Early Modern Academies, Universities and Growth*

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Abstract

I use a novel micro-level database of Early Modern scholars and educational institutions to investigate the relationship between knowledge production and Europe's economic growth from 1500 to 1800. Micro-level data on scholars' fields of study show that literary academies contribute to an initial decline in population growth rates, an effect that dissipates over time. In contrast, scientific academies drive urban growth 15% faster after 100 years and this effect persists, compared to cities without scientific academies. I analyze this database of historical evidence and test support for the hypothesis that the presence of academies prompted universities to reform and innovate. I find that where there is a scientific academy, universities in the same cities are of higher quality. I provide the first evidence of the pivotal role scientific academies played in Europe's economic growth and the modernization of its universities.

Keywords: Academies, universities, human capital, growth, science

JEL Classification: N13 , N23 , N33 , I23 , O31 , O47

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*You can find the most recent version of the paper here: https://chiarazanardello.github.io/files/zanardello_jmp.pdf.

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1 Introduction

Today, we recognize the value of knowledge: human capital and innovation lead entire societies to progress (Nelson & Phelps, 1966) and high-level innovation skills are essential in modern economies (Barro, 1991, 2001; Cohen & Soto, 2007; Hanushek & Woessmann, 2008). However, questions linger about the contribution of human capital to the first Industrial Revolution and its major technological advances, due to mixed results and a lack of historical data (Bosker, Buringh, & Van Zanden, 2013). In particular, academies are often overlooked for their historical contribution to innovation. The main difference between universities and academies is in their intellectual perspective: the first followed traditional and Aristotelian, ancient views, while the latter started to diffuse innovative, empirical and Baconian approaches. In this paper I study academies, universities and the interaction between the two, and their contribution to the Early Modern economic growth of European cities, from their creation until 1800.

Using new data and evidence, I study the idea that a few, most skilled people were crucial for European development before the Industrial Era (Mokyr, 2005a; Mokyr & Voth, 2009). I do so by extending a unique database of academicians and university professors active in European educational institutions between 1000 and 1800 (de la Croix, 2021).

We have precise, extensive data that we can use to analyze the short-term impact of contemporary higher educational institutions (Bianchi & Giorcelli, 2020), but we cannot measure, today, the long term effects of current investments in human capital. We can, however, use historical data to project how such investments might unfold in the future, based on patterns observed from the past. In this paper, I use a novel dataset to broaden the current perspective by collecting historical information and making a more precise projection of long run consequences (Cantoni & Yuchtman, 2014; de la Croix, Docquier, Fabre, & Stelter, 2023; Squicciarini & Voigtländer, 2015).

Between the 16^{th} and 18^{th} century European culture underwent significant change. New scientific methods and thinking emerged: scientific truths and procedures no longer relied on past authorities such as Aristotle or Ptolemy, but were constantly proved, reviewed, and challenged (Mokyr, 2016). Intellectuals throughout Europe brought their curiosity and academic methods under an umbrella of more dynamic and scientifically-oriented institutions known as *academies*. These new organizations were alternatives to the traditional curricula of universities, which were created from the 12^{th} and 13^{th} century (Applebaum, 2000; McClellan, 1985). The new academies also differed from the primarily humanistic and informal academies that emerged during the Renaissance in the 15^{th} century.

The institutional shift towards "New Science" can be traced to the founding of the *Accademia del Cimento* in 1657 in Florence. As one of the first Renaissance academies driven by scientific research and experiments, it paved the way for modern and innovative institutions (McClellan, 1985). The motto of the Cimento Academy, *"provando e riprovando"*, which translates to "by trial and error" (Knowles Middleton, 1971, p.53), exemplifies the transition to the experimental approach. Indeed, academies were committed to testing observed facts empirically based on longitudinal data, as advocated by Francis Bacon (1561 – 1626) (McClellan, 1985; Mokyr, 2016). Bacon was the greatest proponent of the New Science, arguing for more dynamic, accurate, and data-driven research, which could lead to more practical discoveries and inventions (McClellan, 1985), a concept Mokyr refers to as "useful knowledge" (Mokyr, 2005a, p.287). I investigate the economic effects of this introduction and diffusion of the scientific approach throughout European cities by this new class of innovative academies.

