Science under Inquisition: The allocation of talent in early modern Europe[*]

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Abstract

We study the impact of the Roman Inquisition on science during the Scientific Revolution of the 16^{th} and 17^{th} centuries. A structural model of occupation and location decisions enables the quantification of causal mechanisms and counterfactual historical experiments in a setting where a reduced-form approach is undermined by migration and knowledge spillovers. Using historical data on notable people, we find that the drivers of Italy's scientific decline since the 1540s are the Inquisition's *deterrence effect* – which induced scientists to migrate, thus also discouraging talented individuals to engage in science in the first place – and the *training effect* stemming from the consequent reduced availability of science masters. We conclude that the Roman Inquisition depressed scientific scholarship in the Italian peninsula by about 24% during the run-up to the Industrial Revolution. Owing to such migration and knowledge spillovers, this institution also had overall negative consequences for science in the rest of Europe.

JEL Classification: N33, J61, Z12

Keywords: Science, Inquisition, Counter-Reformation

> What good would it do you to have all the time you want for research if any witless monk of the Inquisition could simply suppress your ideas?
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> Bertold Brecht, *Life of Galileo*

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1 Introduction

Governments that embrace strong ideologies often strive to control through repression and violence the production and diffusion of knowledge, with potentially disastrous economic consequences. A central institution of early modern Europe, the Roman Inquisition (RI), was established precisely for that purpose in the wake of the Protestant Reformation. Started in 1542, the RI was a centrally-organized, detective and judicial network of tribunals spread across the Italian peninsula, which served as the repressive long arm of the Catholic Counter-Reformation. More systematic and formalized than the Medieval and Spanish Inquisitions (12^{th} and 15^{th} centuries, respectively), the RI sought to investigate and prosecute all forms of innovative thinking that contradicted the christian sacred scriptures. Thus, this institution soon clashed with the ideas of modern science, in particular during the Scientific Revolution (16^{th}–17^{th} centuries), as famously illustrated by the cases of Galileo or Gerolamo Cardano. As shown in Figure 1, the aggregate stock of scientists who ended their career in states where the RI was active started diverging from other European states around 1550-1560.[1] It is a long-lasting question whether the relative decline of Italian science during the two centuries that led to the Industrial Revolution is actually related to the Roman Inquisition.[2] The present paper aims at answering empirically this unsettled question.

This task is conceptually and empirically challenging. While Figure 1 may naturally suggest a Difference-in-Differences (DiD) research design, we argue that such reduced-form approach would be unreliable in this historical context. To see why, consider the case of Niccolò Buccella, a physician and surgeon born in Padua in 1522 who engaged in anatomical dissection of corpses with students at the University of Padua. The Catholic Church strongly disapproved such activity, and in 1571, following a threat to be arrested by the Inquisition, Buccella fled to Romania and then Poland, where he prospered as King's doctor and surgeon. He died in Krakow in 1599 (Caccamo, 1972). Like Buccella, many scientists from RI states decided to migrate to non-RI states to avoid punishment, thereby leaving their pupils without masters. At a time when training via apprenticeship was a crucial mechanism for the intergenerational transmission of skills (de la Croix, Doepke, and Mokyr, 2018), fleeing

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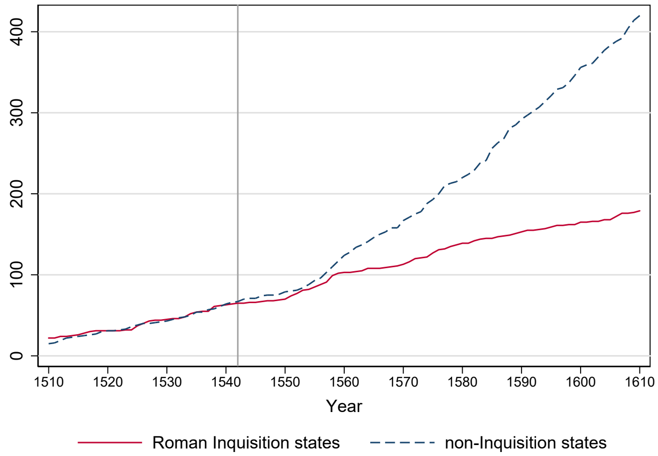
[1] This pattern is consistent with historical evidence from other sources (e.g., Anderson, 2015).

[2] For example, in his influential book on the cultural roots of economic growth, Joel Mokyr notes: "Suppression of intellectual innovation may well have affected to some extent the pursuit of truly innovative work in countries where the Inquisition held sway [...]. It is anything but clear whether the decline in the sciences in Catholic Europe [...] was actually because of the fear of the Catholic reaction" (Mokyr, 2016, p. 156).

Figure 1: Cumulative stock of scientists and the Roman Inquisition



Notes: The figure shows the stock of scientists who ended their career in states affected or not affected by the Roman Inquisition. Data source: Index bio-bibliographicus notorum hominum (IBN), see Section 4 for details.

scientists depressed scientific activity in RI states not only directly, but also indirectly by depriving of science masters the young generations of high-talent individuals.

The key implication of this process is, in DiD jargon, spillovers from treated states that were losing scientists (i.e., RI polities) to control states that were receiving them (i.e., non-RI polities). This is a direct violation of the stable unit treatment value assumption (SUTVA) that a state's outcome (i.e., scientific scholarship) does not depend on the treatment status of other states, a necessary condition for causal identification in the DiD design.[3] Moreover, and perhaps more importantly, a reduced-form approach would be largely silent about the mechanisms driving the possible impact of the RI on science.

To overcome these limitations, we build and estimate a structural, dynamic Roy model that explicitly micro-founds career and location choices of high-talent individuals in early modern Europe. Our theoretical framework takes into account endogenous migration responses, inter-generational spillovers, pre-existing different trends in scientific scholarship (as reflected in wage and total factor productivity dynamics), and the fact that the decision to become a scientist is not separable from the location decision. Once estimated, the model allows us to quantify the role of these different factors, as well as to perform counterfactual historical experiments that provide a magnitude on the net, causal effects of the RI on both

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[3] When the "parallel trends" assumption holds, deviation of RI states' trend in scientific scholarship from non-RI states' trend is the causal effect of the RI on scientific scholarship. However, if non-RI states' trend is also affected by the RI then the DiD design fails to identify a causal effect. DiD with spillovers is still in its infancy (Roth, Sant'Anna, Bilinski, and Poe, 2023).

treated states and non-treated ones. Estimation leverages newly-assembled biographical data on the universe of recorded notable individuals, their political entities, and labor markets. We find compelling evidence that the persecution of scientists by the RI contributed to the decline of scientific scholarship in Italian states during the 16th–17th centuries, through deterrence and intergenerational training mechanisms. Perhaps less obvious, we also find a net negative impact on science also in other European states, because the positive impact on polities that were receiving fleeing scientists from RI states is more than compensated by the negative impact arising from the reduced stock of Italian scientists.

In our model, overlapping generations of high-talent individuals are born in a given place and live for two periods. A career decision (scientist or non-scientist) is made in the first period, knowing that the best residential location (possibly one's birthplace) will be chosen in the second period. Utility is career- and location-specific, and depends on net earnings that are proportional to one's specific human capital. The latter increases in the fraction of *masters*, i.e., scientists or non-scientists from the previous generation in one's birthplace. After the establishment of the RI, some locations are within the Inquisition's reach, which affects career and location decisions in three intertwined ways: (i) the threat of punishment for scientists, which we label as the *deterrence effect* and which can be avoided by either choosing a non-scientific career or by moving to a non-RI state;[4] (ii) the establishment of anti-scientific social norms, and thus stigma on individuals who pursue a scientific career in RI states, which we label as the *cultural effect*, and which, contrary to deterrence, is tied to one's place of origin and therefore cannot be avoided;[5] and (iii) a cumulative reduction in the availability of science masters, a key input in the technology of scientific skill formation for future generations. We refer to this third effect, which is triggered by (i) and (ii) and unfolds over subsequent generations, as the *training effect*.[6] Because of scientists' migration option, the negative impact on RI states translates into an impact on non-RI states that may be either positive or negative depending on whether, after the establishment of the RI, the pool of scientists born in Italy shrinks faster than their out-migration rate or not.

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[4] Lecce, Ogliari, and Squicciarini (2021) study the migration of scientists in 19th-century France, where the Catholic Church had taken an antiscientific stance.

[5] Squicciarini (2020) studies how a particular cultural trait, religiosity, affects education and economic development in France between 19th-20th centuries. Using given names as indicators of religious identity, Andersen and Bentzen (2022) argue that parents' religiosity influences children's scientific careers.

[6] Moser, Voena, and Waldinger (2014) study the dynamic human capital spillovers triggered by the persecution of Jewish scientists in Nazi Germany.

This framework features interdependent discrete choices at two different levels, and leads naturally to a structural econometric model via standard parametric assumptions on unobserved preference components that result into the nested logit model. The "lower model" explains location decisions conditional on a career choice, while the "upper model" explains career choices that are forward-looking because an individual takes into account the out-migration option exercisable in the future. The separate identification of the parameters that govern deterrence and cultural effects hinges upon the fact that Italian scientists can avoid the RI's threat by moving to non-RI states, while cultural influences in the place of upbringing cannot be avoided. Thus, endogenous mobility choices are pivotal in our empirical strategy.[7] The training effect, in turn, is identified by the variation in the fraction of scientists from the previous-generation in the place of origin. This baseline model is then extended in two important directions: first, we allow for "agglomeration effects" in migration decisions, i.e., we consider the fraction of scientists who move to a certain location as an additional pull factor in that location; second, we allow for an intensive margin of deterrence, which we model empirically as within-Italy variation in the number of RI tribunals.

We estimate the model using data from the *Index bio-bibliographicus notorum hominum* (IBN), a project initiated in 1978 that aims at gathering all individual biographies ever written. These *notable people* can be regarded as talented individuals with the highest human capital (de la Croix and Licandro, 2015), as revealed by their outstanding contribution to knowledge or human affairs.[8] Our baseline sample consists of 11,550 notable individuals born between 1454 (Gutenberg's bible) and 1618 (Thirty Years' War) in European states, excluding those under the jurisdiction of the Spanish Inquisition.[9] Each entry includes textual biographical information from which we can extract individuals' occupations, and thus track scientific vs non-scientific careers over time. In addition, we geolocalize individuals' places of birth and death, and cross them with historical maps of Europe's political entities, their religion status (including the location of all RI tribunals), and labor markets.

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[7] Similar to our separation of deterrence vs culture, Buggle, Mayer, Sakally, and Thoenig (2023) leverage movers' destination choices to separately identify the role of persecution threat vs diaspora network in shaping German Jews' outmigration incentives during Nazi Germany. In their case, however, there is no equivalent to the occupation decision: the upper model describes a binary migration decision (move of out of Germany or not), while the lower model is about the multinomial choice of destination country for those who move out of Germany.

[8] IBN is not a random sample. We discuss potential selection issues in Section 4.1.2.

[9] These individuals are "treated" by a different inquisitorial institution both before and after the RI establishment, thus impacting the interpretability of our estimates. We nonetheless show the robustness of our results when including them, resulting in a larger sample of 13,250 individuals.

Descriptive evidence is consistent with the hypothesis that the RI reduced the stock of scientists in RI states: the share of scientists who end their career in these states significantly dropped after the RI was established.[10] The break in trend is particularly visible for scientists and not for other occupations. Structural estimation allows us to disentangle mechanisms and to provide reliable causal magnitudes. We find that the decision to become a scientist in early modern Europe is significantly influenced by the RI via two of the three central mechanisms, namely the *deterrence* and *training* channels. For the former, the presence of the RI in a state reduces by almost 11 p.p. the probability that a scientist remain in or move to that location. Since migration is costly, deterrence reduces indirectly the likelihood of choosing a scientific career in the first place for individuals born in RI states. As for the training effect, increasing the fraction of notable individuals who are scientists in one's birthplace from 0 to 1 increases the probability of becoming a scientist by 13 p.p., approximately, implying an important role of science masters in the training of future scientists. Finally, the cultural effect turns out to be statistically and economically insignificant, a result that reflects the stickiness of social norms. Cultural change is slow, and it is possible that the RI's impact on scientific scholarship via the cultural channel may be detectable only after sufficiently long exposure to inquisitorial institutions. Interestingly, we find instead a significant cultural effect when we augment the sample with European polities controlled by the Spanish Inquisition, which was established some 60 years earlier than the RI. In this sample, being raised in a place where any Inquisition is present at birth, decreases by about 20 p.p. the probability that a young notable person becomes a scientist.

These results are robust to a range of alternative specifications. In particular, they hold when introducing within-Italy variation in RI intensity (proxied by the location and number of Inquisition tribunals), and when restricting the sample to Catholic Europe only, suggesting they are driven by the Inquisition itself, and not more diffuse Counter-Reformation, or Italian confounders. Extending our model to allow for agglomeration effects in the number of scientists, we find that these effects are positive but they do not alter our baselines estimates of deterrence, training, and cultural effects. These estimates also are unchanged when varying the occupations included in the 'scientist' category, suggestive of a broader phenomena that is not just experienced by borderline scientific occupations (like architecture or cartography).

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[10] The data also indicate high levels of migration, in particular from RI states, pointing to the importance of this margin of response.

A counterfactual historical experiment allows us to quantify the net contribution of these different channels to the number of scientists in Italy. Absent the RI, the model predicts the share of notable Italians engaging in science would have been about 13.9%, vis-a-vis 10.6% under the RI presence.[11] This is a drop of 3.3 p.p., or 24% of the model pre-RI average share of scientists in RI states. As receivers of scientists fleeing the Inquisition, non-RI polities benefited from a relatively higher inflow of scientists from RI states, and thus a larger fraction of masters. However, the negative impact of the RI on the total number of scientists in RI states decreased the pool of potential scientists that would have migrated to non-RI locations anyway. We find that this second effect prevails: in the absence of the RI, scientific scholarship would have been *also higher* in non-RI states. In a counterfactual Europe without the RI, 12.2% of notable individuals born after 1542 would have ended their career in non-RI states, against an actual share of 11.3%. This indirect effect is suggestive of the "global" implications of "local" repressive institutions such as the RI.

Related literature and contribution. In terms of methodology, we exploit the advantages of a structural, micro-founded approach to historical economics, in contexts where a major historical event makes reduced-form methods of lesser use to identify causal effects and to quantify mechanisms, as advocated by Bisin and Federico (2021). In this respect, our work is related to Buggle, Mayer, Sakally, and Thoenig (2023), who take a similar route to study push and pull factors behind the migration of German Jews escaping Nazi persecution.

