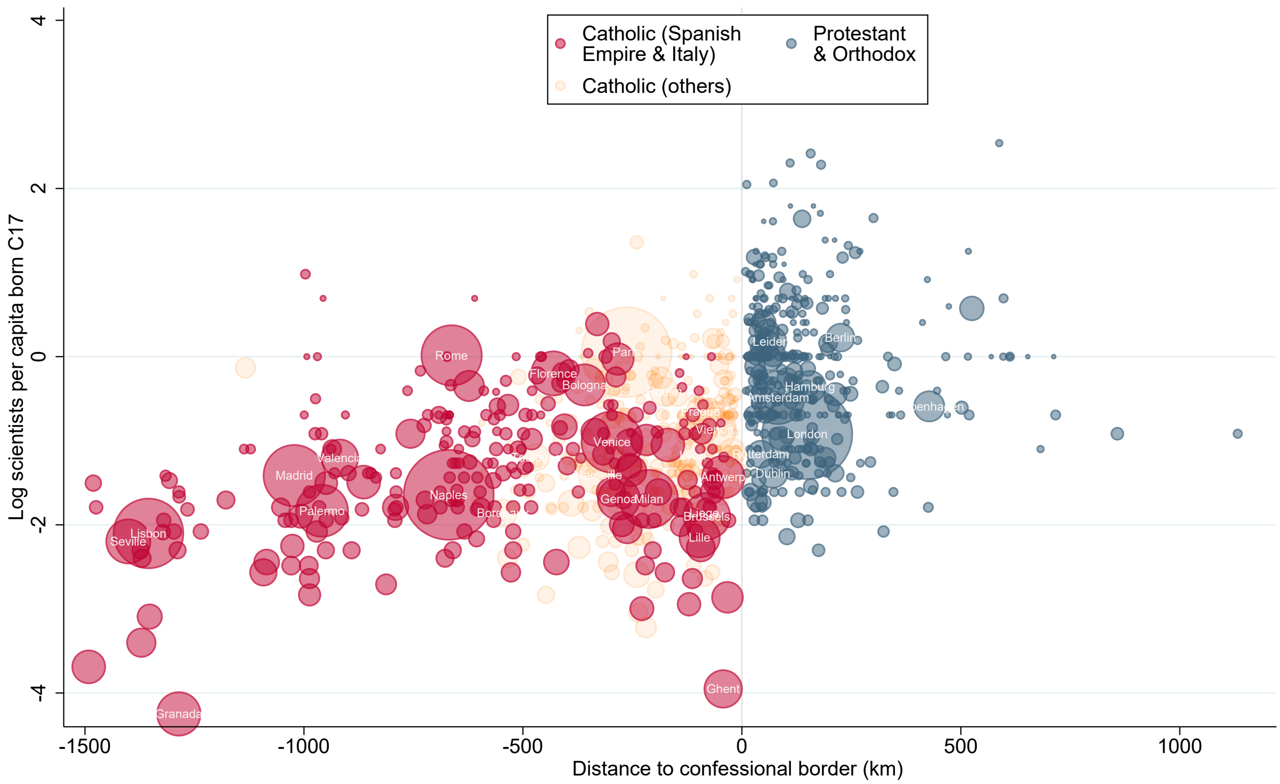
Spain's military victories and defeats have long been seen as consequential for both the religious fate of Europe and its intellectual development. What "propelled scientific advances toward the end of the seventeenth century," Eisenstein (1980) wrote, "began with defeats suffered by the Spanish Habsburgs in the sixteenth-century Dutch war—minor scuffles on a corner of the globe, to be sure, but with world-wide repercussions nonetheless."[38] According to Mokyr (2016, p. 169): "Had [Catholic conservatives] gained more control in France, Britain and the Netherlands—say, because of decisive

the presence of several Protestant communities . . . who managed to survive until . . . 1648" (Thomas, 2014, p. 296).

[37] Neither destruction by war nor plague outbreaks (two negative shocks affecting the south more than the north after 1600) can explain such a large decline, as we will see below.

[38] "[T]he fate" of the "rise of science," she writes, "was still being affected by the shifting fortunes of the Thirty Years War"—which ended with the decisive defeat of Spain in 1648, but could have ended otherwise (pp. 647–9).

Figure 5: Discontinuity at the border



Notes: The figure shows that 17th-century science was depressed close to the confessional border especially when subject to the Spanish Empire or to the Roman Inquisition. This points to the importance of centralized structures enforcing intellectual control. Dot size represents population in 1700. *Sources*: see section 3.

Spanish military victories—the intellectual development of Europe inevitably would have been impeded." And according McCloskey (2010): "Had the Armada landed [in England], and then the United Netherlands collapsed, it seems likely that Europe would have suffered from the innovative sclerosis that infected at the time the great empires further east." What these narratives point to is the loss of fragmentation and intellectual pluralism entailed in Spanish-led recatholicization of the Continent in its entirety. Yet, as we have seen in the case of the Low Countries, already a partial takeover seems detrimental for science in the affected territory. This negative association of science with Spanish occupation by 1600 is shown to be systematical in table 1. Besides holding around the frontier between Spain and the rebellious Dutch (column 8) it holds also within Italy (column 6) and across Europe after controlling for Catholic rule (column 7).

Logistics and intensity. An interpretation of these results is that the Counter-Reformation was particularly intense in territories controlled by Spain, which had not just the determination to implement it but also the military, political, and financial resources—i.e., the logistic capacity—to enforce it. That logistic capacity was important is suggested also in figure 5, which explores discontinuities at the confessional border in the number of notable 17th-century-born scientists per capita. It shows that Catholic cities close to the "heresy frontier" had particularly low numbers of scientists *if* they were in

Italy (hence under Inquisitorial control) or in Spanish imperial territory, while the remaining Catholic borderland shows a much less pronounced discontinuity.[39] This suggests that cities at similar risk of Protestant infection were more negatively affected by the Counter-Reformation's policies if these were effectively enforced thanks to the coordination of the Inquisition and weight of Spanish power.[40]

Columns 9 and 10 suggest a strong negative effect of two more Counter-Reformation-intensity indicators associated with logistics. The first is the presence of a university if it is a Catholic one. Notice that universities are associated with higher scientific growth in the full sample, but the interaction with a university's Catholic denomination neutralizes virtually the entire positive correlation. This makes sense if we consider that universities were places where the Counter-Reformation was particularly intense: universities were closely associated with the Church and provided religious education; they had a tradition of being engaged in censorship; their hierarchical nature made them easy to control; and Catholic authorities saw them as dangerous spots for the propagation of Protestantism, what made them key targets of the Counter-Reformation (more details in appendix A).[41] Back then, universities were predominantly conservative institutions, more concerned with the *preservation* of knowledge (including religious "truths") than with discussing and changing it. They cooperated with and sometimes even acted as religious authorities. Finally, that logistics matter is also suggested by the negative coefficient of a city's share of Catholics—i.e. the share of people that support the Counter-Reformation measures, making them more effective.[42]

Overall, we find a highly significant negative association of science with the intensity of the Counter-Reformation and especially with proxies for enforcement-logistics—the Spanish Empire, the inquisitorial tribunals, the presence of a university, and a large supportive population, all which points at the importance of logistic capabilities in enforcing intellectual control.[43]

[39]France is an interesting case, as it granted official toleration of Protestantism during much of the 17th century (see figure 6d below). Protestants minorities were scattered all across, and at times they had so much political power that they constituted a "state within the state." Toleration and political fragmentation, added to how "France found itself opposed to the [Spanish-led] Counter-Reformation" (Trevor-Roper, 2001),

appears to have restricted repressive capacity and allow a much more plural environment, possibly explaining why France outperformed its Catholic neighbors in terms of scientific growth. A similar point can be made with regard to Austria and Poland (Müller, 1996; Pánek, 1996; Péter, 1996).

[40]Was Spain's empire a really centralizing and coordinating entity in this regard? Certainly yes. Even if the Spanish Empire was rather decentralized in matters such as taxation or market integration (see, e.g., Espinosa, 2008 and Grafe, 2012), it was very centralized in matters of war and religion. While this may seem a contradiction, it was not. Decentralization in form of so-called "privileges" (like monopolies or tax exemptions) was an important pillar granting legitimacy to dynastic composites agglomerated by inheritance and marriage, particularly so for the Habsburgs (see, e.g., Nexon, 2009). At the same time, the Habsburgs also relied heavily on religious legitimacy, what explains why the empire was decentralized economically yet very centralized in religion. Religious unity was indeed one of the primal objectives of Habsburg policy—Philip II for example, stated that he would prefer not to have subjects at all than having to rule over heretics; and he consistently appointed regents which shared this view (Kamen, 1997; Parker, 2014).

[41]In Spain, "before the second half of the sixteenth century, scholarship at the universities had been relatively dynamic and free." Thereafter, "Castile's rulers attempted to make certain that the universities would be free from all heretical and revolutionary ideas, a policy which led to the active discouragement of curricular innovation and change" (Kagan, 1974, p. 231).