I examine the economic roles of academies and universities across time and space. Understanding the distinctions and the interactions between these two types of institutions is essential for assessing the long-term impact of the scientific approach (de la Croix et al., 2023). By 1800, nearly every nation and urban center in Europe either hosted an academy or felt the influence of the academy movement and the spread of experimental thinking (McClellan, 1985). However, our understanding of how high-skilled human capital embodied in these institutions contributed before the Industrial Revolution remains incomplete. Contemporaries of the academy movement had already pointed out certain institutional flaws. Jean-Paul Marat (1743–1793), a French politician and scientist, published a pamphlet in 1791 titled *"Les charlatans modernes, ou Lettres sur le charlatanisme académique"*, which translates to "Modern Charlatans, or Letters on Academic Charlatanism." In this work, he criticizes academicians as rent-seekers who expend large amounts of public funds on innovations that yield little to no return (Boissier, 1907).[1] Although Marat directed his critique at the *Académie des Sciences* in Paris, his observations can be broadly applied to other academies that regarded the Parisian Academy as a model. I investigate whether all academies were a waste of resources, or if some were actually linked to higher economic growth. I explore the connections between these new academies and traditional universities to identify complementarities, and I use qualitative methods to look for evidence that universities leveraged the presence of academies to modernize their structures and curricula.

My data comes from a novel database on academicians and university professors, which is detailed in de la Croix (2021). This database, to which I contributed, covers the universe of scholars active in European Academia during the Early Modern Era. We collected micro-level information for every scholar. We tracked their movement through their appointments in different institutions, and from their birthplace to their place of death. We also defined their field of study, so that we can distinguish between scientific and literary institutions. I enlarged the database and improved the coverage of academies that utilized a scientific approach, and which appeared in McClellan (1985).

[1] The original text and its translation are in Appendix A.

The current database encompasses over seventy-six thousand scholars from more than 380 institutions (de la Croix, 2021).[2]

My main outcome variable is population at the city level, which is usually taken as a proxy for income, as it is the case in the Malthusian model by Ashraf and Galor (2011). I employ city-level population data to gauge the economic well-being of local urban areas before the technological take-off of the Industrial Revolution. First, I present OLS regressions to grasp simple correlations. I include only time and city fixed effects due to the lack of control variables for my sample of cities. The magnitudes associated with the presence of academies are always higher than those linked to the presence of universities, and both are positive and highly significant. These preliminary observations already indicate some relevance of innovative academies. However, these results also suffer from endogeneity issues, especially from reverse causality.

I use a difference-in-differences (DID) design to more accurately study the economic impact of academies' scientific approach. I include population data up to 1900 so that I have enough post-treatment periods. Employing dynamic Two-Way Fixed Effects (TWFE) regressions, I study the effects before and after the establishment of academies and universities.

Defining the exogeneity of these events presents a significant challenge. Universities can, arguably, be considered exogenous, as they were established long before any notable economic growth (Dittmar & Meisenzahl, 2022). However, the exogeneity of academies is more difficult to define. Despite gathering extensive information on the history of these innovative institutions, including their organizational and financial structures, along with the biographies of their founders, I was unable to identify a suitable instrumental variable. Nonetheless, the origins of these academies support the notion that many were established by enlightened lords or eminent scholars who aimed to revitalize scientific studies, which were seen as crucial for societal advancement. Various kings, local lords, and bishops recognized the importance of these institutions and advocated for their creation. In this paper, I do not claim that these institutions, both universities and academies, are entirely exogenous. Instead, I use a step-by-step empirical strategy designed to progressively reduce concerns about endogeneity, such as reverse causality. Additional concerns may arise from unobserved variables that affect both city growth and the creation of these institutions. I have limited ability to address this issue, as I lack controls for the entire panel used in my analysis. I can only include city and time fixed effects, and these at least partially mitigate concerns related to omitted variables.