In terms of empirical contribution, our findings illuminate the far-reaching, detrimental effects (and driving mechanisms) of institutional ideological control of knowledge on scientific development. The RI is an important case in point, as conjectured by Mokyr (2016). There are other examples: Chaney (2023) argues that religious elites' increased political power during the "Sunni Revival" (11th–13th centuries) accounts for a large share of the scientific decline decline in the Islamic world. In particular, he shows that following the spread of madrasas (educational centers that pivoted on the Islamic law), the scientific output of authors affiliated with these centers decreased by between 3 and 5 p.p., or between 30% and 50%.[12] Squicciarini (2020) points to the negative effects of religious institutions on

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[11] One limitation of the model, and thus of this experiment, is that it does not allow for wages to respond endogenously when changing the institutional setting (e.g., when "erasing" the Roman Inquisition). The Lucas critique also applies, of course.

[12] Interestingly, this estimate is of the same order of magnitude as our main aggregate effect, despite the different context and margin of variation (the production of books).

the diffusion of knowledge in a context where political and religious power are separated. Studying Catholicism in France during the Second Industrial Revolution, this author shows that schools located in more religious districts adopt technical curricula more slowly.[13]

We build on theoretical contributions on the incentive structures underlying the coexistence of religious or scientific knowledge, such as Bénabou et al. (2022), Mokyr (1998, 2004), and Carvalho and Koyama (2016), among others. These papers stress that investment in religious or scientific knowledge depends on relative payoffs that are affected by institutional and economic conditions. We study the impact mechanisms of a sudden tightening of these conditions. Our paper is, to the best of our knowledge, the first to adopt a comprehensive, structural approach to analyzing such impact on both occupation and location choices in a dynamic framework.[14] As such, it complements Cantoni, Dittmar, and Yuchtman (2018), who demonstrate that the shift of bargaining power and wealth from religious to secular authorities induced by the Protestant Reformation resulted in a reallocation of talent toward non-religious occupations, especially administrative ones.

Our findings may also contribute to rationalize the long-run effects of past Inquisitions on current economic development documented by Drelichman, Vidal-Robert, and Voth (2021), who show persistent effects of the Spanish Inquisition on municipality-level development indicators in the 20th century Spain; Cabello (2023), who studies the negative long-term effects on post-18th century economic growth of the reduced number of per-capita scientists in European cities affected by inquisitorial activities between 1550 and 1700; and Xue (2021), who shows that the lower social capital and political engagement of some prefectures in contemporary China can be traced to the Literary Inquisition of 17th and 18th centuries.[15]

The present paper is also connected to recent research on the impact of book censorship during the Counter-Reformation. Becker, Pino, and Vidal-Robert (2021) provide evidence that European states that introduced book indices experienced reduced printing of forbidden

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[13] The far-reaching effects of ideological control of knowledge include cases of non-religious, ideological ostracism towards scientists. In Soviet Russia after World War II (Krylov, 2021), or in China during the "cultural revolution" (Freeman and Huang, 2015), scientists could be blamed for adopting Western-derived ideas that were considered pseudo-science. More generally, Serafinelli and Tabellini (2022) find that the emergence of city institutions that protected economic and political freedom facilitated the attraction and production of creative talents in Europe between the 11th and 19th centuries.

[14] Lecce, Ogliari, and Squicciarini (2021) study occupation and migration decisions of scientists in a reduced-form setting, focusing on religiosity.

[15] Also related, Rubin (2017) argues that the relative decline of science in the Islamic world relative to Europe – particularly to regions *not* subject to the Counter-Reformation – is the main culprit for the reversal of fortunes between the Middle East and Europe.

authors, less knowledge diffusion, and slower city growth. Focusing on Venetian publishers, Comino, Galasso, and Graziano (2021) find similar negative effects of censorship on publishers' market share and their propensity to publish new, contemporary authors. Blasutto and de la Croix (2023) study the effect of censorship on knowledge production of Italian academics between 1400 and 1750. Estimating an endogenous growth model with occupation choice, they conclude that censorship reduced per-scholar publication in Italy by more than 1/3. The common finding in these papers – that the Counter-Reformation negatively affected the stock of knowledge embodied in books – are helpful in appreciating from a different angle the deterrence impact of the RI on those that are most likely to consume these books: scientists themselves, especially given Dittmar's (2019) findings on the importance of the printing press for modern scientists.

The key role of science masters in training the next generation of scientists that we emphasize and detect empirically, is consistent with Moser, Voena, and Waldinger (2014), who show that the migration of Jewish scientists from Nazi Germany to the US had long-lasting positive consequences on innovation in the receiving country, as well as with Moser and San (2020), who quantify the large and persistent decline in inventions induced by the reduced inflow of European scientists following the introduction of immigration quotas in the US during the 1920s. The role of masters in shaping young talented individuals' creativity and skills is also demonstrated in a different context by Borowiecki (2022), a quantitative study of musicians' careers since 1450.

Finally, we contribute to the broad literature on the economic consequences of religion, which dates back to Weber (1905). More recently, Barro and McCleary (2003, 2005) and Guiso, Sapienza, and Zingales (2003) study how religious beliefs affect economic growth. Becker and Woessmann (2009), Chaney (2011), Botticini and Eckstein (2012), Saleh (2016) and Valencia Caicedo (2019) emphasize the impact of religion on human capital – a key mechanism in our model. Chaney (2013) and Belloc, Drago, and Galbiati (2016) study how proximity between secular and religious authorities affects politics and institutional change.

The rest of the paper proceeds as follows. Section 2 provides some historical background; Sections 3 and 4 present, respectively, the model and the data; baseline results are reported in Section 5; Section 6 contains extensions and robustness checks; Section 7 concludes.

2 Historical Background

2.1 Reformation and Counter-Reformation

At the beginning of the 16th century, the Italian peninsula was – like the rest of Europe – in great intellectual ferment. Theology was no exception: Luther's ideas spread to Italy soon after the publication of the "Ninety-five Theses" (October 1517). The first Italian translation of his texts appeared and started circulating in 1518. Even after Luther's excommunication (1521), there were active doctrinal debates in Italy throughout the 1530s. Juan de Valdes, a Spanish scholar, brought to Naples in 1529 the doctrines of Erasmus and Calvinus, which became very influential in the peninsula. By 1540, new ideas and heterodox Christian doctrines had percolated through the Italian society, including the ecclesiastical elite. Even prominent figures in the Catholic hierarchy like reformers Vittore Soranzo, bishop of Bergamo, and cardinals Reginald Pole and Giovanni Morone were open to discussing protestant ideas.

However, Pope Paul III and a number of cardinals led by Gian Pietro Carafa regarded these ideas as a threat. After the failure of the Ratisbon Conference, where Catholic and Protestant leaders gathered in 1541 in search of a theological reconciliation, these conservative leaders prevailed and started the so-called Counter-Reformation within Catholicism. In May 1542, Paul III announced the Council of Trent (1545-1563), which is considered the Catholic Church's doctrinal response to Lutheranism and Calvinism; two months later, in July 1542, he released the Papal bull *Licet ab initio*, which created a centrally organized judicial body whose mission was to deal with the *new heresies*: the Congregation of the Holy Office (*Sant'Uffizio*), better known as the Roman (or Italian) Inquisition (RI)

The development of the RI was fast and pervasive. In the few months following its creation, six inquisitorial proceedings were filed in Bologna. In 1549, when Pope Paul III died, 92 investigations had already been conducted; by the 1580s, Venetian tribunals had processed at least 1,200 denunciations and accusations. In 1567, the execution of Pietro Carnesecchi represented a "key inquisitorial turn" (Black, 2009), as this Florentine nobleman close to Reformation ideas was convicted by the RI and executed despite his influential political connections with Cosimo I de' Medici, Duke of Tuscany. This event was effectively the tombstone of intellectual diversity in states reached by the RI. By then, it was clear that secular rulers were no longer willing to disappoint the Catholic Church by protecting notable individuals who the RI regarded as heretics.

2.2 The Roman Inquisition

Jurisdiction. The RI targeted the entire population of Papal States and polities in the Italian peninsula were the papacy exerted strong political influence. In these other polities, the RI needed the agreement of local sovereign rulers, who typically required some procedural guarantees ranging from simple consultation to power-sharing agreements like in the Republic of Venice. Such agreements were made at different rates and with various levels of resistance, yet the RI spread relatively quickly across the Italian peninsula because the reliance of local rulers on the Catholic Church for legitimization of their political power forced a relatively fast acceptance of inquisitorial activities (Bonora, 2019; Ekelund et al., 2002). Section A-1.3 of the Online Appendix summarizes the formal spread of the RI across Italian states. By the end of the 16th century, almost all of these states, the papal city of Avignon, Malta, and Venetian territories in the Balkans were under RI jurisdiction through a network of local tribunals. Sardinia and Sicily were under Spanish rule and had Spanish Inquisition tribunals since the late 15th century. In the Kingdom of Naples, the *Sant'Uffizio* was constrained to operate through old medieval episcopal tribunals, yet it operated extensively. Figure 2, which is described in greater detail in Section 4, illustrates the RI's jurisdiction.[16]

As mentioned in the Introduction, inquisitorial activities were not a novelty in Europe. Even before the Spanish Inquisition (set up in 1478), a Medieval Inquisition had been in place in Italy since at least the 12th century, to deal with Cathars and Waldesians. However, its practices were disparate and had low intensity. Medieval inquisitors were often chosen by local ministers among clergymen with many other duties. Most of them devoted little time and energy to inquisitorial activities that were targeting religious heretics rather than heterodox intellectual pursuits. The Spanish Inquisition, instead, was tightly linked to the secular powers and served political purposes by targeting Jews and Muslims. We return to this point in Section 4.

Functioning. The RI was built on a strong legalistic base and it trained full-time professional inquisitors dispatched to local tribunals which responded directly to the *Sant'Uffizio*. It was led by a group of six cardinals, one of whom was the future-pope Gian Pietro Carafa, whose diplomatic experience in Spain resulted in a harsh and methodical conception of the

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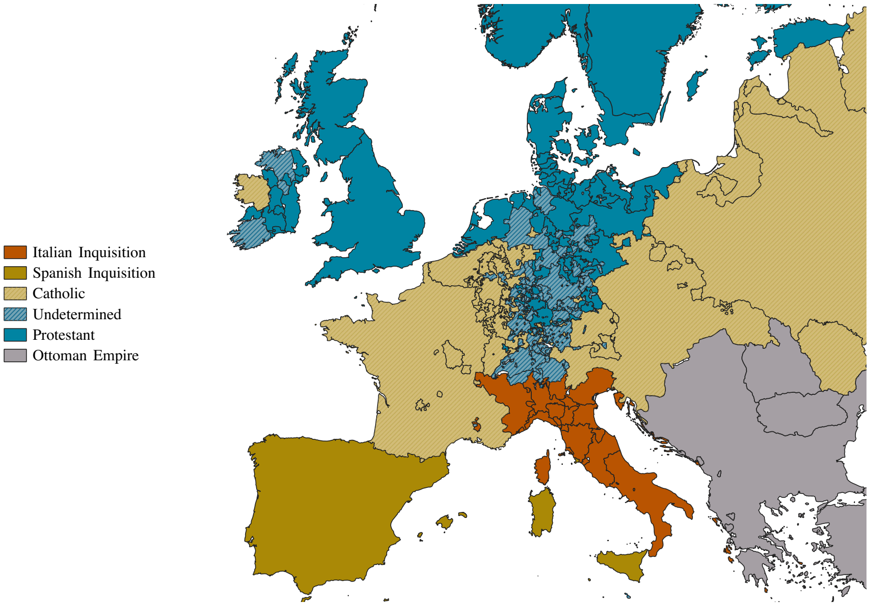
[16] In the states of Este, Modena, and Savoy, the RI only became effective in the 1560s and 1570s (Jenkins Blaisdell, 1975; Lavenia, 2008); these are the cutoff dates used in our empirical analysis for these states.

Figure 2: Religion in Europe at the end of 16$^{\text{th}}$ century



Notes: The figure shows the boundaries of political entities (states, which are the geographic level of our analysis) around 1600 and the imputed religious status. Source: EurAtlas historical maps for polities' boundaries and several historical sources for their religious status. See Section 4 for details.

inquisitorial activity. The RI was based on two key principles. The first, of Thomistic derivation, was that heretical ideas may arise by mistake; thus, the first step of the judicial procedure – like in the case of Galileo – was an attempt to persuade the accused to correct his or her errors. The second principle, derived instead from the Papal bull *Apostolici regiminis* issued in 1513 by Leo X, established the primacy of the sacred scriptures over all scientific and philosophical ideas; thus, philosophy and science could not claim as true in their own domains those ideas that theology regarded as false. The *Apostolici regiminis* constrained academic scholars but it was also used to control thinkers in general and to censor books.

Procedures typically started with reports to the RI itself, e.g., from worried neighbors, priest-confessors, or acolytes seeking redemption. Some procedures originated from information sharing between tribunals and the *Sant'Uffizio*. Such an oppressive environment often triggered self-denunciations, with the intention to "return to the Catholic doctrine", a practice that was warmly encouraged by inquisitors. The tribunals heard heresy suspects and possibly witnesses. Based on these first hearings, the tribunal decided whether to start a summary or a formal trial. The former would be resolved without further due and with light sentences; the latter instead could be lengthy and involve lawyers, witnesses and external experts. Sentences varied, with capital punishment being the exception rather than the norm. Aside from imprisonment, historical records report confiscation of property, forced labor, exile, public abjuration, shaming, and flogging.

As emphasized in the work of Becker, Pino, and Vidal-Robert (2021), Blasutto and de la Croix (2023), and Comino, Galasso, and Graziano (2021), an important tool used by the RI was censorship, a process of close control of book production and diffusion. The Catholic Church issued a formal list of prohibited books (*Index Librorum Prohibitorum*) only in 1559, with the election of Gian Pietro Carafa as Pope Paul IV, but already in 1543 some books were prohibited and relationships with publishers were established to spot editorial production that was in contrast with the catholic orthodoxy (Black, 2009).

2.3 Relation with the Scientific Revolution

The late medieval and early modern periods of European history are characterized by profound shifts in the nature of scientific inquiry, often referred to as the "Scientific Revolution" (Koyré, 1957; Butterfield, 1965; Hall, 1983). Although there is no consensus on when it actually started (Huff, 2017), the paradigms that emerged during the 16th and 17th centuries are regarded by most historians as the first examples of modern science. This period is spanned by key figures in the history of science, such as Copernic (1473–1543), Bacon (1561-1626), Galileo (1564-1642), or Newton (1642-1727).