[42]Without popular support, measures may be ignored, resisted, or implemented lukewarmly; with popular support, they may succeed also without any need to use force. Anecdotal evidence suggest that the Counter-Reformation's success was indeed largely dependent on popular support (see, e.g., footnote 51).

[43]For the robustness of these finding using different metrics of scientific and intellectual decline, alternative radios of spatially autocorrelated errors, and weighting by data quality, see appendix table B3.

4.2 The timing of scientific decline

When did the scientific decline of Catholic Europe begin? Figures 1 and 2 of the introduction show that, overall, this decline occurred approximately between 1550 and 1700. As similar timing is confirmed in the rolling regressions of appendix B after time-varying geographic, economic, and ethnic controls. On average, Catholic cities and especially those hosting the Inquisition experienced a scientific decline from 1550 to 1700 (figure B2), roughly coinciding with the Counter-Reformation in Europe as a whole.[44]

From country to country, however, the timing of the Counter-Reformation differed. For example, when we look at the number of Protestants executed for heresy (appendix figure A9), Germany experiences its peak already in the 1520s, southern Europe in the decade after 1555, and the Low Countries even later, in the 1570s during the Spanish reconquest.

Does this different timing match with different episodes of decline? As shown in figure 6, the answer is yes. Within Germany (figure 6a), we observe that Catholic and Protestant cities showed similar paths until around 1520 but decoupled markedly afterward. This coincides with the condemnation of Luther in 1520 and the Edict of Worms of 1521, issued by Charles V (king of Spain and newly-elected Holy Roman emperor), which prohibited Luther's works and initiated the persecution of Protestantism. The edict proved ineffective in most of the German states, where enforcement was weak. However, some states, most notably Bavaria and Cologne, actively enforced the edict right after 1521 (Creasman, 2012, pp. 58, 35–36). In Cologne, one of the major printing centers in Germany, the enforcement was exceptionally effective, Scibner (1976) argued, because of the close cooperation between the state, ecclesiastical authorities, and the university.[45] These cities remained Catholic and, on average, stagnated in science relative to Protestant ones after 1521.

A similar divide occurs in the Dutch-speaking Low Countries (figure 6c), but with a delay of almost 90 years. There, firm Spanish control of the southern territories (and thus *de facto* enforcement of the Counter-Reformation) could not materialize until after 1585, the year Antwerp was retaken. Prior to that, "not only the rebel provinces of the north, but also the greatest cities of the southern Netherlands were firmly in the grasp of militant Calvinist minorities" (Tracy, 1985, p. 549). The success of Protestantism up to that point reveals that even if, *de jure*, the Low Countries were subject to the Edict of Worms (and subsequent similar regulations) and even if the central authority tried to impose it with brute force—burning books and people— the control of Dutch intellectual discourse failed.[46] This may explain why the divergence in science that begins already by 1521 in Germany, and

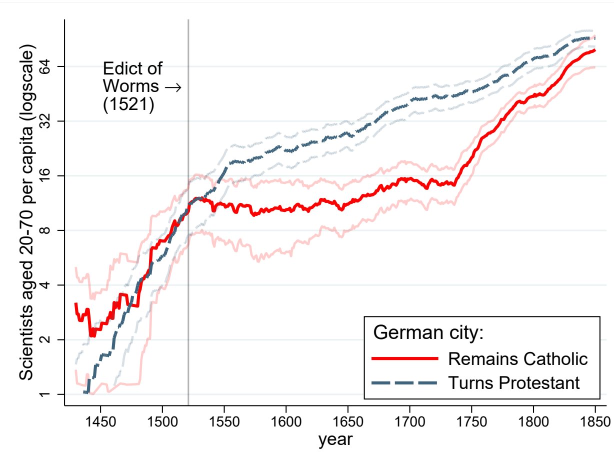
[44]While the timing of Counter-Reformation varies across geographical regions, there is general agreement on a European-wide reactionary movement initiated around the mid 15th century (e.g., Mullett, 2010, pp. 118–20). Some historians date its beginnings around the Council of Trent (1545–1563) and other "significant episodes that cluster ...during the decade 1555–1564" (Monter, 1996), which include the papacy of Paul IV and the discovery of Protestant cells in Spain in 1557. The ending of this period also depends of the region, but tends to be placed around the late 17th century (recall section 2). In Spain, 1700 significantly coincides with the death of the last Habsburg ruler.

[45]See also Creasman (2012), pp. 35–36.

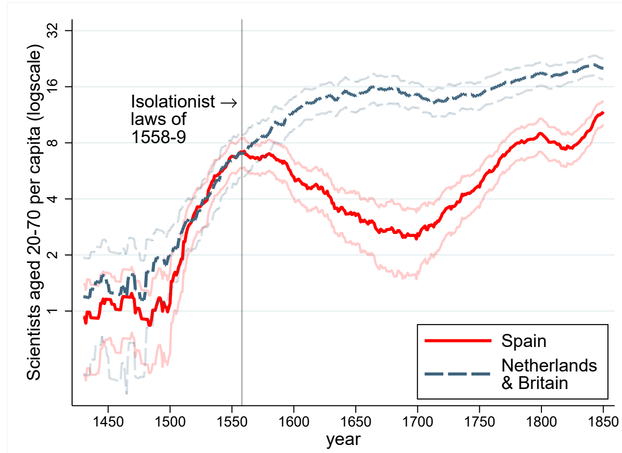
[46] The powerful book industry was not willing to give up neither control nor profits. Intellectuals, including Catholics such as Erasmus, saw the edict as an attack to humanist principles. Judges, often sympathetic to the Protestant cause, were unwilling to enforce it. Holland, already an important printing location, was almost untouched by the edict. And in Antwerp, the capital and printing powerhouse of the Low Countries, the day in which the edict was read aloud in the town hall and books began to burn, the crowd went out of control and made a public mockery of the ceremony

Figure 6: Divergence when we would expect it – country-specific cases

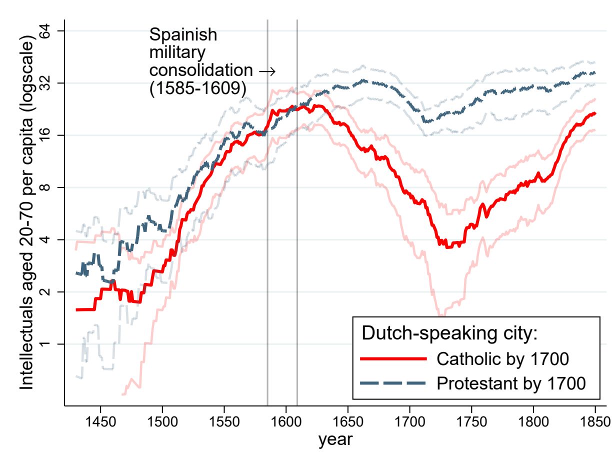
(a) German-speaking cities



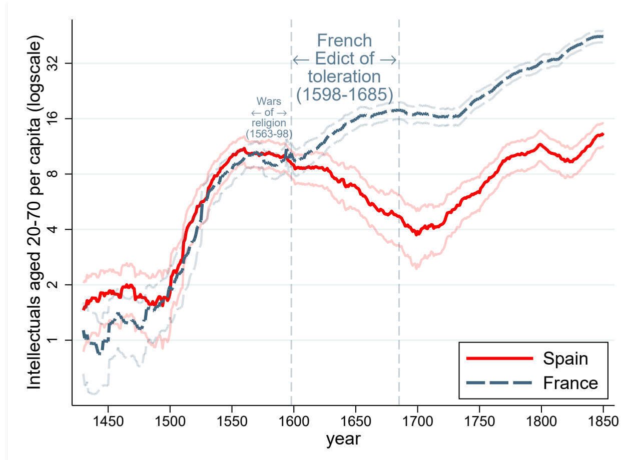
(b) Spain vs. Britain and the Netherlands



(c) Dutch-speaking cities



(d) France's special case



Notes: The figure illustrates how the Catholic scientific decline begins precisely when one would expect. In Germany, this happens 30 to 40 years prior to most other Catholic regions, right after the Edict of Worms (1521), which inaugurates the repression of Protestant literature in states such as Bavaria and Cologne (Scibner, 1976). By contrast, in the Low Countries this happens only in the decades after Spain takes effective military control (1585–1609). In Spain, after sharing a trend with Britain and the Netherlands, an abrupt decline begins after 1559, right after the isolationist laws triggered by the discovery of Spanish Protestant cells since 1557. In France, the trend was like that of Spain for more than hundred years but diverges markedly during the implementation of the Edict of Nantes (1563), which grants Protestants extensive religious and civil liberties, including access to education, public worship, and the right to maintain military fortifications. *Sources*: Population is from Bairoch, Batou, and Chevre (1988), extended with Biraben and Blanchet (1999), Lees and Hohenberg (1989), de Vries (1984), Lourens and Lucassen (1997), and others to cover changes within the 16th and 17th centuries. Scientists and intellectuals are based on biographical data retrieved from Wikidata (see section 3).