First, I explore pre-trends that could complicate the interpretation of the estimates. The parallel trends assumption holds between 1500 and 1900, the relevant period for my analysis (i.e., cities with an educational institution would have grown as cities without any educational institution), which already reduces reverse causality concerns. Then, I define buffer zones around each city

[2] Access the database at the following link: https://shiny-lidam.sipr.ucl.ac.be/scholars/

with an academy to test for spatial spillovers. Interestingly, excluding cities within each buffer zone does not change the main results. Therefore, the effect I find is an unbiased local effect. This does not preclude the institutions' impact from reaching locations outside the urban area. Using "donut" regressions, I observe that cities in the first donut of 25km experience an anticipated positive effect compared to cities hosting an academy, which sees a positive impact only later, although it persists for the remainder of the sample period. This may be because the urban host areas bear the initial costs of establishing the academy and only later yield the long term benefits. Beyond 25 km, there are no positive spatial spillovers but the explanatory power is also much lower, rendering less precise findings.

Nevertheless, traditional dynamic TWFE estimators may be biased when the event is staggered, occurring in different time periods in different cities (De Chaisemartin & D'haultfœuille, 2023; Goodman-Bacon, 2021; Roth, Sant'Anna, Bilinski, & Poe, 2023). In my context, academies and universities were created in different centuries, introducing possible estimation biases. To address this concern, I employ recent difference-in-differences (DID) estimators. My primary outcomes are based on Sun and Abraham (2021), although I also present results using estimators developed by Callaway and Sant'Anna (2021) and by De Chaisemartin and d'Haultfoeuille (2024).[3]

I find the following results: cities with academies initially experience a decline in the population growth rate, followed by an increase in the subsequent century that more than compensates for the initial downturn. Moreover, thanks to individual-level information in the database, I show that the scholars' field of study is crucial for understanding where this pattern originates from: cities that establish academies with more than 50% of members specializing in scientific subjects exhibit around a 15% higher growth rate after 100 years, compared to cities without scientific academies. These lagged effects align with the literature on the long-run impact of human capital (Dittmar & Meisenzahl, 2022; Juhász, Squicciarini, & Voigtländer, 2020; Mokyr, 2005a, 2005b; Squicciarini & Voigtländer, 2015). In pre-industrial times, any increase in productivity was a gradual process, not a sudden change. Academies contributed by improving the returns from research activities and innovations, but it was some time before these effects became visible. I contribute to this literature by demonstrating that it takes a century before scientific knowledge drives economic growth of local urban areas. By contrast, cities creating literary academies with over half of their members focusing on humanities subjects experience negative effects for the initial 50 years, with a population growth rate that is 10-13% slower compared to cities without literary academies. While this effect appears to diminish over the following 50 years, its initial impact is still noteworthy. Murphy, Shleifer, and Vishny (1991) already demonstrates the critical role that talent allocation plays in economic growth. My

[3] I also used earlier versions of similar estimators like De Chaisemartin and d'Haultfoeuille (2022); De Chaisemartin and d'Haultfoeuille (2020) which produce very similar results.

findings suggest that scientific academies direct resources towards economically beneficial activities, whereas literary academies divert human capital into low-return projects. This interpretation aligns with recent literature exploring the inhibitory effects of religion and law on economic progress. For instance, Squicciarini (2020) shows that regions with a stronger emphasis on religious education tend to be less innovative and less industrially developed. Similarly, Curtis and de la Croix (2023b) find a negative correlation between regional income and individuals dedicated to the study of law.

In addition, creating an academy in cities with existing universities might trigger different interactions and complementarities that yield benefits other than direct economic growth. There are several channels of interest, when it comes to the positive influence of academies on local urban areas. There is some historical evidence documenting how universities reformed and updated their organization and curricula towards the end of the eighteen century: the presence of academies provided a strong push to these innovations (Applebaum, 2000; McClellan, 1985).