While initially the Roman Church did not oppose this movement, the establishment of the RI (and the Counter-Reformation more generally) changed such attitude. The process of re-affirmation of the Catholic orthodoxy described above left little space for scientific ideas that questioned key doctrinal elements, and scientists became part of the RI's target.[17] The repression was pervasive and wide in scope, and elite thinkers were not the only ones threatened by the RI.[18] Although some scientists chose to remain in places under the RI's grip

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[17] Examples abound. The famous polymath Giambattista Della Porta (1535-1615) was investigated by the RI because he was suspected of sorcery. Closeness to the high clergy was no sufficient protection. Bernardino Telesio's (1509-1588) critic of the Aristotelian view of nature led him to be heavily censored despite his influential friendships. The same happened to Francesco Patrizi's (1529-1597) neo-Platonic interpretations, in particular the statement that the earth was rotating. (Black, 2009).

[18] Ginzburg (1976) made the case of Domenico Scandella (Menocchio) famous. Menocchio was a miller from north-eastern Italy who propagated the idea that the earth's origins were similar to that of fermenting cheese and that men emerged from it like worms. He was tried by the RI for challenging creationisms and for possessing prohibited books, and was ultimately sentenced to death in 1599.

and found expedients to continue their work,[19] others chose to flee, like for example chemist Guglielmo Grataroli (1516-1568) who moved from Padua to Basel, or the aforementioned Niccolò Buccella (1522-1599), who moved from Padua to Romania and then Krakow. Not engaging in science in the first place was an even safer option to avoid trouble. Despite some scientists managed to secure relatively tolerant treatment for themselves, the RI worked hard to suppress their legacy. For example, the 1633 trial against Galileo set a radical hunt toward his writing and anyone pursuing his research and thinking. This effort greatly hindered the intergenerational transmission of scientific of knowledge. If books could be hidden, hiding was harder for teachers and classrooms. Besides, universities of the time heavily depended on the supply of teachers, and on their ruler's acceptance of curricula.

Finally, the outcome of RI trials and censorship of scientists were most often made public. The goal was not only to dissuade scholars to engage in similar activities, but also to publicize how much these activities were deemed heretical, and thus improper for any good christian. Missionaries were dispatched among the popular classes to preach a culture in line with the Counter-Reformed Catholic Church, and confessors were used as persuaders, building up "social discipline that was made possible by its integration in conscience" (Prosperi, 2009). Together with the more visible deterrence methods, these various practices persisted at least until and during the Enlightenment (Delpiano, 2017).

3 Structural model

In order to study formally the multi-faceted interaction between the RI and scientists presented above, this section develops a structural stochastic dynamic Roy model of career and location choices under inquisitorial threat. In our framework, forward-looking, high-talent individuals choose between scientific and non-scientific careers, as well as between different locations, some controlled by the RI and the others beyond RI reach. The Inquisition imposes two direct costs – anti-scientific social norms at the moment of choosing careers, and persecution for those who choose to be scientists in RI states. The effect of these costs are both contemporary and intergenerational due to human capital spillovers. This model leads to an econometric framework that enables the estimation of parameters via Maximum Likelihood, and can be used to perform counterfactual historical experiments.

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[19] For instance Galileo was ranking his hypotheses as less probable than the existing, prevailing belief.

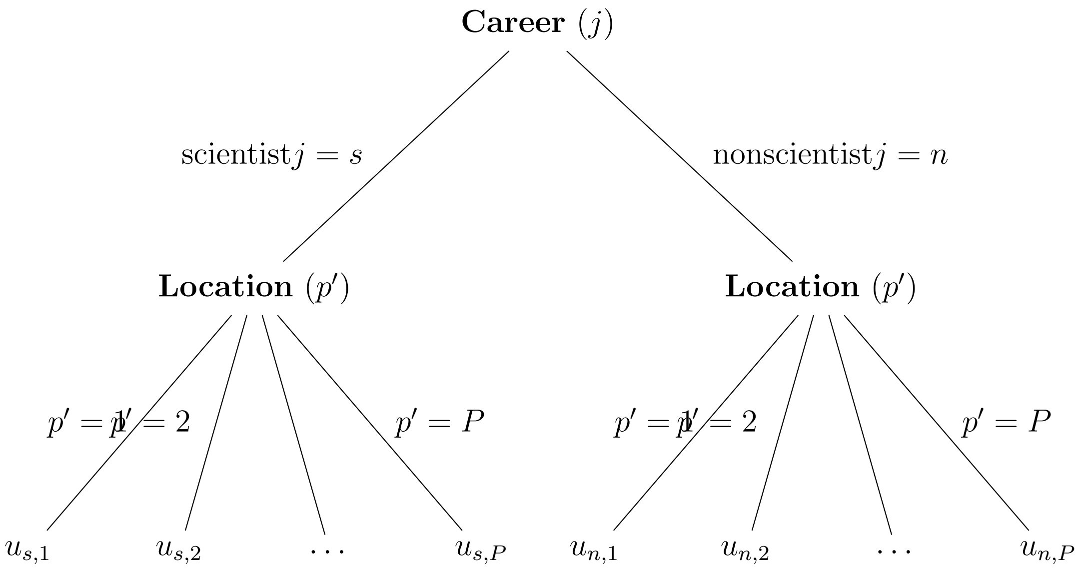
3.1 Baseline model

3.1.1 Setup

Population. Overlapping generations g of high-talent people live for two periods $t = 1, 2$.[20] Each individual was born in an exogenous place $p = 1, \cdots, P$ (a polity) and lives in her/his birthplace during $t = 1$, when a career j is chosen (the *occupation* decision) between scientist ($j = s$) and non-scientist ($j = n$). Migration to a different location p' (the *location* decision) is possible at $t = 2$, at a cost equal to fraction $m_{pp'}$ of earnings at $t = 1$. For "stayers", it is $p' = p$ and $m_{pp'} = 0$.

Objective and timing. Individuals maximize lifetime earnings and there is no discounting.[21] Occupation and location decisions are parts of the two-stage decision problem illustrated in Figure 3. It is a discrete-choice problem and therefore boils down to choosing the maximum value among the utilities $u(j, p')$ given by the terminal nodes of the decision tree, to be specified below.

Figure 3: The decision problem of a notable person



Notes: This figure illustrates the decision problem that a high-talent individual solves given a birthplace p and a generation g. A career j is chosen in the first period of the life cycle, $t = 1$, and migration to location p' is possible in the second period $t = 2$. Choices are represented here in a sequential fashion but they may be simultaneous. In either case the problem is dynamic.

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[20] In the empirical analysis, $t = 1$ to correspond to age 0-20. Thus, $t = 2$ begins with one's 21st birthday.

[21] Assuming that the discount rate is zero may lead, if anything, to underestimating the central mechanism parameters.

Human capital and earnings. An individual in generation g who was born in place p and later chooses place p', earns w_{jpg} at $t = 1$ and $w'_{jp'g}$ at $t = 2$. Earnings are given by the return to an individual's career-specific ability and location-specific total factor productivity (TFP, denoted by A), i.e.,

$$w_{jpg} = A_{pg} \tag{1}$$

$$w'_{jp'g} = A'_{p'g} \exp(\alpha_{jp'}) H'^{\rho}_{jg} \tag{2}$$

where ρ is the skill elasticity of earnings and $\exp(\alpha_{jp'})$ is a job- and place-specific productivity shift. Note that the overlapping generations structure implies $A'_{pg} = A_{pg+1}$.

Individuals in any generation are endowed with a unit of job-specific skills, $H_{jg} = 1$. Human capital grows via on-the-job training during $t = 1$. This training process occurs in one's place of birth, through a technology whose only input are local *masters*, i.e., high-talent individuals from the previous generation who live in that location. In other words, we assume that scientific, technical, artistic, or any other type of advanced knowledge are transmitted across generations locally. The share of older high-talent individuals who embraced a certain career and who live where a young person grows up can be interpreted as the probability of meeting a master with specific skills. The model rules out that a young talented individual migrates to a different place in search of masters during $t = 1$. However, we later extend the model to allow migration decisions to be driven by the share of individuals who specialize in different occupations across alternative locations (i.e., agglomeration effects).

Denoting by ϕ_{spg-1} and ϕ_{npg-1} the endogenously-determined fractions of high-talent individuals who are, respectively, scientists and non-scientists in place p and generation $g - 1$, a generation g individual's ability at $t = 2$ is given by

$$H'_{jg} = (1 + \phi_{jpg-1})^{\theta}, \tag{3}$$

where $\theta > 0$ is a parameter ruling the masters elasticity of skills. If there are no masters locally, i.e., $\phi_{jpg-1} = 0$, then $H'_{jg} = 1$, which is the first-period skill endowment.[22]

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[22] Ideally, the fractions of scientists and non-scientists (ϕ_{spg-1} and ϕ_{npg-1}) should be calculated over the total population of a given place p. Since data on polity population at the generational frequency are not available, we calculate the fractions ϕ_{spg-1} and ϕ_{npg-1} using the total number of masters (high-talent people) in a given place p in generation $g - 1$. This is appropriate as these fractions capture the probabilities that a high-talent individual engages with a scientist or non-scientist from a previous generation conditional on interacting with notable locals.

The Inquisition and preferences. The *Inquisition* is an institution that may punish high-talent individuals who become scientists. We model this punishment as an earnings tax at $t = 2$, such that the expected penalty is $\pi w_{jp'g}$. The Inquisition also establishes anti-scientific cultural norms. An individual born in a place where the Inquisition is active and choosing $j = s$ experiences disutility γ (social stigma) for deviating from such norms.

Preferences over job types j and second-period locations p' are represented by a lifetime utility function $u(j, p')$. This function, which is conditional on one's exogenous birthplace p and cohort g (we do not keep track of this fact in order to simply the notation), is given by

$$u(j,p') = \underbrace{\ln(w_{jpg}(1-m_{pp'}))}_{\text{log net income at } t\text{=1}} + \underbrace{\ln(w'_{jp'g}(1-\pi\mathbb{I}[j=s]I_{p'g}))}_{\text{log net income at } t\text{=2}} - \underbrace{\gamma\mathbb{I}[j=s]I_{pg}}_{\text{social stigma}} + \epsilon_{jp'}, \qquad (4)$$

where $\mathbb{I}[j = s]$ equals 1 if an individual chooses to be a scientist and 0 otherwise, I_{pg} and $I_{p'g}$ denote the presence of the Inquisition in places p and p', respectively, during the lifespan of generation g (equal to 1 if present and 0 otherwise), and $\epsilon_{jp'}$ is an unobserved (to the econometrician), zero-mean preference shock. Approximating $\ln(1 - \pi\mathbb{I}[j = s]I_{p'g}) \approx -\pi\mathbb{I}[j = s]I_{p'g}$, and using (1) and (2), utility can be written as

$$u(j,p') \approx \ln A_{pg}(1-m_{pp'}) + \ln A'_{p'g} + \alpha_{jp'} + \rho\theta\ln(1+\phi_{jpg-1}) - \mathbb{I}[j=s](\pi I_{p'g} - \gamma I_{pg}) + \epsilon_{jp'}. \quad (5)$$

Since individuals maximize $u(j, p')$ with respect to career j and location p', the Inquisition affects scientific scholarship via three mechanisms: a *deterrence effect* (parameter π); a *cultural effect* (parameter γ); and a *training effect* (composite parameter $\rho\theta$) that unfolds over time in response to the reduced number of science masters in Inquisition-controlled places. Note that while the deterrence effect can be avoided by moving to Inquisition-free places, the cultural and training effects are tied to one's birthplace and thus cannot be avoided. This feature enables their separate identification. Therefore, like Buggle, Mayer, Sakally, and Thoenig (2023), we leverage movers to identify competing mechanisms. Also note that the deterrence and masters effects are exerted not only on individuals born in places where the Inquisition is present; they are exerted on *all* high-talent individuals who can potentially migrate to those locations, regardless of their birthplace. This is so because the presence of the Inquisition in a certain place discourages in-migration of scientists to that place and encourages their out-migration from that place, thus affecting dynamically the future stock of masters.

3.1.2 Choice

It is convenient to distinguish explicitly between utility components that vary across careers j only, across locations p' only, or across career-location combinations. To this end, we can rewrite equation (5) as

$$u(j,p') = \upsilon + \upsilon_j + \upsilon_{p'} + \upsilon_{jp'} + \xi_j + \xi_{p'} + \xi_{jp'}, \tag{6}$$

where

$$\begin{aligned} \upsilon &= \ln A_{pg} & (7)\\ \upsilon_j &= \rho\theta \ln(1+\phi_{jpg-1}) - \gamma\mathbb{I}[j=s]I_{pg} & (8)\\ \upsilon_{p'} &= \ln A'_{p'g} + \ln(1-m_{pp'}) & (9)\\ \upsilon_{jp'} &= \alpha_{jp'} - \pi\mathbb{I}[j=s]I_{p'g} & (10)\\ \xi_j + \xi_{p'} + \xi_{jp'} &= \epsilon_{jp'}. & (11) \end{aligned}$$

A high-talent individual solves a dynamic problem,

$$\max_{j,p'} \; u(j,p'), \tag{12}$$

and the timeline of choices is the following. At $t = 1$, the individual chooses whether to become a scientist or a non-scientist, i.e., job type j, by solving

$$\max_{j} \; \upsilon_j + \xi_j + V_j. \tag{13}$$

Here V_j is the value function of the location problem that is solved at $t = 2$. At that point, conditional on a job type j, the individual chooses a location p', by solving

$$\max_{p'} \; \upsilon_{p'} + \upsilon_{jp'} + \xi_{p'} + \xi_{jp'}. \tag{14}$$

The value function V_j that appears in problem (13) is the optimized value of the objective function in problem (14) and indicates that individuals are forward-looking, i.e., they choose a career taking into account that they will choose their location optimally when they are allowed to move. This feature makes the problem dynamic. Note that value function V_j brings to the career-level choice all the relevant information from the location-level choice, a link that is embedded in the deterrence effect. When $\pi > 0$, places under the Inquisition's influence reduce the payoff at $t = 2$ of a scientific career relative to a non-scientific one.

If individuals could freely move to any location at no cost, then the Inquisition could not deter scientific careers via the threat of punishment, which could simply be avoided via costless relocation to places that are beyond its reach. However, in the presence of mobility costs an individual anticipates that avoiding such threat in the future would be costly. The anticipation of this cost discourages those born in Inquisition places to embrace a scientific career in the first place, on top of the cultural effect.

3.2 Econometrics

3.2.1 Specification

This theoretical structure leads to an econometric framework via parametric assumptions on unobserved utility components that are standard in a random utility models with discrete choice. Specifically, we assume that vector $\boldsymbol{\epsilon} = \{\epsilon_{jp'}\}$ has a generalized extreme value (GEV) distribution,

$$F(\boldsymbol{\epsilon}) = \exp\left(-\sum_j \left(\sum_{p'} \exp(-\epsilon_{jp'}/\beta_j)\right)^{\beta_j}\right), \tag{15}$$

which allows us to fit the incidence of careers across locations and over time as the probability of choosing any of the terminal nodes in the decision tree illustrated in Figure 3 given one's birthplace and generation, $\mathbb{P}_{pg}(j, p')$. For any two places k and ℓ, the scale parameter β_j is such that $\beta_j^2 = 1 - \text{corr}(\epsilon_{jk}, \epsilon_{j\ell})$. If, conditional on a career choice j, unobserved preference shocks are uncorrelated across potential destination locations, then $\beta_j = 1$ and the model collapses to the multinomial logit model of choice among alternatives in the $\{(j, p')\}$ set. Otherwise, the model results into the *nested logit* model of McFadden (1978).