around 1550 in Europe as a whole (recall figure 1), appears in the Low Countries only in the decades after 1585, with Antwerp under Spanish control, and especially after the truce of 1609, which allowed Spanish governors to implement the Counter-Reformation internally and with great success.[47]

Even more striking is the discontinuity observed in Spain itself (figure 6b). Scientific activity there had since 1500 been comparable to that of England and the Netherlands but collapsed suddenly after 1558—the precise year of "the turning point" in Spain's Counter-Reformation (Kamen, 2014, p. 104); the year that inaugurates the measures that many have considered causal of Spain's subsequent intellectual and scientific decline (Lea, 1890, pp. 59–62; Elliott, 1970, p. 226; López Piñero, 1979, pp. 140–7; Landes, 1998, p. 180). What triggered this turning point? A shock: the discovery in 1557–8 of underground Protestant cells scattered across Spain, including high-ranking officials of state and church (Luttikhuizen, 2017). Charles V, who "saw to his horror the rise within Spain of the very menace that had split Germany apart" (Kamen, 2014, p. 103), wrote to his daughter in 1558:

> Since this affair is *more important for* [*the*] *preservation of these realms than any other* [(my emphasis)], and since it is only in its beginnings, with such small forces that they can be easily put down, it is necessary to place the greatest stress and weight on a quick remedy and exemplary punishment. . . . Such people, if set free, are at liberty to commit the same offense, particularly if they are educated persons. . . . Believe me, my daughter, if so great an evil is not suppressed and remedied without distinction of persons from the very beginning, I cannot promise that the king or anyone else will be in a position to do it afterwards.
> (Translation by Kamen, 2014, pp. 103–4)

Sure enough, the reaction was bold. Inquisitorial activity exploded (Drelichman, Vidal-Robert, and Voth, 2021, figures A1 and A2) and an array of isolationist decrees were proclaimed, including the death penalty for possessing prohibited literature (1558), the first comprehensive indexes of prohibited books (1559, 1584, 1612, 1634, 1707), and bans on visiting foreign universities (1559, 1568).[48] Whether Spaniards really stopped to study abroad has been debated among scholars.[49] However, appendix figure A3 shows that the share of famous Spaniards studying abroad declined abruptly, almost to zero, suggesting that the measure was effective.[50] Also whether science really declined as a consequence of all these measures has been doubted (e.g., Kamen, 2014; Goodman, 1983). Yet figure 6b suggests that the effects were immediate and long-lasting. It is important to note that all these post-1558

(McDonald, 2017).

[47]Especially during the Twelve Years' Truce (beginning in 1609), given peace and economic recovery, did the governors of the Spanish Netherlands concentrate their efforts in the internal implementation of the Counter-Reformation. As Parker (1977) remarks: "[the] new 'south Netherlands identity', religious and political, was born under the archdukes and above all during the Truce."

[48]For details of these measures and their effects, see appendix A.

[49]"The frontiers"—writes Kamen (2014, p. 107)—"were never closed." See also Goodman (1983).

[50]This finding also is consistent with López Piñero (1979), who studied international interactions of Spanish researchers and identified two "clearly differentiated phases," divided by the aforementioned panic of 1557-58 (the discovery of Protestants within Spain): before 1559, about half of Spanish researchers had visited foreign universities; thereafter, the share fell to virtually zero (p. 141). The decline of mobility was strongest in Spain, yet it fell in Europe as a whole during the 17th century, as shown in the appendix (table D2). Similar effects were recently found by de la Croix and Morault (2020), who analyze mobility of early modern researchers and find that the decline of connectivity was particularly strong in southern European universities during the Counter-Reformation.

measures counted with massive popular support, what helps explaining why they seem to have been so effective.[51]

We have seen that the effective implementation of the Counter-Reformation correlates in time and space with subsequent scientific decline. Did the *relaxation* of such policies generate the opposite effect? An interesting case is France in the 17th century, precisely when the Counter-Reformation was peaking throughout the rest of Catholic Europe. In an act that would have been unthinkable in neighboring Spain, Italy, or Belgium, France issued in 1598 the Edict of Nantes, which granted effective toleration of Protestantism in specific locations scattered all across the kingdom. Figure 6d suggests that the edict may have been key in limiting the effects of the Counter-Reformation: France had shared a path of intellectual development comparable to that of Spain for a long time but diverged markedly after 1598, after which France decisively took off.[52] Moreover, the revocation of the edict by Louis XIV in 1685 seems to have had a negative effect until his successors reintroduced some degree of toleration after he died in 1715.[53] Indeed, all over Europe science began to recover fast after 1700, when religiously-driven policy receded in favor of the more tolerant ideas of the Enlightenment. This recovery was particularly strong among Catholics, apparently thanks to the retreat of the Counter-Reformation. We will confirm this interpretation later in section 5 when studying, for example, how science reacted to the relaxation of the Spanish Inquisition after 1700, its revival after the French Revolution, and its eventual dissolution in the 1830s.

4.3 Which measures and mechanisms caused the decline?

While the objective was one—to stop the spread of Protestantism—the measures implemented to reach that goal, and the ways in which the measures may have impacted science, were many. Can we say what, specifically, caused the decline? Identification is challenging due to simultaneity (recall, for example, the many joint measures implemented in Spain during 1558–59). Still, some conclusions can be reached.

Was it the Inquisition? Inquisitorial activity is associated with the magnitude of the decline of famous scientists. However, it is by no means the only driver nor even a necessary one. In Belgium, for example, where science collapsed in a magnitude comparable to Spain or Portugal, there was *no* analogous institution to the Spanish and Portuguese Inquisitions.[54] Nor were there

[51] For example, when the accused Protestants were to be taken to the court, "the public outcry . . . was such that the prisoners had to be moved at night to prevent enraged mobs from lynching them," and one prisoner "was convinced that his family would have him assassinated before he reached court" (Rodriguez-Salgado, 2008, p. 218). Comparable popular support was missing in the Low Countries before the 1600s (Parker, 1977; Thomas, 2014; McDonald, 2017).

[52] That the devastation during the Wars of Religion may explain part of the preceding downturn more than repression and intolerance seems unlikely, given that in other similar cases of devastation such as the Thirty Years War, the Italian Wars, or the Dutch Revolt there is no visible decline of intellectual activity (more on this in appendix B). That said, there are two qualifications to the interpretation. First, some arrangements of toleration were already implemented during the stalemates of the Wars of Religion, yet the number of scientific and intellectual biographies continued to fall. And second, the chaos of the wars may have rendered much of the repression attempts fruitless anyway.

[53] Hornung (2014) finds positive economic effects in Prussian cities were these French Protestant relocated.

[54] Despite being under Spanish-Habsburg control, the Low Countries effectively opposed the establishment of the Spanish Inquisition (among other reasons, because "so many heretics came to Antwerp to trade that its prosperity would be ruined if a resident inquisition were introduced"; Parker, 1977, p. 47). Heresy trials still took place in large numbers, specially during Alba's Council of Troubles, but under secular jurisdiction (Gielis and Soen, 2015; Parker, 1977; Monter,

inquisitorial tribunals in most of the many Catholic cities in central Europe that saw a decline of science too. Moreover, the Inquisition without Counter-Reformation seems relatively harmless. In Spain, for example, the Inquisition was founded in 1478 and was particularly repressive in its very early years (Kamen, 2014, p. 68, estimates that over three-quarters of all executions ever made by it occurred before 1510). Science declines massively only after 1557-8, however, coinciding with the swift implementation of the Counter-Reformation measures enumerated before. The Inquisition, we can conclude, was a mere instrument that helped implement and strengthen the measures associated with Counter-Reformation.

A brain drain? Emigration of talent cannot explain much of the scientific decline. It is true that the net cross-confessional migration of scientists favored Protestant cities over Catholic ones: close to the religious borders (table A5), in Europe as a whole (figure A14a), in Germany (figure A14b), and especially in the Low Countries (figure A14c), where cities like Antwerp saw much of its educated population emigrate to Protestant cities after the Spanish takeover. However, among migrating scientists, those moving across the religious frontier account for only a tiny fraction of their total number.[55] Most importantly, net migration is not clearly connected to the decline of science. This can be seen in figure A12, which plots net migration against the number of scientists per capita, suggesting no relationship (see also table A6). A similar conclusion is suggested by figure A13, which shows the evolution of the Europe-wide number of scientists per capita: had talent emigration been the primary causal mechanism behind the Catholic scientific decline, the decline should have been compensated with higher growth elsewhere; yet the growth of science slowed in Europe *as a whole*, meaning that the Counter-Reformation, and confessionalism more generally, affected science through channels beyond mere spatial reallocation.[56]

Occupational choices? Did the Counter-Reformation push potential scientists out of science and into alternatives occupations, such as theology or law? Generally speaking: no. The fraction of scientists among newly appointed scholars evolved in Catholic universities just as it did among Protestant ones, as shown in figure A5b.[57] In this sense, Catholic universities did not at all become antiscientific. However, the average number of known publications and the overall fame of these scholars collapsed during the Counter-Reformation, as shown in figure A5a. This suggests that the decline was not in the number of people doing science but in the quality of their research.