Exploiting the features of our database, I can investigate whether and how much universities reformed. I use the university quality index introduced by de la Croix et al. (2023) as a dependent variable, and I show a significant positive effect of creating a purely scientific academy on university quality after 50 years: universities in cities with a science-focused academy improve their quality by 57.86% on average, compared to universities in cities without scientific academies. Letters-focused academies do not prompt universities to innovate. I also find a positive effect of big academies on university quality: academies with more than 30 members increase university quality by 45% on average after 50 years, and by 63% after 100 years. The positive effect of big academies is not only larger, but also more persistent.

Both the sign and the timing of these findings align with the historical academic context and with the conjectural evidence that experimental and scientific academies prompted reforms within universities. The presence of experimental and scientific academies pushed these traditional institutions to innovate and adopt the modern structures that persist to the present day. To the best of my knowledge, my paper is the first to empirically assess this impact. (Applebaum, 2000; McClellan, 1985).

I present detailed sensitivity analyses to assess the impact of a specific unit of analysis that may influence the results, given their large involvement with the academy movement. I find no significant variation when excluding from the sample the two most important cities for innovative academies, London and Paris. Italy, Germany, and the UK[4] alone do not bring about relevant changes in the results. However, France appears to affect more the main results: excluding France (with its 30 academies) from the analyses mitigates the negative

[4]In all my analyses, I use present-day country boundaries, as in Buringh (2021). I acknowledge that this approach may introduce anachronisms, particularly in the case of the United Kingdom, which experienced significant political changes between 1700 and 1801.

impact of academies found in the first 50 years after their creation and, for the same reason, increases the positive effect seen in the following century.

My paper contributes to multiple strands of existing literature. The first is, I collect more generalized, micro-level historical data. Existing literature has often emphasized the importance of highly skilled and well-educated individuals active in Europe during the pre-industrial era (Mokyr, 2005b; Mokyr & Voth, 2009), a time when the foundations of the Scientific Revolution and the Enlightenment were being framed (Mokyr, 2016; Ó Gráda, 2016). However, current digitalized databases lack biographical information. Here I extend further the already detailed database of de la Croix (2021), augmenting it with micro-data on European academicians before 1800. I extend the current empirical studies that have been focused on a specific country to analyze high-quality knowledge in pre-industrial times (Cantoni & Yuchtman, 2014; Cinnirella & Streb, 2017; Dittmar & Meisenzahl, 2022; Squicciarini & Voigtländer, 2015). I emphasize the importance of both having micro-level data, and of taking an European perspective (Bosker et al., 2013), to better gauge the economic impact of high-level human capital on the eve of the Industrial Revolution (de la Croix et al., 2023; Serafinelli & Tabellini, 2022).

The second contribution is to the current debate about the role of human capital and higher educational institutions during the Middle and Early Modern Ages (Becker & Woessmann, 2009; Cantoni & Yuchtman, 2014; Galor, 2005; Ó Gráda, 2016; Serafinelli & Tabellini, 2022; Squicciarini & Voigtländer, 2015). Indeed, at the aggregate level, universities have mostly been used to represent high-level human capital in long-run empirical studies (Bosker et al., 2013; Serafinelli & Tabellini, 2022; Squicciarini & Voigtländer, 2015). While universities played a role in mediating uncertainty during Middle Ages (Cantoni & Yuchtman, 2014), recent research fails to provide clear evidence of significant benefits for urban areas from hosting a university (Serafinelli & Tabellini, 2022; Squicciarini & Voigtländer, 2015). Moreover, when significant results are observed, they often have substantial endogeneity issues, to the extent that they become difficult to interpret (Bairoch, 1988; Bosker et al., 2013). Nevertheless, a recent study by Dittmar and Meisenzahl (2022) finds positive and significant effects of German universities on innovations and scientific activity from the early 1800s, but only after research activities and more practical curricula were implemented. My research supports this mechanism. In addition, de la Croix et al. (2023) determine the strength of universities' quality and professors' skills in moving and locating high-level knowledge across Europe during the Middle Ages, until the eve of the Industrial Revolution. With my research, I show the link between creating a university and the economic growth of European cities: through unbiased estimates I am not able to find any positive effect on population growth. Furthermore, I emphasize the importance of other more innovative educational institutions, rarely considered in the literature. I demonstrate that scientific academies played a positive and relevant role in accelerating the economic growth. To the best of my knowledge, my paper is the first to also study the interaction between an academy and a university in the same city and show that this relationship would shape a more modern university education.