This terminology reflects that, as represented in Figure 3, a career choice leads to a "nest" of possible location choices whose utility is nest-specific. A non-zero correlation between ϵ_{jk} and $\epsilon_{j\ell}$, i.e., $\beta_j \neq 1$, means that utilities are correlated within nests, i.e., $\text{corr}(u_{jk}, u_{j\ell}) \neq 0$ for a given career choice j. For example, unobserved preferences for being a physicist in Tuscany are allowed to be correlated with unobserved preferences for being a physicist in Cologne. Such unobservable component may be the kind of pure scientific talent that someone like Galileo had. However, our parametric assumption implies that unobservables, and therefore utilities, are uncorrelated across career choices, i.e., $\text{corr}(\epsilon_{sk}, \epsilon_{n\ell}) = 0$ for any two places k

and ℓ, like in the multinominal logit model. For example, unobserved preferences for being a physicist in Tuscany are uncorrelated with unobserved preferences for being a painter in that place or any other place. In other words, there are no relevant location-specific unobservables after migration costs, occupation-by-place fixed effects, and the presence of the Inquisition have been taken into account, i.e., $\xi_{p'} = 0$. This is the identifying assumption in the nested logit model. We believe that it is reasonable in the historical context under investigation. It implies that, for example, Galileo grew up and died in Tuscany because, after taking into account the presence of the Inquisition, it was too costly to permanently move elsewhere given the benefit of living in Tuscany captured by the occupation-by-place fixed effect $\alpha_{jp'}$ and the idiosyncratic benefit of being a scientist in that place captured by $\xi_{jp'}$.

As demonstrated by Ben-Akiva and Lerman (1979), when $\xi_{p'} = 0$, so that $\epsilon_{jp'} = \xi_j + \xi_{jp'}$, the parametric assumption in (15) is equivalent to assuming that: (i) the terms $\xi_{jp'}$ are i.i.d. GEV with scale parameter b_j; and (ii) the terms ξ_j are such that $\max_{p'} u(j, p')$ is GEV with scale parameter $b_{p'}$.[23] This allows us to derive choice probabilities in conditional logit form, which provides a more intuitive representation given that it is natural to interpret occupation and location choices as sequential in our life cycle setting. That is, choice probabilities can be conveniently represented as the product of marginal and conditional logit probabilities (Ben-Akiva and Lerman, 1979; Anderson et al., 1992; Train, 2009):

$$\mathbb{P}_{pg}(j, p') = \mathbb{P}_{pg}(j) \times \mathbb{P}_{pg}(p'|j). \tag{16}$$

Thus, proceeding backward along the decision tree in Figure 3, the conditional probability that a high-talent individual in generation g who was born in place p and who has chosen career j lives in location ℓ at $t = 2$ (the "lower model") is given by:[24]

$$\begin{aligned} \mathbb{P}_{pg}(p' = \ell \mid j) &= \mathbb{P}_{pg}(u_{j\ell} \geq \max_k u_{jk} \mid j) \\ &= \frac{\exp(\beta_j^{-1}(\alpha_{jp'} + \ln A'_{\ell g} + \ln(1 - m_{p\ell}) - \pi \mathbb{I}[j = s] I_{\ell g}))}{\sum_{k=1}^{P} \exp(\beta_j^{-1}(\alpha_{jk} + \ln A'_{kg} + \ln(1 - m_{pk}) - \pi \mathbb{I}[j = s] I_{kg}))}. \end{aligned} \tag{17}$$

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[23] The ratio of these scale parameters is equal to the corresponding parameter for $\epsilon_{jp'}$, i.e., $b_j / b_{p'} = \beta_j$. Since only this ratio can be identified, we impose the normalization $b_{p'} = 1$. Ben-Akiva and Lerman (1979) show that random utility maximization requires $\beta_j \leq 1$, which is a testable hypothesis.

[24] The multinomial logit form follows from the fact that $\xi_{jk} - \xi_{j\ell}$, which is a difference between two independent GEV random variables, is logistically distributed.

The marginal probability that this individual, who will optimally choose to live in place p' at $t = 2$, chooses at $t = 1$ to be a scientist (the "upper model") is instead given by

$$\begin{aligned}\mathbb{P}_{pg}(j = s) &= \mathbb{P}_{pg}(u_{sp'} \geq u_{np'}) \\ &= \Lambda\left(\rho\theta \ln \frac{1 + \phi_{spg-1}}{1 + \phi_{npg-1}} - \gamma I_{pg} + V_s - V_n\right), \end{aligned} \tag{18}$$

where $\Lambda(X) = \frac{1}{1+\exp(-X)}$ is the logistic function, and where, for $j = s, n$, value functions

$$V_j = \beta_j \ln \sum_{k=1}^{P} \exp(\beta_j^{-1}(\alpha_{jk} + \ln A'_{kg} + \ln(1 - m_{pk}) - \pi \mathbb{I}[j = s] I_{kg})) \tag{19}$$

are, in nested logit jargon, the "inclusive utility" terms representing the expected utility of choosing among alternative locations, for a given occupation.

3.2.2 Identification and estimation

The model parameters are identified and can be estimated via Full-Information Maximum Likelihood. The occupation-by-place fixed effect $\alpha_{jp'}$ is identified relative to a base (j, p) combination. Given a sample of $i = 1, \cdots N$ high-talent individuals described in the next section, the estimator maximizes the following log-likelihood function,

$$\begin{aligned}\ln L &= \sum_{i=1}^{N} \mathbb{I}[i \text{ is a scientist}] \mathbb{P}_{ipg}(j = s) \\ &\quad + \sum_{i=1}^{N} \sum_{\ell=1}^{P} \mathbb{I}[i \text{ is a scientist and works in location} \ell] \mathbb{P}_{ipg}(p' = \ell \mid j = s), \end{aligned} \tag{20}$$

where $\mathbb{P}_{ipg}(j = s)$ and $\mathbb{P}_{ipg}(p' = \ell \mid j = s)$ are the individual versions of (18) and (17), respectively, after indexing appropriately all quantities that vary across individuals. We use an individual's place of death to determine second-period location, as this information captures individuals' most mature migration decision (besides being more systematically available than individuals' intermediate places of activity – see Section 4).

To clarify the meaning of identification in this context, recall that identification simply means that model parameters are "uniquely determined from the observable population that generates the data" (Lewbel, 2019, p. 835). The population analog of (20) is globally concave and so there is only one maximum and the model parameters are uniquely determined. The claim that mechanism parameters π (deterrence), γ (culture), and $\rho\theta$ (training), capture the causal effect of the RI on scientific scholarship in Europe relies on the model being correctly specified. Although no model truly is, we believe that the forces that we have built into our framework are the fundamental ones at play (additional forces are added in Section 6 to substantiate this claim) and therefore our structural analysis provides a reasonable and disciplined way to inferring the effects of the RI in a context in which reduced-form approaches are less credible.

We take three final steps toward estimation. First, we express unobserved TFP as $\ln A'_{pg} = \alpha \ln W_{pg}$, where W_{pg} is the average aggregate wages in place p during the second period of a generation's lifespan, a measurable historical variable (see Section 4), and where α is an additional parameter to be estimated.

Second, we assume a linear mobility costs $m_{pp'} = \mu d_{pp'}$, for $d_{pp'}$ the geodesic distance between the centroids of polities p and p' and where μ is also a parameter to be estimated. It is convenient to approximate $\ln(1 - \mu d_{pp'}) \approx -\mu d_{pp'}$.

Third, we take into account that the RI is established *during* the lifespan of individuals part of the "transition generation". Consider individuals born before 1522 and still alive in 1542. They are older than 20 years of age when the RI is established in 1542. Observed through the lens of our model (where $t = 1$ to correspond to age 0-20), these individuals already made their occupational and location choices at the time the RI is established, thus under the expectation that there is no RI. They are "caught by surprise", so to speak: these individuals can still revise their location plan, but, if they have already embraced a scientific career, they cannot revert this choice (e.g., they may have already circulated ideas that make them notable as scientists). Therefore, they may exhibit different responsiveness to the RI relative to younger (and future) individuals, whose entire career decision were made in a world with the RI. In order to allow for this timing (which also provides some check on the model's behavioral assumptions), we modify utility component $\upsilon_{jp'}$ in equation (10):

$$\upsilon_{jp'} = \alpha_{jp'} - \pi \mathbb{I}[j = s] I_{p'g} + \widetilde{\pi} \mathbb{I}[j = s] \widetilde{I}_{p'g} \tag{21}$$

where $\widetilde{I}_{p'g}$ is equal to 1 if the RI is established in place p' when an individual in generation g is alive but *older* than 20 (i.e., born before 1522), and equal to 0 otherwise. The third term on the RHS of equation (21) introduces a triple interaction (being a scientist in a location where the RI is not initially present but is present later on) in the utility of a location given one's occupation decision. The sign of the additional parameter $\widetilde{\pi}$ is unrestricted.

4 Data and descriptive evidence

We collected data on individual scientists and non-scientists, as well as their states and labor markets, over the 15th, 16th and 17th centuries. This section describes our sources, the definition of variables that we build from them, and sampling and selection issues. It then provides *prima facie*, descriptive evidence of the RI's impact on scientific scholarship in a "reduced-form" setting, which can be meaningfully compared with our structural estimates.

4.1 Sources, sample selection, and definitions

4.1.1 A dataset of notable people and their societies

IBN. The individual-level information employed in our analysis comes from the *Index Bio-Bibliographicus Notorum Hominum* (IBN), an ongoing project started in 1978 that aims at gathering all biographies ever written.[25] As described by de la Croix and Licandro (2015), this collection represents individuals who "belonged to the upper classes of human societies, including the richest, most powerful and influential individuals, with the highest human capital." (p. 265). As of 2023, the IBN has 205 volumes published, containing data from more than 6,000 biographical sources (from virtually all historical periods) on individuals with family names starting with the letters A to P. Each entry contains dates and places of birth and death, and a short biographical text, for example:

> *dalmare, cesare; 1558-1636; tottenham - london; british jurist, judge of the admiralty, master of the chancery, master of requests*
>
> *ferrari, lodovico; 1522-1565 (1560); bologna - bologna; matematico, professore e scrittore*
>
> *goclenius, rudolf (rudolph); 1572-1621; wittenberg - marburg; deutscher mediziner, physiker und mathematiker, professor in marburg, autor*

We collect records of all individuals whose date of birth information indicates a birth between 1454 (the completion of the first copies of Gutenberg bible, which marks the beginning of the age of printed books) and 1618 (the beginning of the Thirty Years' War, a major shock

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[25] Compared to other existing databases of famous biographies, such as Laouenan et al. (2022), IBN is hard copy/expert-based instead of online/crowd-sourced. This is arguably better for our purposes, because what matters in our application is *historical* notability rather than *current* notability from online sources.

that reshaped religious boundaries, mobility barriers and careers returns in Europe).[26] This selection provides us with a sample of 107,052 individuals; 87,650 of them lack information on either place of birth or death, and hence are dropped (steps 1 and 2 in Table 1).

Table 1: Sampling steps

Step	Category	Sample		Individuals
		All 1454-1618 births		107,052
1	*Geography*	−Missing place of birth	-70,443	
2	*Geography*	−Missing place of death	-17,207	
3	*Geography*	−Not geolocalized	-4,217	
4	*Religion*	−Spanish rule	-1,934	
5	*Religion*	−Ottoman Empire and RoW	-604	
6	*Occupation*	−Missing occupation	-371	
7	*Occupation*	−Army/Nobility	-473	
8	*Estimation*	−Non-chosen locations	-37	
9	*Estimation*	−Inaccurate date of birth	-216	
			Final Count	11,550

Notes: This table lists the sampling steps from the universe of 107,052 notable individuals in the *Index Bio-Bibliographicus Notorum Hominum* (IBN) whose date of birth information indicates a birth between 1454 and 1618, to our baseline final sample of 11,550 individuals usable for estimation purposes.

Political entities. We geocoded notable people's places of birth and death, and we mapped them into historical states (or "polities") using EurAtlas historical maps. These are states ruling over a clearly defined territory and population. Although their political power may derive from other states, they are considered as distinct entities provided that they maintain a clear degree of political autonomy and homogeneity.[27] For each birth and death location, we extracted polity in 1500 and 1600; when the two differed, we investigated and encoded changes between the two dates. Figure A-1 in the Online Appendix maps the resulting entities and notable people's birthplaces. These states are then assigned a religious status, as explained in more detail below. In addition, the birth and death places' coordinates allow us to capture several geographical features of places (such as access to the sea and elevation) that will serve as control variables in our reduced-form analysis.

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[26] See Section A-1 of the Online Appendix for more details on data collection and processing.

[27] E.g., the Duchy of Milan, which during the 16th century was under French, then Spanish Habsburg rule, but kept direct oversee of its local administration and, contrary to its rulers, hosted the RI.

Inquisitorial and religious status. As summarized in Section 2, the RI was developed via the establishment of local tribunals. We use the presence of these tribunals, an objective element that we collect from Black (2009), for the key distinction of our analysis – whether or not a state was subject to the RI. A detailed list of RI political entities is reported in Section A-1.3 of the Online Appendix. In addition, non-RI polities in our data set are imputed a religious status by cross-checking detailed encyclopedic maps and historical accounts. Of course religious predominance does not follow political boundaries, so our classification is based on simplifying assumptions. In particular, we considered the main and most stable position of each entity's governing body. The result is illustrated in Figure 2 above.

The binary RI vs non-RI status is certainly a coarse indicator to infer the RI's impact on a specific state, and thus misses subtle aspects such as the fact that repression intensity varies across and within RI states, or that non-RI but catholic states (like France or Austria) might have pursued similar repressive objectives through civil tribunals. Although the focus of our research is on the impact of a specific repressive institution that is appropriately captured by the RI vs non-RI dichotomy, in Section 6, we extend our structural estimation to include an intensive margin of inquisitorial activity (as captured by the within-Italy variation in the number of RI tribunals) on top of the RI vs non-RI extensive margin, and we show that our results are robust to dropping non-catholic states from the sample (so as to retain only the within-catholic Europe variation in inquisitorial activity).