Isolation? To avoid contagion with the "virus of heresy," Catholic authorities attempted to close their domains to infection from abroad.[58] Did isolation reduce the access to Europe's scientific advances, thereby reducing the quality of Catholic science? Closure was never complete, meaning that

1996).

[55]Moreover, within Catholic territory, the cities hosting inquisitorial tribunals did not suffer any such brain drain relative to other Catholic cities (figure A10).

[56]For similar results, see Lecce, Ogliari, and Squicciarini (2021). They find that the "birth" of scientists is more important than their migration, what they interpret as evidence pointing to education as a key mechanism.

[57]An exception is Spain, where science (but also theology!) declined in favor of law (see Kagan, 1974). In Catholic Germany, the opposite was the case (results available upon request).

[58]The censorship of Protestant-authored books, the bans to study abroad, and the founding of inquisitorial tribunals and universities close to the religious borders are evidence of this general policy goal (see appendix A). Spain is said to have been particularly affected by closure. "The siege mentality which typified the 'closed society' of Hapsburg Spain induced the authorities to treat all non-Spanish influences as suspect" (Goldstone, 1987, citing Henry Kamen).

ideas did eventually travel all across Europe. However, the costs of scientific communication were no doubt increased as a consequence of these policies. The collapse of Spaniards studying abroad following the post-1558 laws is evident (figure A3); and de la Croix and Morault (2020) have documented more generally how academic connectivity declined during the Counter-Reformation, coinciding with a shift of science to the north. Further, increased costs of scientific communication through censorship and banned academic mobility must have *delayed* the arrival of ideas.[59] If during World War I the blockade of scientific literature entering Germany decreased that country's scientific quality (Iaria, Schwarz, and Waldinger, 2018), then, during the Counter-Reformation, the late and timid arrival of the newest findings into the Catholic world is likely to have decreased scientific quality—at least in terms of novelty, thereby discouraging those motivated to do science to be the first among peers.

Lack of books? Scientific literature, while still accessible through various means, began to move to the north too by the 17th century—to the Netherlands, Germany, and the UK, where the proportion of printed international scientific literature largely exceeded that of population (figure A2). In these territories, science books retained a stable share of total printing (at around 1%); but in Spain, for instance, the share declines from nearly 2% when the first comprehensive index appears in 1559 to just 0.2% in the decade after the 1630 index. Ongoing work by Becker, Pino, and Vidal-Robert (2021) finds that the various indexes implemented across European cities were effective in reducing printing of the censored books, suggesting that not science in general, but the specific controversial areas that were explicitly censored, such as atomism or non-Galenic theories, may have become particularly costly to access were the indexes were enforced. However, as revealed by a draw of confiscated books in Spain (table A2), scientific books made up a much higher share than the index would imply; and most of the scientific books confiscated by the Inquisition were not even prohibited by the current index. This suggests that the risk of a book being confiscated despite not being in the index was larger if it was a scientific one.Such arbitrariness affecting science specifically may have prevented booksellers, readers, and scientists from exposing themselves to risky subjects, even if they were not clearly prohibited by the index.

Dogmatism? Quality is likely associated with novelty, but novelty may imply non-compliance with the dogma and a higher likelihood of being suppressed. Scientific decline may thus reflect more compliance, as recently argued by Blasutto and de la Croix (2023). They find that Italian scholars censored by the *Index Librorum Prohibitorum* in the 15th century were "of much better quality, on average, than the non-censored authors." Specific areas of conflict existed indeed: infinitesimal mathematics, for example, which laid the ground for many of the advances in mathematics of the late 17th century, became targeted by the Jesuits (Alexander, 2015);[60] helicentrism, atomism, non-Galenic medicine, and non-traditional chronology provide further examples of revolutionary advances seen with suspicion by Counter-Reformation authorities (Spruit, 2016). A reallocation may have occurred not

[59]Recall Juan de Cabriada's complaint (written in 1686) that Spaniards were "the last to receive [the news,] as if [they] were Indians."

[60]"In a fierce decades-long campaign, the Jesuits worked relentlessly to discredit the doctrine of the infinitely small and deprive its adherents of standing and voice in the mathematical community. Their efforts were not in vain: as 1647 was drawing to a close, the brilliant tradition of Italian mathematics was coming to an end as well. It would be centuries before the land of Galileo, Cavalieri, and Torricelli was once again home to creative mathematicians of the highest rank" (Alexander, 2015).

out of science, more broadly defined, but just out of such risky areas. Evidence supporting this channel is still weak, however (especially considering the previously mentioned arbitrariness in confiscation practices). Further, an alternative explanation for the role of dogmatism would be that the belief in the Counter-Reformation's dogma led to a *thought* system that hindered innovation. Jesuits, for example, were no doubt highly interested in science, were enormously educated, and constructed a formidable international web of idea-exchange and peer review (Gorman, 2020), which provided access to state-of-the art science. Yet, as argued by Cabello (2024b), since the 17th century and within a given city and time period, Jesuits have been on average much less likely to become scientific superstars than other scientists embracing less dogmatic religious beliefs, such as Unitarians, Quakers, and especially deists.[61]

Lack of pluralism? Prior to the Counter-Reformation, southern Europe had been home to Muslims and to large and influential Jewish communities, but religious diversity declined thereafter dramatically. Meanwhile, some Protestant-controlled lands became increasingly religiously diverse after the Reformation. Is religious pluralism, which declined among Catholics but increased among Protestants, associated with scientific outcomes? Column 10 of table 1 offers support for this interpretation. In Catholic-ruled cities, the decline of science was greater when the share of Catholic population was larger. This may reflect a greater capacity to enforce philosophical dogmatism when the population is more supportive. Meanwhile, in Protestant-ruled cities, the dummy for Catholic minorities correlates positively with science, suggesting that Protestant cities allowing for religious pluralism—most of them in England and the Dutch Republic—generated more scientists than others. By contrast, those overwhelmingly subject to Calvinist orthodoxy produced fewer scientists. This is consistent with the view that dissenters and religious minorities foster innovation, as argued by Mokyr (2011, pp. 361–3) in the context of the British Industrial Revolution, and as found by Cinnirella and Streb (2017) in the case of 19th-century Prussia.

But why is pluralism related to positive outcomes? Did it *enhance* the ferment of ideas, or did it just *preclude* their effective repression, absent popular support? The evidence points more to the latter. Had ferment under pluralism foster science directly, not just Holland and Britain but also the other tolerant and religiously diverse regions of the Continent—especially Poland and the Christian territories under Ottoman rule in present-day Hungary and Romania—should have become new scientific powerhouses. Yet, despite attracting religious dissenters from across Europe, these regions did not experience the same flourishing of science as areas further west. Far more important, it seems, were the dense networks of universities, courts, and academies supporting science—factors in low supply in the east. But further west, where science was already established—rooted in traditions including the Church itself, which had long served as a custodian of ancient thought and human capital—religious pluralism appears to have played a key role in hindering the enforcement of orthodoxy, thereby mitigating its negative side effects on science.[62]

[61] The Jesuits' humble collectivist cooperation ethos may explain part of their low visibility. Still, the possibility of ideological blockades, such as those suggested by Alexander (2015) (recall footnote 60), cannot be ruled out.

[62] Science seemed destined to emerge in the very same locations where the Church had long enhanced conditions conductive to science: a well-educated elite (including the clergy), an international network of scholars, and education institutions such as universities (which were largely absent outside Latin Christendom). Yet, some of the same logistic advantages that made science emerge among clerical circles—the network, know-how, and tradition associated with

Overall, the decline in science seems more related to lacking pluralism, diminished communication, and widespread philosophical conservatism than to any specific role played by the Inquisition, codified censorship, or the reallocation or emigration of talent. It must be emphasized, however, that all this came together, with one element supporting the other, and with the formidable power of Spain and the Church. Power and logistics seem indeed essential, since the stronger the capabilities to implement intellectual control—ordered structures, popular support, cohesiveness, resources—the more did science decline.

4.4 Alternative explanations?

The assertion that the Counter-Reformation caused intellectual and scientific decline has been contentious since the 18th century at least.[63] Appendix B thus deals with alternative explanations in detail. Among them, an often-mentioned one is the economic decline suffered Spain and its empire in the 17th century. Spain's economic decline, however, is comparable to other episodes of economic decline in early modern Europe, which did not cause scientific decline at all (figure B1).[64] Another popular alternative explanation is the development of parliamentary activity, which fell in Catholic Europe between 16th and 19th century (van Zanden, Buringh, and Bosker, 2012). Yet, as shown in table B1 and discussed in appendix B, the results are not affected by controlling for parliamentary activity and other institutional confounders proposed in the literature, such as those proposed by Dittmar and Meisenzahl (2020) and Serafinelli and Tabellini (2022). Also biographical sampling biases are not driving the overall results. To be sure, ethno-religious sampling biases may cause or exaggerate some observed differences between countries or even between Protestants and Catholics within a country; but ethno-religious biases cannot explain, for example, why Italy's decline was steeper in cities with inquisitorial tribunals than in similar, neighboring ones, nor why a collapse occurs abruptly after 1559 in Spain and after 1609 in Belgium, precisely after the sudden intensification of the Counter-Reformation in these territories.