A third contribution is to enrich ongoing research concerning "useful knowledge," a concept introduced by Joel Mokyr (2003; 2005a; 2005b; 2010; 2016) to define practical skills and purposeful innovations. I showcase the enormous relevance of the scientific approach across centuries and across the whole Europe. I make a unique contribution by quantifying the local economic impacts of research activities, scientific knowledge, and innovative ideas (Abramitzky & Sin, 2014; Dittmar & Meisenzahl, 2022; Hanlon, 2022), capitalizing on the emergence and dissemination of scientific academies. While the role of academies in shaping new modes of thinking and promoting innovations has been acknowledged (Applebaum, 2000; McClellan, 1985), there remains a gap in quantitative research. The intuition I rely on is that to initiate the Industrial Revolution and the technological breakthrough, what mattered most was the scientific method and experimental approach. As far as I am aware, the sole study delving into the newly emerging societies at the end of the 18^{th} century is that of Koschnick, Hornung, and Cinnirella (2022), which centers on German economic societies exclusively. I argue that a distinctive subset of academies, not just the economically-oriented ones but all those institutions moved by the new Baconian reasoning, exerted a notable influence on the economic growth of European cities prior to the first technological breakthrough.

The rest of this paper is organized as follows: in Section 2 I provide historical context regarding the establishment of experimental academies: first by outlining their differences and interactions from more traditional universities, and then by presenting their characteristics in detail. In Section 3, I detail the data I use. I briefly outline my empirical strategy in Section 4, followed by the interpretation of my findings in Section 5. In Section 6 I use university quality as a different channel of growth. In Section 7 I develop additional analyses, including sensitivity and spillover effects analyses.

2 Historical and institutional context

2.1 Universities and academies

Universities constituted the initial wave of higher educational institutions in Medieval and Early Modern Europe.[5] Academies and learned societies came later, in the 1650s, and marking a significant shift in the European educational system. These organizations are significant because of their crucial role in bridging two distinct educational approaches: the traditional, university-based

[5]Universities are among the first higher educational institutions with multiple masters. Before there were cathedral and monastic schools which usually had only one master and the training provided mostly focused on one specific subject (Pixton, 1998). Nevertheless, in some cases the depth and popularity of the teaching attracted many students, also from abroad, as in the case of the School of Laon (Luscombe, 1969).

model and the modern method of scientific knowledge dissemination, which gained prominence in the 19th century (McClellan, 1985).

The arrival of academies highlighted various shortcomings in the institutional structure and cultural updating process of universities. Universities were often slow to accept new thinking, especially in the approach to natural philosophy. They continued to value ancient textual authorities and resisted changing their curricula:[6] mathematics and sciences taught at universities focused on qualitative conclusions, neglecting empirical and quantitative applications. Furthermore, most universities continued to teach primarily in Latin well into the 18th century, reinforcing the perception that they were resistant to change. Academies sought to bridge this gap, playing a pivotal role in promoting innovation and reform within universities, forming links and interactions between these two types of institutions. Initially there were tensions between them - for example, the Society of Haarlem, founded in 1752, was not officially approved until 1761, after the University of Leiden (located about 40 km away) accepted that the Society did not intend to offer lectures and to publish in Latin, but exclusively in Dutch. Despite some initial tensions, it became evident that universities retained their role as *teaching* institutions, providing lectures and degrees (in Latin), and focusing on the pursuit of knowledge for its intrinsic value (Applebaum, 2000; McClellan, 1985; Pepe, 2008). Academies assumed a distinct role of *research* institutions, offering scholars a space for discussions and the promotion of the experimental approach. Their goal was to generate and disseminate "useful knowledge" that could enhance the quality of life in local communities (Applebaum, 2000; McClellan, 1985; Mokyr, 2005a, 2016). The interactions between these two types of institutions led universities to update their thinking, curricula, and organizational structure towards the end of the Scientific Revolution (Applebaum, 2000).