Spanish Inquisition and non-European states. As already mentioned, states under Spanish rule were already subject to the Spanish Inquisition (SI) at the time the RI was established. The SI was a centralized structure – effectively a State Department controlled by the Crown (Black, 2009) – set up in 1478 with the primary objective of repressing Jews and Muslims. In our baseline analysis, we drop the 1,934 individuals born or dead in territories under SI jurisdiction (step 4 in Table 1), because they are "treated" by a different inquisitorial institution both before and after the RI establishment, thus impacting the interpretability of our estimates. However, in consideration of important similarities between the Spanish and the Roman inquisitions during the Counter-Reformation,[28] in Section 6 we extend our structural analysis to a larger sample that includes Spanish Inquisition territories.

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[28] The Spanish Inquisition held over 67,000 trials until 1820 (Drelichman et al., 2021), against between 51,00-75,000 Inquisition trials held in Italy from 1542 onward (Del Col, 2006). The Index of prohibited books was established in Spain in 1551 and in Italy in 1556 (Becker et al., 2021).

Notice that our structural model naturally handles the staggered introduction of centralized inquisitorial institutions in Spain and Italy. We also drop 227 individuals born or dead in the Ottoman Empire (which spanned at some point large portions of Eastern Europe, but is hardly comparable to christian polities) and (for the same reason) 377 individuals who were born or migrated outside Europe, a total of 604 individuals (step 5 in Table 1).

Occupations. We determine an individual's occupations from the IBN biographical text. Table 2 shows the ten most common occupations in our data. Following de la Croix and Licandro (2015), we group them into broader categories also shown in Table 2. An individual may be associated with multiple occupations, and hence multiple occupation categories. Online Appendix Figure A-4 shows the distribution of such categories among all individuals in our data. About 55% have more than one. We define as a "scientist" someone whose occupations includes *at least one* of the following: *agronomist, architect, astronomer, botanist, cartographer, chemist, doctor, engineer, geographer, geologist, inventor, mathematician, naturalist, pharmacist, physician, physicist, surgeon, zoologist*; i.e., occupations that make use of scientific knowledge. We show in Section 6 that our results are robust to adopting a narrow definition of scientists, namely excluding occupations whose nature is more technical than scientific, i.e., *architect, cartographer, engineer, geographer, inventor*. Online Appendix Figure A-6 shows that although the average number of occupation categories is higher for scientists than for non-scientists (2.28 vs 1.64), it does not significantly vary with the presence and timing of the RI. We drop 371 individuals have no categorized occupation and 473 individuals whose only occupation is "nobility" (which one cannot choose) or "army" (which is too heavily affected by military events). These drops are steps 6 and 7 in Table 1.

Wages. To calibrate model variable W_{pg} (aggregate wages in each states during the second period of a generation's lifespan), we use historical data on real wages across 14 European cities between 1300 and 1800 from Fochesato (2018). After constructing a mapping between these cities and polities based on a plausible definition of regional labor markets, we set W_{pg} as the average imputed wage in place p over the fifty years after each individual of generation g turns 20 (i.e., $t = 2$ in our model). These wages are reported in Online Appendix Figure A-3, which shows that during the period that we study real wages were declining across cohorts, with convergence between RI states and other states.

Table 2: Notable individuals' occupations

Top 10 occupations

Occupation	Count	Frequency
author/writer	4269	0.365
professor	1542	0.132
teacher	1499	0.128
priest/pastor	1218	0.104
theologian	1172	0.100
doctor/physician	1147	0.0981
poet	1072	0.0917
painter	1071	0.0916
clergyman	1007	0.0861
lawyer	730	0.0625

Categories

Category	Count	Frequency
army	365	0.0312
art et metiers	3412	0.292
business	610	0.0522
education	5210	0.446
humanities	1206	0.103
law and government	2397	0.205
nobility	547	0.0468
religion	5007	0.428
science	1390	0.119

Notes: These tables count the occurrences of profession/profession-categories among notable individuals. Multiple occupations are possible. Sample: 11,550 notable individuals described in Table 1.

Final baseline sample. Estimation requires each destination polity p' to have at least one migration occurrence, so we drop 7 small states not chosen by any scientist (28 observations) and one small state not chosen by any non-scientist (2 observations). Baseline estimation also drops 206 individuals whose birth year was imprecise (e.g., "before 1420"). These are the two final steps in Table 1 that lead to the final sample of 11,550 individuals for our baseline estimation. Estimation of model's extension or robustness checks carried out in Section 6 may use larger or smaller samples as noted in that section.

4.1.2 Selection issues

IBN is *not* a random sample of high-talent individuals: it is affected by selection and composition issues that de la Croix and Licandro (2015) discuss at length. Two of them are relevant in our study. The first one is a *notoriety bias*: only individuals who develop a sufficiently high public profile are included in IBN. An Italian scientist may respond to the RI's threat by keeping a low profile, and thus never become a *notable* scientist (as opposed to a counterfactual scenario without the RI). However, the consequence is an *attenuation* in measured changes in the fraction of notable individuals who become scientists, because our estimates are gross of the effect of these potential scientists dropping altogether from the pool of notable people. To see this point more clearly, note that the upper model of our nested logit framework (equation 17) fits the share of scientists among notable people, i.e. $\frac{S}{S+N}$, where S is the number of scientists and N are notable individuals in other fields. If potential scientists in locations affected by the RI respond by not becoming notable (i.e., a drop in S without a corresponding increase in N), then this ratio declines by less than it would if such potential scientists became famous in non-scientific fields.[29] So, notoriety bias leads, if anything, to underestimating the impact of the RI on scientific scholarship in Italy.

The second relevant issue is an *occupation bias*: the activities that make people famous change over time as the relative importance of occupations evolves. As discussed in the Introduction, Cantoni, Dittmar, and Yuchtman (2018) argue that the Reformation increased the importance of secular occupations relative to religious ones in Protestant Europe. Similarly, the Counter-Reformation may have increased the importance of theological skills and theological output in Catholic Europe. If the establishment of the RI affected the likelihood of being recorded in IBN for some theologians who otherwise would have not entered the pool of notable non-scientists, then this occupation bias would impact our estimates. There would be no bias, instead, if low-talent individuals cannot become notable by simply sorting into occupations (like theology) that are in higher demand after the establishment of the RI. We show in Section 6 that this bias is small, if any, by running our estimation after dropping theologians from the sample. In other words, our results are not the effect of a relative decline in the demand for theologians in countries not treated by the Counter-Reformation.

4.2 Descriptive evidence

Figure 4 displays the share of notable people who become scientists in each cohort (defined by birth decade). The RI was established in 1542; all individuals born after 1522 (vertical line in the figure) experience it while they are in the process of choosing a career (which in the model is assumed to end at age 20) and, later on, of choosing a location. As shown in the figure, before this cutoff birth year the incidence of scientists was growing roughly at the same rate in both RI and non-RI states, but it was actually higher in the former (17.8% vs 13.7%). After the establishment of the RI, the gap is reverted (10.7% vs 11.2%).[30]

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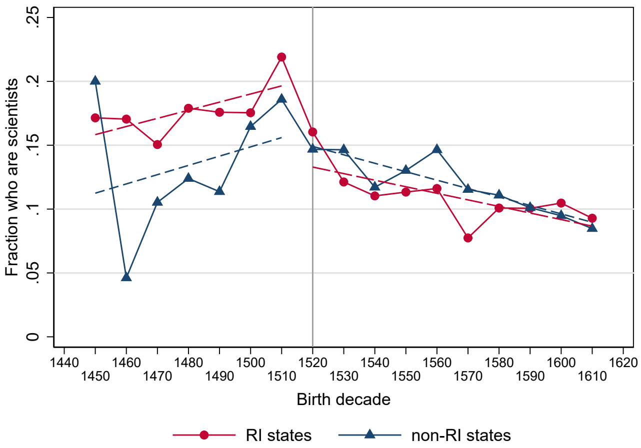
[29] Suppose that there are 100 high-talent individuals in Italy before the establishment of the RI and that they all become notable: 50 as scientists, and 50 as non-scientists, so $\frac{S}{S+N} = \frac{50}{100} = 0.5$. After the RI is established, there are still 100 high-talent individuals. Suppose that 50 still choose science, but 10 of them are deterred. If these 10 decide to express their talent in other fields and become notable as non-scientists, then $\frac{S}{S+N} = \frac{40}{100} = 0.4$, and the treatment effect is -10 p.p. If instead, they keep a low profile and do not become notable, then $\frac{S}{S+N} = \frac{40}{90} = 0.44$ and while the treatment effect is still -10 p.p. if the reference population is kept constant, the estimated effect is only -6 p.p. because the size of the reference population drops despite the incidence of high-talent individuals in the overall population is unchanged.

[30] Online Appendix Figures A-7 and A-8 show that the break in trend is driven by scientific occupations.

Figure 4: Incidence of scientists among notable people



Notes: The figure shows the fraction of scientists among notable people born in RI and non-RI polities (states), by birth decade. Sample: 11,550 notable individuals described in Table 1.

Notable people also exhibit high and differential degrees of geographic mobility, as measured by comparing places of birth and death. Among pre-1520s cohorts, about 55% of all individuals died in a state different from the state of birth. This fraction is lower but still substantial (about 42%) for later cohorts. Moreover, about 71% of movers born before 1520 move toward non-RI states, and this share *increases* to about 83% for later cohorts. As shown in Online Appendix Figure A-5, such increase is larger for scientists (from 70% to 86%) than for non-scientists (from 71% to 82%).

Preliminary Diff-in-Diff estimate. We first estimate the impact of the RI on scientific scholarship in Italy by Diff-in-Diff (DiD). As explained in the Introduction, the DiD assumptions are necessarily violated in the historical context under investigation, and so the reduced-form parameter that we estimate cannot be interpreted as causal. Yet, it provides us with *prima facie* descriptive evidence that can be meaningfully compared with our structural estimates. For these purposes, we employ the following linear probability model,

$$s_{icpg} = \alpha + \beta_1 \text{RI}_p + \beta_2 \text{Post-RI}_g + \beta_3 \text{RI}_p \times \text{Post-RI}_g + \gamma \mathbf{X}_c + \mu_g + \nu_p + \epsilon_{icpg}, \tag{22}$$

where s_{icpg} is a variable equal to 1 if notable individual i, born in city c located in polity p, during decade g is a scientist, and 0 otherwise. In line with the timing featured in the theoretical model, RI_p and Post-RI_p are indicator variables equal to 1 if i is born, respectively, in a RI state and after 1522. Vector $\mathbf{X}_c$ contains city-level controls (elevation, river, sea, presence of a university, and a proxy for city-size), and μ_g and ν_p are decade and polity fixed effects, respectively. Standard errors are clustered at the place of birth level. The coefficient of interest is β_3, which measures the differential impact of the establishment of the RI on the probability of becoming a scientist for a notable individual born in a RI state with respect to another individual born in a non-RI state.

Results are reported in Table 3. The all-inclusive specification in column [4] indicates that the RI is associated with a 4.7 percentage points (p.p) decrease, on average, in the share of individuals born in a RI state who chose to become scientists (relative to those born in other states). This is a decrease of about 26% relative to the pre-RI average incidence of scientists among notable people of 17.8% in RI states. Appendix Tables A-1 and A-2 show that these results hold when comparing scientists to sub-groups of occupations, and when comparing RI states to sub-groups of non-RI states with a specific religion. However, as remarked above, this is presumably a biased estimate of the average treatment effect on the treated (ATT), because it does not take into account out-migration of scientists and the ensuing indirect effect on individuals not exposed to the RI. The structural results presented next allow us to correct this bias and to estimate the average treatment effect (ATE) of the RI both on states directly affected by the RI as well as on states beyond the RI reach.

Table 3: Reduced-form estimate of the effect of the RI on scientific scholarship in Italy

	Dep. Var. Mean= 0.12; SD= 0.32			
	[1]	[2]	[3]	[4]
Post-RI	−0.024	−0.025		
	(0.010)	(0.010)		
RI State	0.048	0.038	0.041	
	(0.022)	(0.022)	(0.022)	
Post-RI×RI State	-0.042	-0.039	-0.048	-0.047
	(0.023)	(0.023)	(0.023)	(0.024)
City-level controls		✓	✓	✓
Decade FE			✓	✓
Polity FE				✓
Observations	11,550	11,550	11,550	11,550

Notes: The dependent variable is an indicator variable equal to one if a notable individual is a scientist. Columns [2]-[4] include city of birth controls (city size, elevation, proximity of rivers and access to the sea). Columns [3]-[4] add birth decade fixed effects, and Column [4] adds polity fixed effects. The models are estimated via OLS. Standard errors are indicated in parentheses and are clustered at the place of birth (city) level. Sample: 11,550 notable individuals described in Table 1.

5 Structural analysis

5.1 Parameter estimates and model fit

Baseline estimates are reported in Table 4, for three groups of parameters: those affecting occupation choice (Panel 1), those affecting location choice but also, indirectly, occupation choice (Panel 2), and the scale parameters of the distribution of unobservables in equation (15), i.e., the nested logit "dissimilarity parameters" (Panel 3). For each parameter we report point estimate, standard error, and, in order to facilitate the interpretation, a measure of marginal (for continuous variables) or differential (for discrete variables) effects.

In Panel 1, the training effect (parameter $\rho\theta$) is statistically and economically significant: the marginal effect indicates that increasing the share of science masters from 0 (i.e., having strictly no access to a science master in one's state during the training stage of the life cycle) to 1 (i.e., meeting a science master for sure, conditional on interacting with notable people), increases the probability of becoming a scientist by 13 p.p., a large effect relative to the average baseline incidence of 12%. This confirms the key role of masters in training young scholars, in particular scientists. The cultural effect (parameter γ), instead, is insignificant and with a marginal effect close to zero, meaning that the probability of becoming a scientist is not affected by a set of social norms built up around the introduction of the RI in an individual's place of birth. This is a rather surprising result given the many accounts of the large cultural impact of the Counter-Reformation. A possible interpretation is that cultural norms are sticky and cultural change (which entails a process of intergenerational transmission) is slow, so a cultural effect on occupation choices of notable people may materialize after a longer period of society's exposure to inquisitorial activities than the seven decades that we consider for Italian states (1542–1618). This conjecture is confirmed by one of the extensions presented in Section 6, where we augment the baseline sample with individuals born in states under the jurisdiction of the Spanish Inquisition (which predated the RI by about six decades), thus increasing the length of exposure to inquisitorial activities that may eventually trigger a cultural change that, in turn, affects career choices.

The first two estimates of Panel 2 confirm a large literature documenting the negative impact of distance (parameter μ) and the positive impact of TFP (parameter α) on the attractiveness of places (e.g., Beine et al., 2016). In our context, an additional 100km distance between one's birthplace and a potential alternative location, decreases by 15.3 p.p.