4.5 Protestant-driven science?

A particularly prominent confounder is Protestantism. According to Landes (1998, p. 179), "[i]t gave a big boost to literacy, spawned dissents and heresies, and promoted the skepticism and refusal of authority that is at the heart of the scientific endeavor." And Merton (1936; 1938; 1968), inspired by Max Weber, argued that peculiar elements of the Protestant ethos—found especially among Calvinists, Puritans, and Pietists—were (and remained being) particularly conductive to science.[65]

the Church—seems instrumental in generating the collapse when these logistic advantages were repurposed against the spread of heresy.

[63] The debate has been particularly intense among Spaniards. See Goodman (2005) for a excellent overview.

[64] The lack of correlation is consistent with Serafinelli and Tabellini (2022), who find that, between the 11th and 19th centuries, the densities of intellectuals in European cities seem not driven by prosperity (measured either by population size or by wages). I may also point to the case of Belgium during the Twelve Years Truce (1609–1621), a period of vigorous economic recovery but enormous scientific decline.

[65] As summarized by Shapin (1988, p. 597), Merton "systematically mobilized evidence from eighteenth- and nineteenth-century Germany to argue that 'the impression made by this [Protestant] ethic has lasted long after much of its theological basis has been largely disavowed.' Indeed, the 1957 bibliographic postscript to that essay reasserted and

Yet the scientific gap favoring Protestants over Catholics emerges *only after* the Counter-Reformation, and especially where it was strongest, suggesting that the causal forces explaining this gap are to be found not in the features of Protestantism, but rather in those of the Catholic reaction. Moreover, data in this paper suggest that a strong-enough intensification of Protestantism, either across time or space, is not associated with scientific growth but rather with poor scientific outcomes, even decline. Calvinism in particular—the ideal form of Protestantism in Weber's and Merton's hypotheses—is not statistically associated with better outcomes. As mentioned already (recall column 10 of table 1), while science grew slightly more in cities with moderate shares of Calvinists (arguably because these were more tolerant cities, allowing the presence of unconventional views and religious minorities), in fully-Calvinist cities science *declined*. The results suggest that once Calvinism took control of a city, the imposed Protestant orthodoxy had negative effects analogous to those stemming from the Counter-Reformation.[66] A similar argument can be made from the time-series perspective: the "second Reformations"—the rise of Pietism and Puritanism in the 17th century in Germany, Holland, and England—is not associated with accelerating but comparatively stagnant famous scientists per capita.[67] These findings should not be surprising: "censorship was by no means the exclusive province of the Roman Catholic Church" (Creasman, 2012, p. 11); and "when Martin Luther, John Calvin, and other[s] established their own Protestant churches, the latter showed themselves to be no less intolerant of heretics and dissenting Christians than was the Catholic Church" (Zagorin, 2003, p. 2). In terms of violence, the Catholic Inquisition was by no means severe compared to Protestant authorities.[68] Protestants were indeed often more intolerant and repressive that Catholics, and some Protestant rulers tried to implement strict Protestant orthodoxy through censorship, persecution, and bans to visit foreign universities as late as the 19th century.[69]

refined the claim for persistence, citing 1940s and 1950s studies of U.S. scientists that purported to show a disproportionately large representation of Protestants and a correspondingly small representation of [C]atholic[s]."

[66]On Calvinist intolerance and social control, see Gorski (2003).

[67]In the Netherlands (see figure 6c), science begins to slowdown during its "Further Reformation" (*Nadere Reformatie*) of the 17th century, and even declines by the end of it, coinciding with war and economic problems, but also increased religious intolerance (e.g., Prak, 2002) and stricter censorship (der Weduwen, 2015): "In the second half of the seventeenth century a shift occurred in the use of repressive censorship. The number of edicts and persecutions against 'seditious' books and pamphlets increased and financial punishment for convicted authors and booksellers increased tenfold throughout the century." The record in Germany is not much better: the rise of Pietism—a Protestant revival peaking around 1750, clearly visible in figure 7b—correlates with rather unimpressive growth of Protestant scientists per capita (figure 6a), especially if compared to the stunning acceleration experienced by their Catholic counterparts in the same period. And, in Britain, the density of scientists decelerated with the establishment of Stuart Puritanism from 1603 to 1714 (figure D2). Overall, Protestantism seems not to have accelerated science in Europe as a whole, but rather slowed it down through the increased intolerance that governed the Continent until around 1700 (see figure A13).

[68] "[The Spanish, Portuguese, and Roman Inquisitions] put far fewer people to death . . . than the 40,000 people who were executed for witchcraft by secular authorities across Europe between 1580 and 1650. There is blood on the inquisitors' hands, . . . but there is much less of it than the 'black legend' has supposed" (Monter, 2004, p. 267). And Galileo's trial, perhaps the most significant anti-scientific action of the Counter-Reformation, sentenced him not to be burned at the stake as popular culture imagines, but simply to house arrest.

[69]Miquel Servetus—the first Westerner to correctly describe the function of pulmonary circulation—was burned alive by Calvinists in Geneva in 1553. Even during the Enlightenment, in 1723, German Pietists managed to dismiss Christian Wolff, an influential philosopher, from his university position in Halle; he had to abandon Prussia "in forty-eight hours or be hanged" (Mokyr, 2016, p. 245). And as late as 1790 did Prussia try to censor the views of philosophers nonconforming to the religious dogma, such a Immanuel Kant (Epstein, 2015, pp. 365–6). Indeed even in "1824, the Prussian crown prohibited its subjects from studying at Tübingen as well as Basel, due to insufficient rigor on the part of the Württemberg and Swiss authorities in suppressing radical ideas" (Israel, 2002, p. 796).

But why, then, didn't Protestants experience a collapse of science like the one observed among Catholics? A simple argument—suggested by many scholars since the 19th century at least, and which is consistent with the evidence presented so far—is that Protestants "lacked a central organizational structure to administer a uniform censorship policy," and that they "could not articulate a unified response to the problem of heterodoxy" because they "were divided on basic theological principles" (Creasman, 2012, pp. 11-2).[70]

Catholics, by contrast, organized and deployed *coordinated* intellectual control based on the unity of the Catholic Church and the geopolitical power of imperial Spain. Moreover, as shown in figure 7, the power of clergymen (proxied by a city's share of clergymen among famous people) increased among Catholics after the Reformation but fell among Protestants, opening a large gap between the two confessions (see also Cantoni, Dittmar, and Yuchtman, 2018). This gap must have been reflected in the clergymen's capacity to effectively implement religious and intellectual control, either by force or by argument.

This comparative ineffectiveness of Protestant repression might be a crucial factor behind the so-called European miracle. Had Protestants been more hierarchical, homogeneous, and organized, had the teachings of Calvin—who "himself deprecated science" (Merton, 1938, p. 417)—not led to an increasing number of dissenting sects "bickering and quarreling amongst themselves" (p. 416), or had the anti-Copernicanism of Luther prevailed, supported by some geopolitical superpower, science may have collapsed not just in Belgium and the Mediterranean but in Europe as a whole.[71] That would have meant no scientific revolution, and hence no industrial one.[72]

5 Shock persistence and economic effects

5.1 Persistence into the 18th and 19th centuries

Returning to figure 1a, we see that while 1550–1700 was a period of Catholic scientific decline, 1700–1850 was a period of Catholic scientific recovery.[73] The recovery took long time, however, and Catholics had on average still fewer scientists per capita around 1800—a key point in time for economic history, marking Europe's transition to what we call "modern" or "science-based" economic growth (Kuznets, 1960, pp. 1–16). Can we attribute this underperformance to enduring legacies of the Counter-Reformation? An answer is provided in table 2. Except for column 9, it shows estimates

[70]See, e.g., Draper (1875, pp. 216–8), Reusch (1883, pp. 595–8) and Putnam (1906, p. 206). The argument may be traced back to the Enlightenment. Hume ([1742] 1994), for example, argued that the "arts and sciences" would benefit from small, limited, states, as well as from "a variety of sects." He accused that the "[C]atholic church," by contrast, "being really one large state within itself, and united under one head," stuck dogmatically to one sort of philosophy only, "to the utter depravation of every kind of learning" (p. 65). This interpretation has come increasingly under attack by revisionist historiography (Harris, 2000; Feingold, 2003b; Olson, 2004; Gorman, 2020), which dismisses the interpretation as a reflection of the anti-Catholic biases of 19th-century historians. The data, however, seems fully consistent with this interpretation .