I use the city of Turin to exemplify the influence of scientific thinking within academies, and elucidate the disparities and interactions between these two types of institutions.[7] Table 1 contains a summary of these distinctions.

In Turin, the education level was notably low prior to the establishment of the university. In 1404, Prince Ludovico D'Acaia founded the university, which received papal recognition the following year (Vallauri, 1875). The university's history is closely tied to enlightened rulers who implemented laws and reforms to strengthen academic pursuits. This trajectory is illustrated in Figure B1, which traces the university's quality over time (further details on quality measures are provided in Section 3). The initial pre-1600 peaks are attributed to three key figures: Amedeo VII, his successor Ludovico, and Duke Emanuele Filiberto. In 1424, Amedeo revitalized the university by enacting reforms that attracted students from Piedmont and beyond, while reducing taxes to just 10 silver marks. His heir, Ludovico, continued this approach and restored the

[6] Universities were teaching some sciences within the *Quadrivium*, which included arithmetic, geometry, astronomy, and music (Applebaum, 2000).
[7] For more examples, refer to the *Repertorium Eruditorum Totius Europae*: https://ojs.uclouvain.be/index.php/RETE/index.

university to Turin after it had been temporarily relocated to nearby cities due to the Black Death. This epidemic is responsible for the downturns in the university's lifecycle, as seen in Figure B1. The year 1572 marked a peak since the university's inception, largely due to Duke Emanuele Filiberto's reforms, which mandated that young scholars return to Turin to resume their studies. However, the 17th century presented significant challenges for Piedmont, including wars and unstable regencies. Only at the start of the 18th century did Vittorio Amedeo II refocus on the university, centralizing higher education in Turin and introducing a meritocratic system for appointing faculty chairs (Vallauri, 1875; Zanardello, 2022).

Despite these efforts, scientific fields and experimental methods were given comparatively little attention. In 1757, three students of university professor Giovanni Battista Beccaria (Mondovì 1716 – Turin 1781) created the Scientific Academy. Inspired by Beccaria's progressive vision, Giuseppe Luigi Lagrange (Turin 1736 – Paris 1813), Giuseppe Francesco Cigna (Mondovì 1734 – Turin 1790), and Giuseppe Angelo Saluzzo (Saluzzo 1734 – Turin 1810) established a platform for the dissemination of "useful knowledge." King Vittorio Amedeo III of Savoy officially recognized the academy more than 25 years later, in 1783, transforming it from a private society into an official institution. Guided by the motto *veritas et utilitas*, the academy sought both truth (*veritas*) and its practical application (*utilitas*), organizing public competitions to address everyday challenges (Accademia delle Scienze di Torino; de la Croix and Zanardello (2021)). The inaugural competition in 1788 aimed to identify alternative employment opportunities for workers in the textile industry who were affected by a mulberry-picking crisis. Subsequent competitions led to innovations such as public lighting for the city and the development of advanced agricultural machinery (Accademia delle Scienze di Torino; de la Croix and Zanardello (2021)).

Figure B1 compellingly illustrates the surge in university quality during the latter half of the 18th century, following the academy's establishment. The advances are reflected in the increase in the number of publishing scholars[8] and the arrival of prominent professors, such as Carlo Danina (Ravello 1731 – Paris 1813).

2.2 Academies' characteristics

Having outlined the differences between universities and academies, in this section I describe the main characteristics of the latter type of institutions across European countries.