Table 4: Structural estimates

Parameter	Effect	Estimate	(s.e.)	“Marginal” effect
1. Occupational choice: scientist				
$\rho\theta$	training	0.686	(0.219)	0.130
γ	cultural	0.073	(0.116)	0.008
2. Location choice				
μ	distance	-0.418	(0.142)	-0.153
α	log wages	0.193	(0.073)	0.071
π	deterrence	-0.425	(0.162)	-0.110
$\pi + \tilde{\pi}$	deterrence, transition generation	0.250	(0.144)	0.082
3. Dissimilarity				
β_s		0.342	(0.115)	
β_n		0.314	(0.106)	
Observations		11,550		

Notes: The table reports structural parameter estimates obtained by Full-Information Maximum Likelihood on equation (20). Standard errors in parentheses. The “marginal” effects are marginal for continuous variables and differential for binary variables. To facilitate the interpretation, for the training channel the marginal effect refers to increasing the share of science masters from 0 (no chance of meeting a science master) to 1. Sample: 11,550 notable individuals described in Table 1.

the probability of moving to that location; while notable individuals are 7.1 p.p. more likely to move to a certain state if wages in that state increase by 1%, *certeris paribus*.

As for the third mechanism that mediates the RI’s effect, deterrence (parameter π), the presence of the RI in a given location reduces by 11 p.p. the probability that a scientist chooses to live in that location. Thus, after the RI establishment, scientists become more likely to move out of RI states and to relocate (or remain, if born there) into non-RI states. Note that this deterrence effect has an impact on occupation choices too. By increasing the likelihood that a scientist bears a moving cost to avoid punishment, the RI discourages scientific careers in the first place for forward-looking, notable individuals born in RI states.[31] However, deterrence is statistically insignificant for transition generations (parameter $\pi + \widetilde{\pi}$), i.e., for those scientists who have already chosen their career when the RI is established in their birthplace. This finding may be explained by the fact that it takes time to set up tribunals and by the initial uncertainty about the RI’s actual severity.

Finally, estimates of both scale parameters are below 1 as required by random utility maximization. The null that they are equal to or greater than 1 is comfortably rejected.

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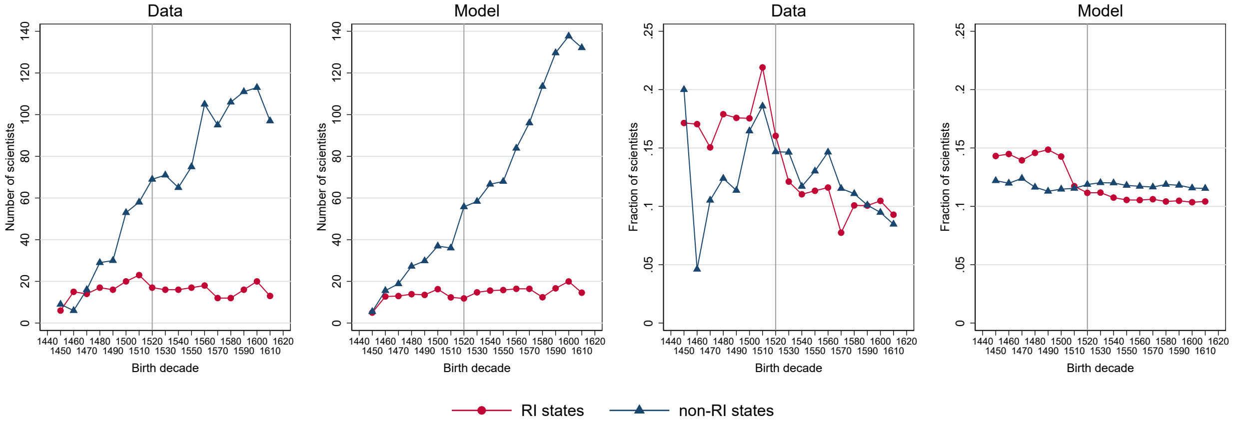
[31] Formally, this connection is captured by the value function in equation (19).

The model's fit is illustrated in Figure 5 for the absolute number of scientists (first and second panels) and for the incidence of scientists among notable people (third and fourth panels). This figure is obtained from a numerical simulation after calibrating the model with the estimated parameters. Statistically insignificant parameters are calibrated to a value of zero, while significant ones are calibrated to the value of the point estimate. Of course the model averages out noise that is present in the data and so the model's predictions result in much smoother series than the empirical ones. Yet the model reproduces fairly accurately the key trends, particularly the decline in the frequency of scientists among notable people in RI states after the RI was established.

Figure 5: Model fit



Notes: The figure reports the actual, total number of scientists vs the model's prediction (first and second panels), and the actual incidence of scientists among notable people vs the model's prediction (third and fourth panels), in RI and non-RI polities by birth decade. Sample: 11,550 notable individuals described in Table 1.

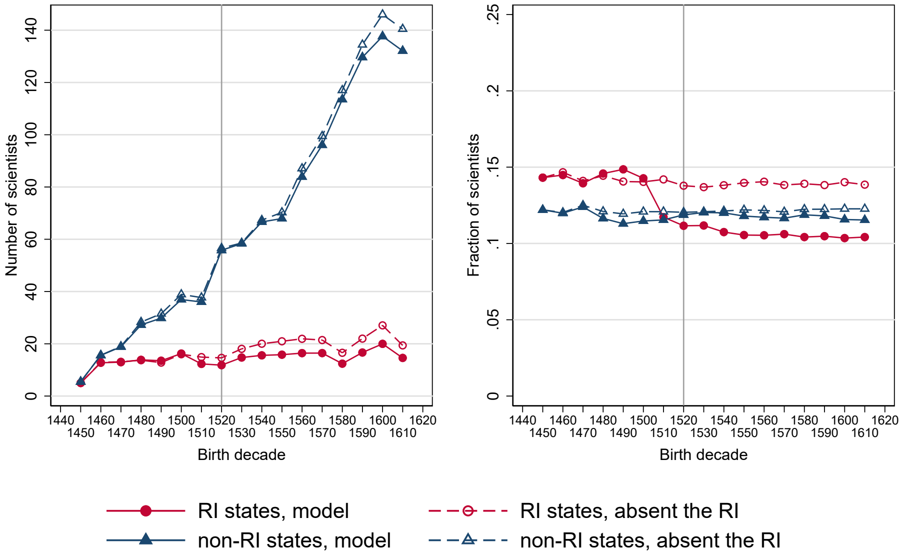
To summarize, our structural analysis indicates that the RI depressed scientific scholarship in Italy via an interaction between deterrence and the ensuing reduction in science masters. The RI reduced notable people's propensity to engage in science, in anticipation of possible punishment. Those who nonetheless chose to be scientists became more likely to migrate out of states under the RI's control and towards states free from it (the story of Niccolò Buccella mentioned in the Introduction is a case in point). Symmetrically, the RI reduced the propensity of scientists located outside its sphere of influence to move inside it. These altered propensities directly reduced the fraction of scientists located in RI states (and increased it in non-RI states). As generations unfolded, this latter effect translated into an altered availability of science masters. That is, there was an indirect effect that reduced the fraction of scientists located in RI states because high-talent individuals in younger generations became less likely to meet a science master and therefore less likely to become scientists themselves, while the opposite happened in non-RI states, where science masters became relatively more frequent thanks to a positive spillover from the RI. Yet, the reduction in the number of Italian scientists also generated a negative spillover on non-RI states, as some of the missing scientist in RI states would have migrated toward non-RI states even in the absence of the RI. The net indirect effect on non-RI state is *a priori* uncertain. We next present a quantitative exercise that quantifies these direct and indirect effects.

5.2 Counterfactual historical experiment

The model allows us to quantify, via an artificial historical experiment, the evolution of scientific scholarship in Europe in a counterfactual scenario where the RI is not established. Of course the results of such an exercise should be taken with a grain of salt, for two reasons. First, the complexity of history cannot be captured by a simple model like ours; while our theoretical framework represents in a reasonable way the impact of the RI on the career and location choices of notable individuals (which is what it is designed for), it is silent about broader events and so it cannot tell us what Europe would have looked like (including the dynamics of science) in the 16th and 17th centuries under the counterfactual scenario. Second, even within the narrow focus of the model, we are taking wages as exogenous and we do not allow them to change in the counterfactual. Most likely, the dynamics of wages in Europe would have been different in the absence of the RI, which would have altered both career and migration decisions in ways that we miss.

Yet, this exercise is useful as it gives a sense of the magnitude of the RI's causal effect on scientific careers of notable individuals implied by the model, and overcomes the limitations of the reduced-form approach by enabling the estimation of both direct and indirect treatment effects. The computational experiment is performed as follows: we shut down the RI in the model by setting to zero Inquisition indicator I_{pg}, for any place p and generation g, even if the RI is present in polity p during the lifespan of generation g; we then re-compute location probabilities under this counterfactual scenario, which determine the expected number of scientists in each place and period and therefore the expected availability of masters for the future generation; finally, we compute the expected number and share of scientists in each generation and place, taking the total number of notable individuals as given. The result is illustrated in Figure 6.

Figure 6: Counterfactual number and fraction of scientists absent the Roman Inquisition



Notes: The figure reports the actual, total number of scientists and their share among notable people born in RI and non-RI polities by birth decade, and the counterfactual total number and share absent the Roman Inquisition, obtained by simulated the model. Sample: 11,550 notable individuals described in Table 1.

Consider RI states first. The model-predicted average incidence of science among notable individuals born after 1522, is 10.6%, similar to the observed, empirical incidence of 10.7% calculated from the data underlying Figure 4. Absent the RI, instead, the average incidence of scientific scholarship in this group would have been 13.9%, which is essentially the same incidence predicted by the model for individuals born before 1522. Thus, in the absence of the RI, there would have been no drop in the fraction of scientists in RI states after the Counter-Reformation. Having built a counterfactual, we can easily estimate the average treatment effect of the RI on the fraction of scientists in RI states as the difference between the model-predicted average incidences of science among notable individuals born after 1522 in the presence and in the absence of the RI. Notice that this is the same causal parameter as the DiD estimand, i.e., the ATT. This model-based ATT is $10.6\% - 13.9\% = -3.3$ p.p., which is a drop of about 24% relative to the model-predicted, pre-RI rate of scientists in RI states (13.8%). Such an estimate is smaller, in absolute value, than the DiD-based ATT of -4.7 p.p. reported in column [4] of Table 3. Hence, DiD exaggerates the drop in scientific scholarship in RI states that is induced by the establishment of the RI.

Turning to non-RI states, the simulation indicates that the net RI spillover on them is *negative*. Although these polities gain in terms of more out-migration from RI states from a given pool of scientists, they lose more from the reduction in the size of such pool, as some of the missing scientists in RI states become missing immigrants in non-RI polities. Thus, absent the RI, the model-predicted incidence of scientific scholarship among notable people who end their career in non-RI states would have been 12.2% instead of 11.3% (the latter is, again similar to the observed, empirical incidence of 11.2% calculated from the data underlying Figure 4), a net, negative indirect treatment effect of 0.9 p.p. that is about 27% of the direct treatment effect on RI states.

6 Extensions and robustness checks

In this section we present estimates of structural parameters from extended versions of the model that relax key modeling assumptions. We also check the robustness of our estimates to alternative definitions of scientists and sample selection choices.

Peer effects in location decisions ("Agglomeration"). The baseline model rules out direct productivity spillovers between scientists, like documented in the empirical literature on modern scientific careers (e.g., Borjas and Doran, 2012; Moser et al., 2014). Such spillovers generate agglomeration effects in location decisions (which may be negative, i.e., congestion) as locations with more scientists would be more (or less) attractive to scientists who migrate. We allow for this possibility by modifying equation (3) as follows:

$$H'_{jg} = (1 + \phi_{jpg-1})^{\theta}(1 + \phi_{jp'g})^{\zeta}, \tag{23}$$

where $\phi_{jp'g}$ is the fraction of own-generation scientists who end their career in one's second-period location p', and ζ parameterizes the agglomeration effect. That is, an individual is more (if $\zeta > 0$) or less (if $\zeta < 0$) productive during $t = 2$ in places where more people who sorted into one's occupation group concentrate. It follows that places with more scientists would be, respectively, more or less attractive to scientists. Notice the use of the rational expectations assumptions ($\phi_{jp'g}$ is endogenously determined) and how the model's non-linearities avoid the "reflection problem" from peer effects in location decisions. The null hypothesis of no agglomeration effect is $\zeta = 0$, which we can test because we identify composite parameter $\rho\zeta$. Results are reported in column [1] of Table 5.[32] A significant positive

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[32] In the interest of space, we do not report in this table the estimates of the deterrence effect for the transition generation or the dissimilarity parameters.

agglomeration effect is detected while the three mechanism parameters are not statistically different from the baseline estimates of Table 4.

Within-Italy variation in RI intensity ("Tribunals"). The baseline model uses a coarse indicator of the impact of the RI on a specific polity, namely an indicator variable. While such variable captures the extensive margin of inquisitorial activities, it neglects a possible intensive margin arising from within-RI-states variation in inquisitorial intensity. In order to also capture such a margin, we leverage the number of RI tribunals in RI states. Formally, we modify net earnings at $t = 2$ in equation (4) as follows:

$$w'_{jp'g}(1 - \pi \mathbb{I}[j = s] I_{p'g})(1 - \nu T_{p'} \mathbb{I}[j = s]), \tag{24}$$

where T is the per-capita number of RI tribunals in second-period locations, and $\nu > 0$ parameterizes the intensive margin of deterrence. This formulation allows for the expected penalty for scientists in a state to be higher the larger the number of RI tribunals (relative to the target population) in that state. Effectively, this specification exploits within-Italy variation in RI intensity. In our data, the average number of RI tribunals per 100 notable persons in RI states is 1.57 with a standard deviation of 1.53. Results, reported in column [2] of Table 5, indicate that the intensive margin indeed matters in the expected direction: one additional tribunal per 100 notable individuals in a state reduces by 10.9 p.p. the probability that a scientist locate in that state. The other mechanism parameters are again statistically unaffected relative to the baseline estimates of Table 4.

Estimation within catholic Europe ("Catholic only"). An issue similar to the coarse indicator of the RI impact arises, potentially, when considering states that we classify as non-RI. Catholic countries where the RI was not operating (such as France, Austria, Belgium, etc.) nevertheless may have pursued similar objectives through civil tribunals and/or without formal coercive institutions. In order to demonstrate that the depressive effect on scientific scholarship that we estimate is indeed specifically driven by the RI and not by catholic identity in Counter-Reformation Europe, we re-estimate the structural parameters after excluding from the sample individuals who are born in or relocate to non-catholic territories. Results, reported in column [3] of Table 5, indicate that the RI had a specific negative impact in science even *within* catholic Europe.