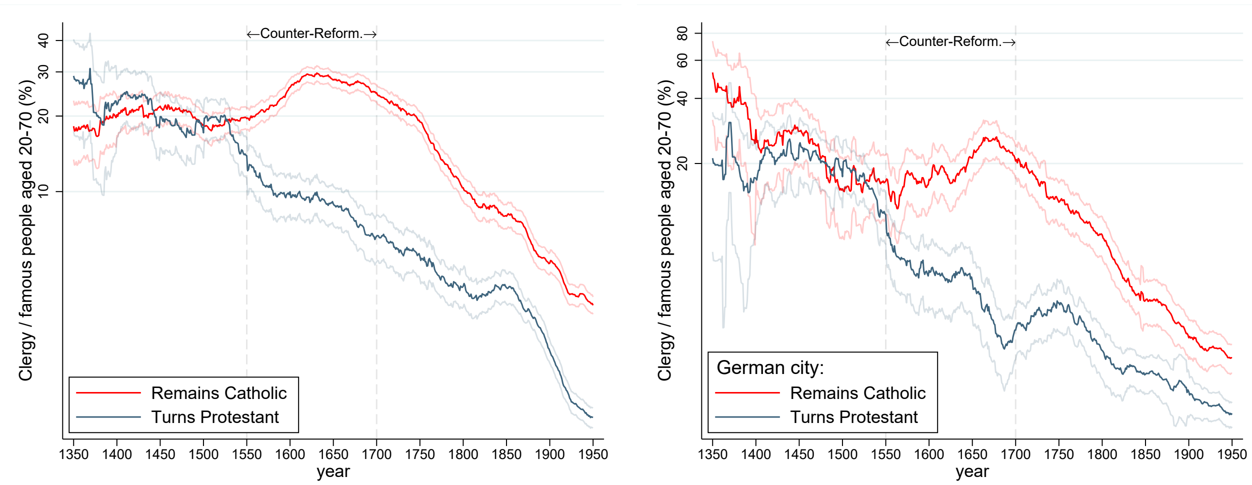
[71]The anti-Copernican stance of Luther and other Protestant leaders is documented by Stimson (1917, pp. 39–48).

[72]For discussions of how these "revolutions" relate to each other, see sources listed in footnote 1.

[73]This is again consistent with causal effects stemming from religiously-driven intellectual conservatism, since the recovery coincides with the retreat of such ideals in favor of the more tolerant views of the Enlightenment.

Figure 7: Power of the clergy – Protestants vs. Catholics

(a) Cities across Europe (b) German-speaking cities



Notes: Share of clergymen among all people aged 20-70 in Wikidata (average ± 2 st. dev.) based on Laouenan et al. (2022). After being comparable among Catholics and Protestants-to-be, this share declined abruptly among Protestants after the Reformation but *increased* among Catholics during the Counter-Reformation.

of

$$\log\left(\text{Scientists p.c. born in century } x_i\right) = \text{Count.-Reform. proxy}_i \cdot \alpha \quad + \text{controls}_i + \text{error}_i, \qquad (2)$$

where the per capita number of 18th- or 19th-century born scientists in city i is regressed on the controls listed in the footer and on different Counter-Reformation proxies, all of which confirm a negative association. The first proxy is a dummy indicating a city's Catholic majority by 1700. Column 1 shows that Catholicism is associated with depressed numbers of scientists either in born in the 18th century (panel A) or in the 19th (panel B); and column 2 confirms the same negative association when restricting the sample to cities north of the Alps and close to the religious frontier, no more than 60 km away from a city with the opposite denomination. The second proxy is a dummy indicating the Spanish Empire by 1600. Again, we confirming a negative association in Europe as a whole (column 3) and north of the Alps (column 4), both among 18th-century- and 19th-century-born scientists. The third proxy captures the degree of enforcement of the Counter-Reformation *within* Catholicism (Protestant cities are excluded from the regressions) through a dummy indicating an inquisitorial headquarter—defined here as a tribunal of the Roman, Spanish, and Portuguese inquisitorial systems, or as the seat of a bishop or archbishop in all remaining Catholic territories, except for the kingdom of France, "where, outside of the Papal territory of Avignon, the king would not allow the Inquisition to exercise its power" (Jacob and Stewart, 2004, p. 4). Again, we find a negative association of the inquisition with scientists born either in the 18th century or in the 19th.

Column 7 introduces yet another proxy for the Counter-Reformation: the share of clergymen among famous personalities born in the 17th and 18th centuries. As shown in figure 7, during the 16th and 17th centuries this share increased among Catholics but fell among Protestants, leading to a

Table 2: Scientists born C18th or C19th still explained by the Counter-Reformation

	CR proxy = Catholic city		CR proxy = Spanish 1600		CR proxy = Inquisit. headq.		Treatement = Clergy/famous C17, C18		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All cities	Northern border (50 km)	All cities	Only north of Alps	Only Catholic	Only northern Catholic	All	Only Catholic	Only Protest.
	PANEL A Dep. var.: 18th-century-born scientists per capita (logs)								
Treatment (see header)	-0.86***	-0.59**	-0.86***	-0.99***	-0.43***	-0.54***	-0.28***	-0.17***	-0.40***
	(0.19)	(0.24)	(0.13)	(0.23)	(0.14)	(0.14)	(0.04)	(0.05)	(0.08)
No. of cities	1098	181	1120	798	765	443	643	491	145
	PANEL B Dep. var.: 19th-century-born scientists per capita (logs)								
Treatment (see header)	-0.48**	-0.39***	-0.75***	-0.62***	-0.29*	-0.51**	-0.17***	-0.28***	-0.11*
	(0.20)	(0.11)	(0.16)	(0.19)	(0.16)	(0.21)	(0.04)	(0.08)	(0.06)
No. of cities	1343	204	1403	929	981	507	776	566	196
<u>Baseline controls</u>									
Education by 1800	✓	✓	✓	✓	✓	✓	✓	✓	✓
Institutions C18	✓	✓	✓	✓	✓	✓	✓	✓	✓
Geography & resources	✓	✓	✓	✓	✓	✓	✓	✓	✓
Urban development by 1800	✓	✓	✓	✓	✓	✓	✓	✓	✓
<u>Fixed effects</u>									
By state (ca. 1820)	-	✓	-	✓	✓	✓	✓	✓	✓
By language (ca. 1800)	-	✓	-	✓	✓	✓	✓	✓	✓

Notes: The table shows that cities treated by the Counter-Reformation or by more clerical power in the past had significantly fewer scientists per capita born in the 18th or 19th centuries. Baseline controls are: literacy rates by 1800; active university in C18; active parliament in C18; no. of parliamentary meeting in C18; representative government (commune) in C18; the distances to the Atlantic, to the Mediterranean, to water transportation ways, to coal fields, and to London; indicators of crop suitability; population growth 1600–1800; and population in 1800 (also squared and cubed to capture non-linearities). To reduce the error produced by noisy measurement of the depend variable in small cities, observations are weighted by the number of biographies available. Standard errors in parentheses, corrected for spatial aucotorrelation within 150 km using the procedure of Colella et al. (2019). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sources*: See appendix section D.3.

large and persistent confession-driven difference in what we may label "clerical power." Unsurprisingly (given how strongly this variable correlates with the Catholic dummy), we find that it associates with fewer scientists born one century later. But also restricting the sample to Catholic cities only (column 8), a negative correlation is confirmed, in line with the Counter-Reformation-*intensity* estimates of table 1, columns 3–10. More interesting still, we confirm a negative association between clerical power and science also when restricting the sample to Protestant cities only (column 9). In other words, science was lower also in cities that were "more Protestant." This calls again into question the Merton thesis, which proposes that the confessional differences in science are explained by a Protestant impulse instead of a Catholic decline. Further, the results reject the notion that doctrinal differences drive the outcomes, and instead point at the intensity of religious control as driving factor, irrespective of the confession. The 1800s, it must be noted, is a time in which a conflict between religion and science—so often exaggerated and indeed rare in previous epochs—*did* unquestionably began to increasingly take place, both among Catholics and Protestants.[74] All that said, it is among Catholics that the clergy had become persistently more powerful ever since the Counter-Reformation. Thus, by 1800, it is among Catholics that the influence of reactionary conservatism against modernism must have been stronger.[75]

Overall, the consistency of negative associations in table 2 offer support to the view that science found difficulties developing in environments of intellectual conservatism associated with clerical power and other legacies of the Counter-Reformation.[76] They offer support to Llorente's (1822) contemporary complaint, quoted in this paper's epigraph, that the "prohibitive laws of the Inquisition" were a hindrance to "learn the modern discoveries of the exact sciences," and to Mokyr's assertion that "the Counter-Reformation . . . slowed down the diffusion of the *nuova scienzia* innovations and the rise of the Enlightenment" (Mokyr, 2016, p. 165). More important still, the results suggest that its impact on the spatial distribution of science lasted at least until the 19th century—that is, until the crucial period in which Europe embarked the era of modern economic growth. But, before studying the consequences of this persistence, let us dig a bit deeper into its causes.

5.2 Why so persistent? Revived legacies, 1789–1990

That the Counter-Reformation had effects on 18th-century science might not be surprising, given that inquisitorial systems and other legacies were only beginning to be dismantled. Yet we saw that effects on science lasted much longer, at least until the 19th century. What could explain such long persistence? A simple explanation would be that the clergy remained more powerful among Catholics than among Protestants, as figure 7 suggest. But this metric fails to explain many stark differences in science. For example, science recovers very fast among the Catholics in Germany, yet the levels of clergymen per famous people evolved just as in other Catholic regions across the Continent where science persisted depressed for much longer. What explains such stark differences?

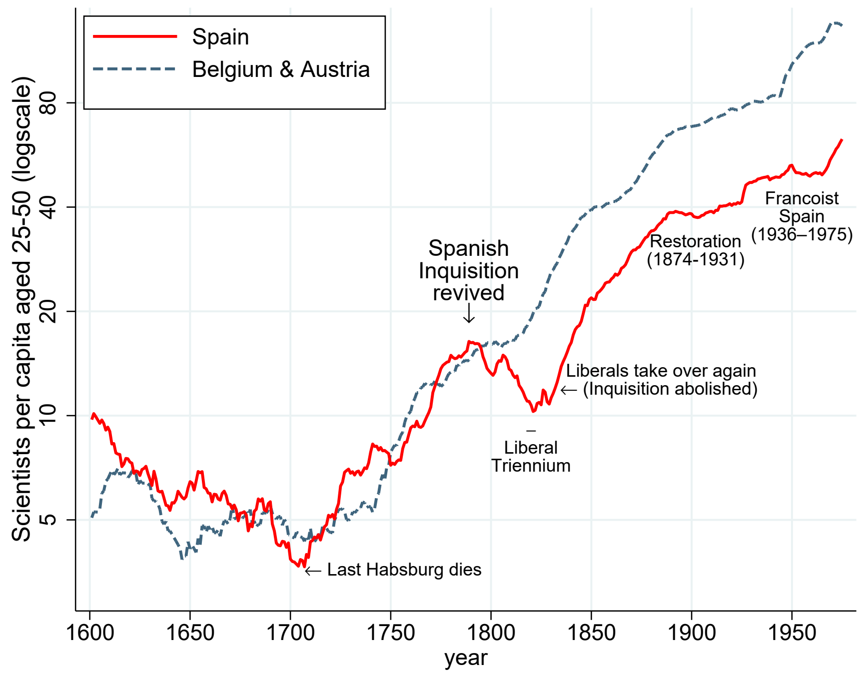
I will propose that much of the decline's persistence (or the absence of it) has to do with how ruling elites reacted in terms of policies during a particular set of shocks: when ideologies emerged that seriously threatened the power of the elites *and* of the clergy, just as the Reformation once did. This happened, for example, after the French and Bolshevik revolutions. In places once subject to the Counter-Reformation, the threatened elites were endowed not just with a reserve army of supportive conservative clergymen, but also with a set of historical laws and traditions rooted in the Counter-Reformation. These were originally designed to counter the dangerous ideas of Protestantism, but they could be revived and repurposed against the new ideological threats. Enacting some of those institutional legacies, I propose, unintentionally harmed science once more and hindered the recovery.

[74] An example is the controversy between evolutionists and creationists after Darwin's seminal work, published in 1859.

[75] For anecdotal evidence on this conflict, see appendix C.

[76] The results resemble those of Chaney (2023), who finds that increased political power of religious leaders explain the decline of Islamic science between the 11th and 13th century. There is indeed great analogy between that episode and the Counter-Reformation: the Tridentine Catholic consensus resembles the emerging Sunni ijmā'; the founding of inquisitorial tribunals and the Jesuit takeover of universities resembles the emergence of madrasas; and the censoring of previously accepted Catholic leaders such as Erasmus, who entered the Catholic indexes of prohibited literature, resembles the rejection of deviant Islamic scholars during the Sunni revival.

Figure 8: The revival of the Spanish Inquisition



Notes: The number of famous scientists in Spain, Belgium, and Austria was comparably low during the 17th century (at the height of the Counter-Reformation) and recovered similarly during the 18th century (coinciding with a retreat of Counter-Reformation policies). However, Spain's recovery stops abruptly around 1790, when inquisitorial censorship is revived in response to the spread of revolutionary ideas from France. Scientific growth resumes only after the definitive abolition of the Inquisition in 1834, yet it stagnates during the conservative regimes of the Restoration and Franco. Population (in millions) based on the Maddison Project Database 2020 (Bolt and Van Zanden, 2020), Buyst (2011), and Prados de la Escosura, Álvarez-Nogal, and Santiago-Caballero (2021).

This mechanism is supported by consistent statistical evidence, presented in appendix C in the form of four examples of what we may call "echoes of the Counter-Reformation." The first one concerns the Spanish reaction to the French Revolution of 1789, which triggered a revival (continuing until the 1830s) of the Inquisition and old censorship laws.[77] As shown in figure 8, the revival of the Inquisition (which had been dormant since nearly a century) coincided with a sudden decline of science in Spain that lasted until the Inquisition was finally abolished in 1834. City-level evidence confirms the interpretation: cities with inquisitorial tribunals saw the steepest intellectual decline in the period of inquisitorial revival but the strongest intellectual growth in periods of inquisitorial inactivity (table C1, column 1). Similar results are obtained when extending the analysis to the conservative revivals triggered by the French Revolution elsewhere in Europe.[78] Intellectual growth in this period was lower among Catholic cities, especially among those that at the height of the Counter-Reformation, by 1600, belonged to the Spanish Empire (table C1, columns 2-4). The next example concerns another

[77]The swift revival of full-scale censorship to counter French revolutionary ideas is known by historians as the "Floridablanca panic." See Calvo Maturana (2014), Lea (1890, pp. 168–73), and appendix C.

[78]On the conservative order emerging after the French Revolution, see, e.g., Epstein (2015) and Israel (2019).

information shock that similarly shaped European politics: the Bolshevik Revolution of 1917, which triggered the emergence of fascism and other forms of right-wing authoritarianism throughout the Continent (figure C2). Again, we will see that it is among former dependencies of the Spanish Empire, where the Counter-Reformation had been particularly intense, that science declined more (table C2). A final example in the appendix concerns dictatorships worldwide since 1870 and shows that dictatorships need not be bad for science overall, but their effect is negative in former dependencies of the Spanish Empire (table C4), where dictators have tended to revive elements of the religiously-legitimized politics of the past. Overall, these examples suggest that episodes of conservatism interacted with a location's Counter-Reformation history to generate negative effects on science from the 18th to the 20th century. Importantly, such echoes of the Counter-Reformation were contingent—as figure 8 illustrates—what explains why some regions escaped their past faster than others.

5.3 Effects on modern city growth: 1800–1939

Leaving aside idiosyncratic events that extended the effects of the Counter-Reformation on science even into the 20th century, we can confidently state that until the 18th and 19th centuries these effects were still strong and widespread across Europe. This has an important implication: around 1800, when science-based economic growth began to spread throughout Europe, cities historically treated by the Counter-Reformation had lower, predetermined, numbers of scientists. Did these cities also grow less during the modern growth regime?

I explore this question in table 3. Panel A show OLS estimates of

$$\text{Pop. growth 1800–1939}_i = \text{Counter-Ref. proxy}_i \cdot \gamma + \text{controls}_i + \text{error}_i, \tag{3}$$

where both the treatment proxies and the controls remain the same as in table 2 but the dependent variable is now population growth of city i between 1800 and 1939—that is, between the beginnings of the modern economic growth regime and the start of World War II.[79] All estimates are significantly negative, telling us that cities treated with the Counter-Reformation grew less after controlling for initial development, education, institutions, geography, and resources.[80]

Can lower growth of Counter-Reformation cities be attributed to the decline of science? I try to answer this question in panel B of the table by jointly including scientists and the treatment proxies

[79] I chose 1939 as ending date because the war dramatically reconfigured the Continent's economic, political, and ethnic map.

[80] How exogenous is the variance provided by these regressors? The Spanish Empire and the imposed Catholicism within its military reach were subject to the randomness of inheritance and other contingencies (recall section 2). However, the strong spatial contiguity of the observations requires the inclusion of the many spatial confounders considered in the regression: the distances to the Atlantic, to the Mediterranean, to coal deposits, and to industrializing London, various crop suitability indicators, institutions, education, and fixed effects at the levels of states and languages. Inquisitorial headquarters, on the contrary, are not spatially contiguous and can be compared to adjacent, Catholic, units. However, they are subject a strong selection bias: treated cities had larger populations, more printing, more universities, and more initial scientists (table A3). But since these attributes correlate otherwise with subsequently *more* science and *more* city growth (tables available upon request), the effects estimated in columns 5-6 can be seen as lower bounds. Furthermore, even though the treatment was presumably more intense close to the tribunals, the control group is partially treated too: officials of the Inquisition tried to enforce their policies through the entirety of their jurisdiction, making surprise visits to remote areas (see Bethencourt, 2009). This again suggest an underestimation bias.