Table 5: Structural estimates: extensions and robustness checks

		[1]	[2]	[3]	[4]	[5]	[6]
Parameter	Effect	Agglomeration	Tribunals	Catholics only	No theology	Including Spain	Narrow science
1. Occupational choice: scientist							
$\rho\theta$	training	0.451	0.685	0.671	0.706	0.843	0.794
		(0.229)	(0.220)	0.(246)	(0.221)	(0.213)	(0.280)
γ	cultural	0.242	0.075	0.062	0.070	−0.235	0.201
		(0.134)	(0.116)	(0.117)	0.(116)	(0.084)	(0.186)
2. Location choice							
μ	distance	−1.424	−0.426	−0.419	−0.425	−0.390	−0.401
		(0.468)	0.(143)	(0.136)	(0.143)	(0.135)	(0.238)
α	log wages	0.640	0.196	−0.004	0.184	0.135	0.181
		(0.234)	(0.074)	(0.046)	(0.070)	(0.053)	(0.112)
π	deterrence	−0.663	−0.217	−0.439	−0.425	−0.359	−0.359
		(0.222)	(0.144)	0.(159)	0.160	0.143	0.219
$\rho\zeta$	agglomeration	2.392	–	–	–	–	–
		(0.788)	–	–	–	–	–
π	deterrence intensive margin	–	−0.109	–	–	–	–
		–	(0.053)	–	–	–	–
Observations		11,550	11,550	6,728	11,311	13,250	11,473

Notes: The table reports structural parameter estimates obtained by Full-Information Maximum Likelihood on equation (20), from extended versions of the model or in different samples as indicated by column number. Column [1] allows for "agglomeration" effects (direct productivity spillovers between scientists). Column [2] exploits within-Italy variation in RI intensity, proxied by the number of RI tribunals per 100 notable people in each state. Column [3] excludes from the sample individuals who are born in or relocate to non-catholic territories, thus exploiting only within-Catholic Europe variation in the presence of the RI. Column [4] removes theologians from the baseline sample. Column [5] augments the baseline sample with individuals born or dead in Spanish Inquisition polities, classifying such polities as Inquisition states (like RI states) since 1480. Column [6] uses a narrow definition of science, i.e., classifies as a "scientist" someone whose occupations includes *at least one* of the following: *astronomer, botanist, chemist, doctor, geologist, mathematician, physician, physicist, surgeon, zoologist.* Standard errors in parentheses.

Removing theologians from the pool of notable people ("No theology"). As discussed in Section 4.1.2, IBN is subject to occupation bias as some occupations, notably theology, became more relevant during the Counter-Reformation. In order to check that our results are not distorted by the relative increase in the demand for theologians in Counter-Reformation countries, we re-estimate the structural parameters after excluding from the sample notable individuals who engaged in theology. As shown in column [4] of Table 5, our structural estimates are unaffected.

Adding Spanish Inquisition polities ("Including Spain"). We have noted in Section 4 that states under the rule of Spain and thereby subject to the Spanish Inquisition are excluded from our baseline analysis in consideration of the different nature of this pre-existing inquisitorial institution. However, during the Counter-Reformation there were many similarities between the Italian and Spanish inquisitions. Column [5] of Table 5 shows how our structural estimates change if we keep Spanish Inquisition polities in the sample, classifying such polities as Inquisition states (like RI states) since 1480. Interestingly, while the deterrence and training effects are unaffected, a significant negative cultural effect is detected in this sample: individuals born in Inquisition states are 23.5 p.p. (*ceteris paribus*) less likely to choose a scientific career. We interpret this result as a manifestation of the stickiness of cultural norms. Cultural change is slow and so a cultural effect is detected only when the Inquisition has been active for a sufficiently long time – the Spanish Inquisition states that we add to the sample are treated for 60 years longer than RI states in the baseline sample.

Narrow definition of scientists ("Narrow science"). Finally, we check the sensitivity of our structural estimates to how scientists are defined. The definition that we use is broad, and includes professions that – despite using scientific knowledge – are more technical than scientific in nature, like for example architects and cartographer. Column [6] of Table 5 reports structural estimates obtained when using a narrow definition of science that excludes technical professions. Specifically, we define more narrowly as a "scientist" someone whose occupations includes *at least one* of the following: *astronomer, botanist, chemist, doctor, geologist, mathematician, physician, physicist, surgeon, zoologist.* Using this definition, about 8% of notable individuals in the sample are scientists, instead of about 10% in the baseline sample. Results are essentially unchanged.

7 Conclusions

Approaching historical research on religion and coercive institutions from a structural economics vantage point, we have shown that the establishment of the Roman Inquisition in 1542 significantly depressed scientific scholarship in the Italian peninsula by about 24%, during the run-up (16th and 17th centuries, the so-called "Scientific Revolution") of the first Industrial Revolution, shedding new light on a long-lasting, still unsettled historical question.

The production of scientists is a key driver of long-run economic growth. As argued by Mokyr (2016), scientific knowledge was a necessary condition for the Industrial Revolution to occur, because of science's potential to improve technology. Thus, our investigation provides a better understanding of how the Counter-Reformation affected the decline of Italy, which up to that point was relatively more advanced than the rest of Europe in terms of scientific scholarship and so, possibly, in a better position to obtain technological breakthroughs.

More generally, our analysis contributes to showing how ideological strictness by states, churches, or other religious organizations that hold political power may have dramatic consequences for individuals who are unaligned with a particular orthodoxy and, ultimately, negative aggregate consequences due to the loss of crucial economic advantages.

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Online Appendix to

Dewitte, Drago, Galbiati, and Zanella (2023),
“Science under Inquisition: the allocation of talent in Early modern Europe”.

A-1 Data set construction

We provide here details on how we assembled our data set on notable individuals’ key dates, occupations, and the political and religious status of the states in which they lived.

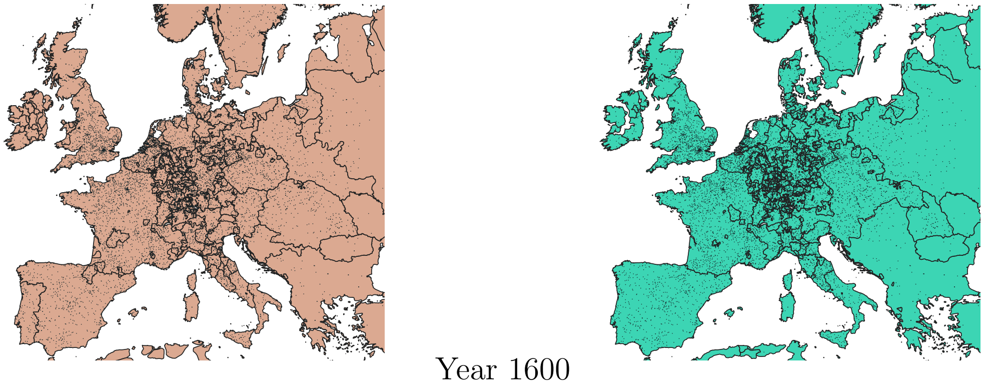
A-1.1 Collection and First Sampling

We scraped data from the online version of the Index Bio-Bibliographicus Notorum Hominum (IBN), available behind a paywall at `http://ibn.zeller-verlag.de/`. The sampling steps are summarized in Table 1 of the paper, and the text provides details.

A-1.2 Geography

We obtained coordinates of the locations listed as individuals’ place of birth or death (if known) using the OpenCage API (`https://opencagedata.com/`). We then used the geographical software QGIS to link these geocoded locations with political entities from shapefiles of EurAtlas historical maps. Using other shapefiles, we also determined whether the locations were (i) close to a river, (ii) close to the sea, (iii) high in elevation. We finally extracted information on where individuals lived (places of “activity”) by searching all the occurences of the above locations in the individuals’ biographical texts.

Figure A-1: Political entities and birthplaces of notable people



Year 1500 Year 1600

Notes: The figure shows the boundaries of political entities (states, which are the geographic level of our analysis) in 1500 and 1600. A dot is a notable person, represented in her or his birthplace. Source: EurAtlas historical maps and *Index Bio-Bibliographicus Notorum Hominum*. Sample: 15,185 individuals born between 1454 and 1618 in Europe, with known and geolocalizable places of birth and death (see Table 1 in the paper).

A-1.3 Religion and the spread of the Inquisition

Within the list of all existing political entities of the 16^{th} century, we identified those that came under the inquisitorial control of the RI after its establishment in 1542, as well as the decade, if different, when this occurred. They are listed below.

- *The Duchy of Ferrara & the Duchy of Modena.* Both under the rule of the House of Este (the former was ceded to the Pope in 1597), the duchies were initially very tolerant to modern scientific ideas (Copernic spent several years in Ferrara under Domenico Maria Novara da Ferrara). This changed when Alphonse II came to power in 1559, and gave free rein to the Inquisition.
- *The Republic of Florence.* During the whole rule of the Medici, the Republic authorized the Inquisition to act on its ground – Cosimo, in particular, had very good relationships with the Vatican –, while maintaining a reputation of relative tolerance. In 1555, it annexed *the Duchy of Sienna*, and, in 1569, became the *Grand Duchy of Tuscany.*
- *The Republic of Genoa.* Independent since 1528, the city was officially catholic and had a milder but active Inquisitorial presence since its start.
- *The Republic of Lucca.* While it did not accept the formal control of the Holy Office, the Republic set up its own tribunal in 1545 to prosecute protestants and other heretics.
- *The Duchy of Mantua.* The initial relations between the Gonzaga family, ruling over the Duchy, and the Inquisition, present from the start, were tensed. But a visit of the Cardinal Borromeo, who promised half of all Inquisitorial confiscations to the duke, ended these tensions and allowed the Sant'Uffizio to operate freely. Since 1536, the Duchy was also ruling over *the March (then Duchy) of Montferrat.*
- *The Duchy of Milan.* Even if the Duchy fell under Habsburg rule from 1556 onwards, the ferocity put by the bishop (then Cardinal) Carlo Borromeoand its successors in prosecuting heretics made it a key center of the Counter-Reformation.
- *The Papal States.* States under the direct authority of the Pope almost immediatly experienced the consequences of the 1541 bull. They included the recently acquired territories of the *cities of Ancona, Bologna, Forli, Perugia, and Rimini*, and the *Duchies of Urbino, Parma and Piacenza.*
- *The Kingdom of Naples*: even if it was under the Spanish rule since the beginning of the 16th century, Naples territories were famously not under the rule of the Spanish Inquisition (contrary to the Kingdom of Sicily); yet, the Pope managed to install Roman inquisitors in the Kingdom as soon as 1547.
- *The Marquisate of Saluzzo.* Occupied by the French for most of the 16th century, the Marquisate nevertheless had an active Inquisition, which gained in intensity after the takeover by the Duchy of Savoy, in 1601.
- *The Duchy of Savoy.* Initially close to the Swiss confederation and protestant ideas, the duke of Savoy formally rejected in 1569 the ”heresy of the reformation” and declares the Catholicism as the only religion in the duchy, thereby paving the way for the Inquisition.

- *The Republic of Venice.* Even if Venetian rulers had a complicated relationship with the Vatican, the Inquisition was particularly active in the city and its territories, in close interaction with secular courts and bishops.

A-1.4 Occupations

To determine individuals occupations, we extracted all words with more than 3 letters from the biographical text and translated all non-English words using DeepL. We then manually determined which of these words were actual professions, and regrouped these occupations into two levels of aggregation, extending those used by de la Croix and Licandro (2015). They are listed below.

- *Army*: admiral, brigadier-general, captain, colonel, commander, corporal, fighter, general, lieutenant, lieutenant-colonel, major, major-general, marshal, military, officer, soldier, sergent.
- *Arts & Metiers*: actor, artisan, artist, bellmaker, blacksmith, bookmaker, caligraph, cantor, carpenter, collector, composer, designer, dramatist, embroider, engraver, glassmaker, goldsmith, gunmaker, iconmaker, illustrator, inlayer, instrument-maker, kapellmeister, lithograph, mason, moneymaker, musician, organist, painter, pewterer, pianist, poet, potter, regisseur, sculptor, singer, tenor, violinmaker, violinist.
- *Commerce & Entreprise*: antiquary, barber, bookseller, banker, businessman, director, editor, explorer, farmer, founder, guildmaster, librarian, merchant, manufacturer, printer, trader, wholesaler.
- *Humanities & Education*: academician, archaeologist, author, classicist, dean, economist, historian, journalist, lecturer, orientalist, pedagogue, professor, philologe, philosopher, rector, scholar, translator, teacher, writer.
- *Law & Government*: administrator, adviser, ambassador, bailiff, beamter, chief, civil servant, congressman, consul, councillor, deputy, diplomat, governor, inspector, judge, jurist, lawyer, magistrato, mayor, minister, money-master, notary, parliamentarian, politician, prefect, president, procureur, secretary, senator, sheriff.
- *Nobility*: baron, baroness, chamberlain, dinasty-member, duke, duchess, earl, emperor, empress, king, knight, lord, marquis, marquise, noble, prince, princess, queen.
- *Religion*: abbot, archbishop, archdeacon, benedictine, bishop, capuchin, cardinal, clergyman, deacon, franciscan, friar, jesuit, martyr, missionary, nun, monk, pastor, piarist, preacher, priest, priar, protestant, rabbi, theologian, vicar.
- *Science*: agronomist, architect, astronomer, botanist, builder, cartographer, chemist doctor, engineer, geograph, geologist, inventor, mathematician, naturalist, pharmacist, physician, physicist, surgeon, zoologist.

A-2 Additional Tables

Table A-1: Descriptive difference-in-differences results – Robustness

	All	vs. other Scholars	vs. Artists & Artisans	vs. Merchants & Entrepreneurs	vs. Civil Servants
	(1)	(2)	(3)	(4)	(5)
Post-RI*RI State	-0.048**	-0.087**	-0.070*	-0.151**	-0.067
	(0.024)	(0.041)	(0.041)	(0.060)	(0.071)
Decade FE	✓	✓	✓	✓	✓
Polity FE	✓	✓	✓	✓	✓
City-level controls	✓	✓	✓	✓	✓
Observations	11,550	6,099	4,473	1,924	3,649
Mean DepVar	0.12	0.23	0.31	0.72	0.38
Sd DepVar	0.32	0.42	0.46	0.45	0.48

Notes: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. The dependent variable is a dummy equal to one if the individual is a scientist. Columns (2)-(5) include city of birth controls (city size, elevation, proximity of rivers and access to the sea). Columns (3)-(5) controls for decade-of-birth fixed effects, and Columns (4)-(5) for political entity ('realm') fixed effects. The models are estimated using OLS. Standard errors are indicated in parentheses and are clustered at the place of birth ('city') level. Coefficients for the controls are not reported in the interest of space. Sample: 11,550 notable individuals described in Table 1 of the main text.