Table 3: Post-1800 city growth explained by the Counter-Reformation

	CR proxy = Catholic city		CR proxy = Spanish 1600		CR proxy = Inquisit. headq.		Treatement = Clergy/famous C17, C18		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All cities	Northern border (50 km)	All cities	Only north of Alps	Only Catholic	Only northern Catholic	All	Only Catholic	Only Protest.
PANEL A: city growth and the Counter-Reformation									
Dep. var.: city's population growth 1800–1939									
Treatment (see header)	-0.29***	-0.39***	-0.30**	-0.36***	-0.24**	-0.28*	-0.15***	-0.22***	-0.11***
	(0.09)	(0.10)	(0.13)	(0.10)	(0.12)	(0.15)	(0.05)	(0.05)	(0.02)
No. of cities	1518	212	1592	899	1153	534	829	617	212
PANEL B: effects other than science? OLS horse race									
Dep. var.: city's population growth 1800–1939									
Log scientists p.c., born C18	0.19***	0.11	0.20***	0.17***	0.21***	0.16**	0.21***	0.24***	0.05
	(0.05)	(0.09)	(0.05)	(0.05)	(0.06)	(0.07)	(0.06)	(0.07)	(0.09)
Treatment (see header)	-0.20**	-0.23	-0.21	-0.17	-0.14	-0.14	-0.06	0.01	-0.11
	(0.10)	(0.18)	(0.13)	(0.12)	(0.11)	(0.14)	(0.05)	(0.05)	(0.13)
No. of cities	1097	181	1119	775	764	442	643	491	152
Log scientists p.c., born C19	0.26***	0.13	0.26***	0.24***	0.29***	0.25***	0.26***	0.27***	0.12
	(0.05)	(0.09)	(0.05)	(0.07)	(0.07)	(0.10)	(0.07)	(0.09)	(0.16)
Treatment (see header)	-0.26***	-0.35***	-0.18	-0.22	-0.19	-0.19	-0.11**	-0.13*	-0.09***
	(0.09)	(0.12)	(0.13)	(0.17)	(0.12)	(0.13)	(0.06)	(0.08)	(0.03)
No. of cities	1342	204	1402	868	980	506	775	565	210
Baseline controls									
Education by 1800	✓	✓	✓	✓	✓	✓	✓	✓	✓
Institutions C18	✓	✓	✓	✓	✓	✓	✓	✓	✓
Geography & resources	✓	✓	✓	✓	✓	✓	✓	✓	✓
Urban development by 1800	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fixed effects									
By state (ca. 1820)	-	✓	-	✓	✓	✓	✓	✓	✓
By language (ca. 1800)	-	✓	-	✓	✓	✓	✓	✓	✓

Notes: Panel A shows that cities treated by the Counter-Reformation or by more clerical power in the 18th century grew less during 1800–1939. Panel B suggests that these growth effects may not stem purely from science, since city growth is sometimes explained directly by the treatment in a horse race. Baseline controls described in table 2. To reduce the impact of measurement error due to few biographies in small cities, observations are weighted by the number of biographies available. Standard errors in parentheses, corrected for spatial aucotorrelation within 150km using the procedure of Colella et al. (2019). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. *Sources*: See appendix section D.3.

in an OLS "horse race." That is, regressions now take the following form:

$$\begin{aligned} \text{Pop. growth 1800–1939}_i = & \log\left(\text{Scientists p.c. born in century } x_i\right) \cdot \beta \\ & + \text{Counter-Ref. proxy}_i \cdot \gamma \quad + \text{controls}_i + \text{error}_i, \qquad x = 18, 19. \end{aligned} \tag{4}$$

The results are ambiguous. One one hand, with the exception of columns 2 and 9, βs have substantially higher t-statistics than the γs, suggesting that much of the negative association reported in panel A is indeed running through science.[81] On the other hand, the decline of the γs is only limited: the coefficients tend to loose their statistical significance but the point estimates often remain above 50% of their original levels, suggesting that the effects on city growth might not be driven exclusively by science.

Exploring what these alternative channels may be goes beyond the scope of this paper.[82] It becomes clear, however, that the narrative blaming Catholic backwardness on the Counter-Reformation, and its effect on science in particular, contains significant elements of truth.

6 Conclusions

This paper studies an episode that some historians believe to have been decisive in explaining Europe's scientific and economic geography: the Counter-Reformation. While the alleged effects are contested (some believe them to be nothing but propaganda), this paper presents evidence suggesting that the Counter-Reformation had important effects indeed. Before it, comparable treated and untreated cities long shared similar trends of scientists per capita. But science fell in treated cities relative to others precisely after the Counter-Reformation was effectively enforced (the timing varies, from 1521 to 1618, depending on contingencies such as military outcomes). Scientific decline is confirmed not just in southern Europe but also north of the Alps, even within a narrow band around Catholic-Protestant borders. Further, within Catholic lands, the decline was deeper where logistics allowed for more intense intellectual control—in cities with inquisitorial tribunals, cities with universities (they were easy to control), or cities subject to the powerful Spanish Empire. And whenever the treatment was weakened, science recovered.[83]

[81] Further, it must be noted that efficiency of the βs is inherently low, given that locations of science production (say university cities) need not coincide with location of science implementation (say mine fields). Thus, for example within a group of coreligionist cities connected through labor mobility, the Catholic dummy may capture the application of science better than the number of scientist born in each individual city, making Catholicism win the horse race even if science is the causal force.

[82] What these alternative channels may be is unclear given the wide spectrum of plausibly-affected societal variables. Recent research by Drelichman, Vidal-Robert, and Voth (2021), for example, find that historical inquisitorial intensity across Spanish municipalities correlates not only with today's income and education but also with today's trust. Yet, without the complete time series of trust beginning the 15th century (like those I show here for scientists), and given how much could have happen in 500 years, it is difficult to be sure about the causal nature of such correlation.

[83] An open question is the relative importance of the many complementary policies jointly implemented during the Counter-Reformation (censorship, restricted academic mobility, persecution) and of the many complementary mechanisms triggered by them (increased costs of scientific communication, self-censorship, conservative minds)—a difficult task, given data restrictions and strong synchronicity. Recent research by de la Croix and Morault (2020), Drelichman, Vidal-Robert, and Voth (2021), Blasutto and de la Croix (2021), Becker, Pino, and Vidal-Robert (2021), Dewitte et al. (2022) deal with some specific mechanisms, but an holistic study remains to be done.

In contrast to Merton's thesis, I find that, if sufficiently strong, also 17th-century Protestantism was detrimental for science. Yet it was clearly much less detrimental than 17th-century Catholicism: while in Protestant territory the observed number of scientists per capita sometimes slowed down its growth or stagnated, in territories subject to a strong Counter-Reformation—Italy, Spain, Portugal, and Belgium—the number of scientists per capita fell back to levels not seen in two hundred years. How can we explain this enormous difference? Not by economic conditions (they played a marginal role, if any at all). And Catholics were *not* more intolerant, nor more violent, nor more anti-scientific than Protestants. However, when implementing intellectual control, they benefited from pre-established structures (such as the Spanish Inquisition, previously directed against Muslims and Jews) and from an increasingly influential clergy (whereas the Protestant clergy saw the opposite: a decline of its influence). More important still, Catholics benefited from a higher degree of coordination, which stemmed from the unity of the Roman Church and from the military, political, and financial might of imperial Spain. Protestants, by contrast, with their weak churches and states, had little chance to block the proliferation of what they considered heresy. They often tried, but failed systematically. Had they instead been more effective at exerting intellectual control, it seems plausible that modern science would have never risen, and modern growth never taken off.

Did the Counter-Reformation affect science also long beyond the 17th century, as some scholars have claimed? While Catholics witnessed a vigorous recovery of scientific activity after 1700 (coinciding with the retreat of the Counter-Reformation's ideals and institutions), I confirm that it still took centuries to close the gap relative to Protestants. Even across closely located, coreligionist cities, those more affected by the Counter-Reformation continued to have fewer scientists than others as late as the 19th century; and across countries, the gap has not been closed yet. Why did the recovery take so long? A key driver of endurance seems to be how, centuries later, shocks triggering reactionary conservatism interacted with a city's Counter-Reformation past. In places once subject to a stronger Counter-Reformation, conservative regimes and dictators were more likely to repurpose old institutions rooted in the clericalism, dogmatism, and isolationism of the 16th century. These events coincide with sudden declines of scientific growth that hindered faster convergence. Importantly, these echoes of the Counter-Reformation were contingent; in this way they explain why some regions managed to escape their past faster than others.

Despite these interesting differences, on average, the decline of science associated with the Counter-Reformation was sufficiently large and persistent to have long-term growth effects. All things equal, heavily treated cities had a scientific disadvantage around 1800 and grew less during the modern growth period that followed. By now, if we condition on country fixed effects, this historical disadvantage has fully disappeared: in southern Europe, inquisitorial cities have long since recovered their leading position as centers of science; and in Germany and the Netherlands, not Protestant but Catholics lead in both science and income. Historically, however, the Counter-Reformation appears to have been one of the greatest and more enduring shocks to science ever recorded, and a long-lasting determinant of policy, society, and development overall.

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