Table A-2: Descriptive difference-in-differences results – Robustness

	All states	vs. Protestant only	vs. Unclear only	vs. Catholic only
	(1)	(2)	(3)	(4)
Post-RI*RI State	-0.047^{**}	-0.064^{***}	-0.056^{**}	-0.032
	(0.021)	(0.025)	(0.025)	(0.023)
Decade FE	✓	✓	✓	✓
Polity FE	✓	✓	✓	✓
City-level controls	✓	✓	✓	✓
Observations	11,669	4,881	4,570	5,692
Mean DepVar	0.12	0.13	0.12	0.12
Sd DepVar	0.32	0.34	0.33	0.32

Notes: * p<0.10, ** p<0.05, *** p<0.01. The dependent variable is a dummy equal to one if the individual is a scientist. Columns (2)-(5) include city of birth controls (city size, elevation, proximity of rivers and access to the sea). Columns (3)-(5) controls for decade-of-birth fixed effects, and Columns (4)-(5) for political entity ('realm') fixed effects. The models are estimated using OLS. Standard errors are indicated in parentheses and are clustered at the place of birth ('city') level. Coefficients for the controls are not reported in the interest of space. Sample: 11,550 notable individuals described in Table 1 of the main text.

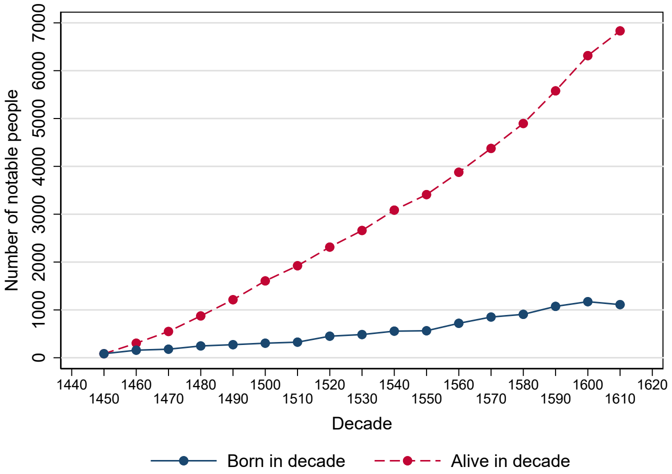
Table A-3: Descriptive difference-in-differences results – Robustness

	Being Scientists, born 1454-1618		
	(1)	(2)	(3)
Post-RI*RI State	-0.046**	-0.046*	-0.046*
	(0.021)	(0.027)	(0.024)
City-level controls	✓	✓	✓
Decade FE	✓	✓	✓
Polity FE	✓	✓	✓
Clustering	Place of Birth	Place of Death	Political Entity
Observations	11,655	11,655	11,655
R-sq (within)	0.001	0.001	0.001
Mean DepVar	0.12	0.12	0.12
Sd DepVar	0.32	0.32	0.32

Notes: * p<0.10, ** p<0.05, *** p<0.01. The dependent variable is a dummy equal to one if the individual is a scientist. The models are estimated using OLS. Standard errors are indicated in parentheses and are clustered at the level indicated in "Clustering". Coefficients for the controls are not reported for the sake of space. Sample: 11,550 notable individuals described in Table 1 of the main text.

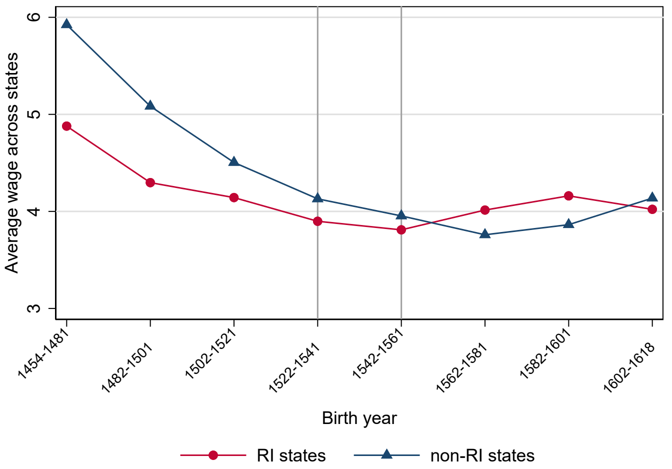
A-3 Additional Figures

Figure A-2: Number of individuals in the *Index Bio-Bibliographicus Notorum Hominum*



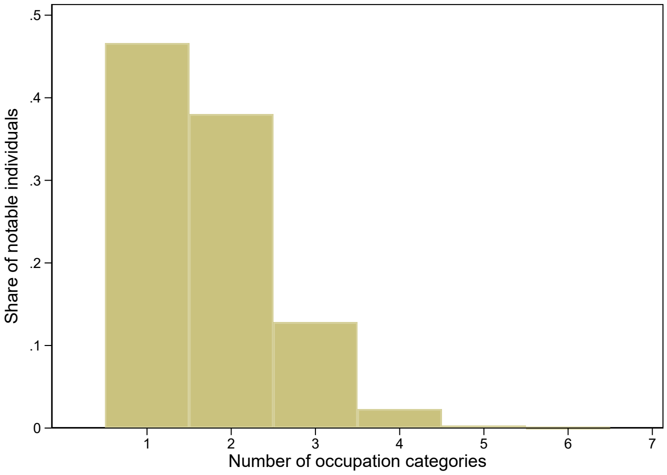
Notes: The figure shows the number of individuals born or alive during a decade. For the latter, early years are truncated because we do not include individuals born before 1430. Source: authors' calculations from the from the *Index Bio-Bibliographicus Notorum Hominum*. Sample: 11,550 notable individuals described in Table 1 of the main text.

Figure A-3: Daily real wages



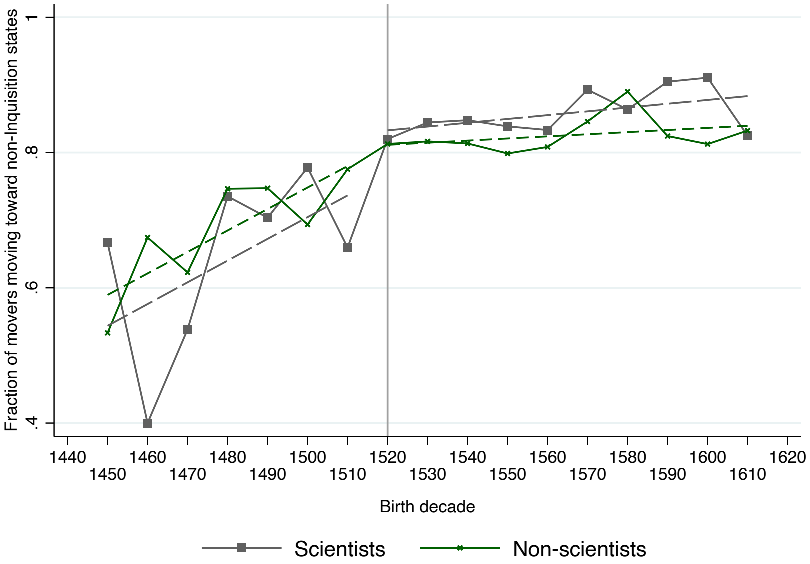
Notes: The figure reports the average daily real wage measured in grams of silver received in their adult life by workers born in a given cohort. Source: authors' computation on wage data from Fochesato (2018).

Figure A-4: Number of occupation categories per individual



Notes: The figure shows the distribution of occupational categories among all individuals in our data. Sample: 11,550 notable individuals described in Table 1 of the main text.

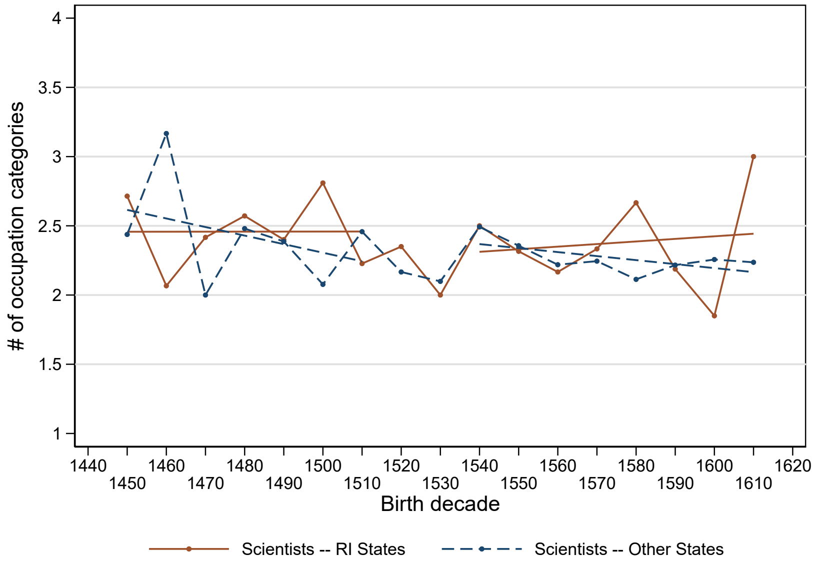
Figure A-5: Migration patterns of notable people



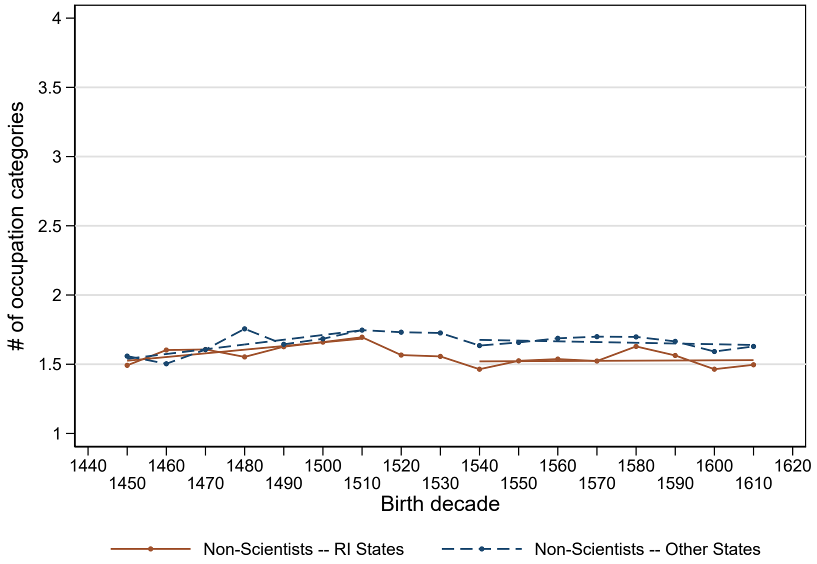
Notes: The figure shows the fractions of notable scientists and notable non-scientists who moved to states outside the influence of the Roman Inquisition, by birth decade. Sample: 11,550 notable individuals described in Table 1 of the main text.

Figure A-6: Number of occupation categories per individual

Scientists



Non-scientists



Notes: The figure shows the average number of occupation categories for scientists (top) and non-scientists (bottom) in RI and non-RI states across birth cohorts. Sample: 11,550 notable individuals described in Table 1 of the main text.

Figure A-7: Occupations in RI states

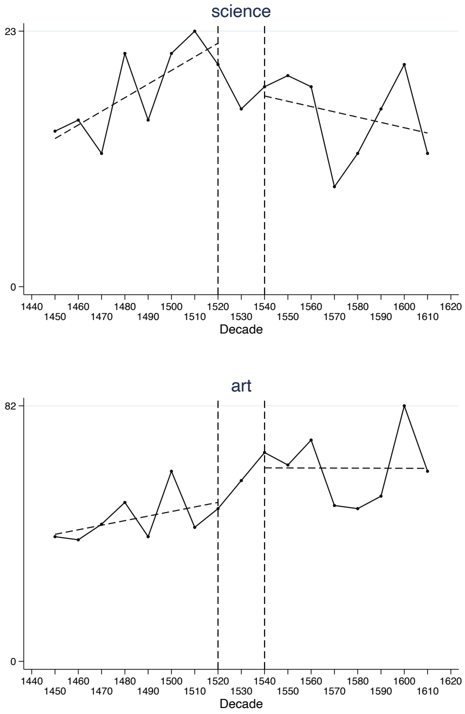
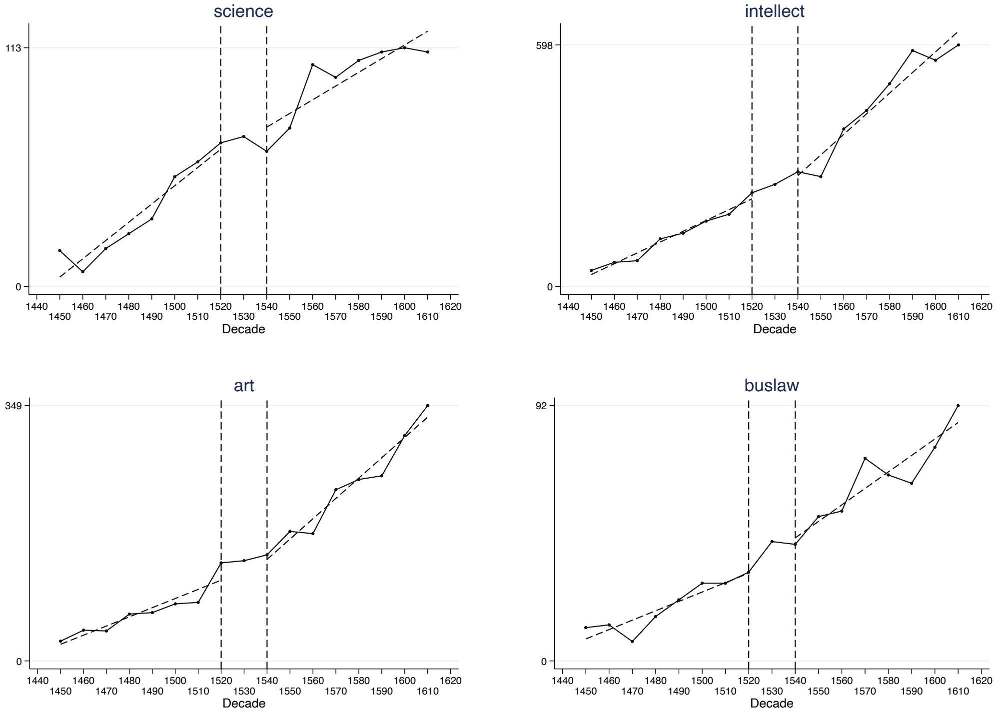


Figure A-8: Occupations in non-RI states



Notes: These figures shows the number of notable individuals in four broad occupational categories (science, intellectual occupations, artistic occupations, and business and law occupations) by birth decade in states affected by Roman Inquisition (top) and in other states (bottom). Sample: 11,550 notable individuals described in Table 1 of the main text.