Overall European trends show that many academies were inspired by the ideas of the Scientific Revolution and the "New Science," with a strong emphasis on experimental research and the use of empirical data. Many establishments recognized the importance of applying scientific knowledge to

[8]A publishing scholar refers to an individual with a documented footprint in Wikipedia or the VIAF catalogue.

Table 1 Main differences between universities and academies

	UNI	**ACAD**
When	From 12^{th}-13^{th} century	From mid-17^{th} century
How	traditional approach *teaching* institutions	experimental approach *research* institutions
Why	learning for its own sake	creating "useful knowledge" (Mokyr, 2005b)
What	theology, law, logic, and medicine	science, maths, medicine, agriculture, and philosophy
Finance	Municipality, student fees, Church	Private donations, memberships fees, only a few public funded

Source: Applebaum (2000); McClellan (1985); Mokyr (2005b)

practical problems related to agriculture, industry, commerce, and the betterment of society. Often these academies originated in the private homes of enlightened individuals who offered their spaces for discussions and experiments. Initially, they invited a small circle of intellectual friends, gradually expanding to more formal meetings and structured organizations. To reach this last step, royal patronage (i.e., official recognition) was a significant factor in the establishment and development of many academies in Europe, particularly in France, Italy, Germany, and Sweden. Additionally, through correspondence and exchange of publications, academies created global networks that facilitated the spread of scientific knowledge. This likely created spillover effects, impacting areas outside the local seats of academies (Section 7.3 shows these spillovers).

In the following paragraphs I list the main characteristics of the official recognition, topics of study, memberships and meetings, general governance, and financing of academies by country:

- France

Official Recognition. Generally, French academies received official recognition from the King relatively quickly, often within 10 years of their informal beginnings. For example, the *Académie des Sciences, belles lettres et arts in Besançon* received official recognition in 1752, just a few years after its initial formation in 1748 (Defrasne, Maurat, Lordereau, & Lassus, 2002). In the academy of Nancy, the first meeting was held on December 28, 1750, and the patent letters arrived exactly one year later, on December 27, 1751 (Stanislas, 2024). Most academies received these patent letters, signifying both royal approval and often some form of financial support either from the Royal Court or from local authorities (e.g., lords and bishops).

Topics of Study. French academies covered a wide range of subjects, including natural sciences, humanities, arts, and practical issues related to local regions. The emphasis on applied science and knowledge for the betterment of society was particularly evident in academies like those in Châlons-sur-Marne and Cherbourg. In Châlons-sur-Marne, the academy's motto was *"L'Utilité"* (i.e., literally "The Utility", (Roche, 1964)), indicating a focus on improving the living standards of the local community. The *Société Académique* in Cherbourg organized local competitions to incentivize young researchers in hydrography (Académie De Cherbourg, 2024). The experimental approach and the influence of the "New Science" were significant factors, as it is clear from the creation of the *Académie Royale des Sciences* in Paris. The latter was officially founded by the minister Colbert "to advance scientific knowledge and promote the practical application of scientific research" (de la Croix & Zanardello, 2022, p.1).

Memberships and Meetings. Typically, French academies had three different membership categories: ordinary members, who usually resided in the city of the academy; honorary members, who were influential personalities that brought fame and reputation to the institutions without advancing knowledge themselves; and often foreign correspondents, who did not reside in the city on a regular basis but sent letters with their thoughts and new findings to be read by the ordinary members during meetings. There was often a maximum limit on the number of ordinary members, explicitly written in the *Statutes* and varying with the academy, but there was no limit on correspondents and honorary members.[9]

Meetings were generally regular, often weekly or bi-weekly, with specific days designated for meetings explicitly stated in the *Statutes* of the academies.

Governance. Most French provincial academies had a hierarchical structure very similar to the Paris Academy, with directors, secretaries, treasurers, librarians, and often a protector (usually a high-ranking figure like the King or a local noble or bishop).[10] The directors or presidents of the academy were elected members and stayed in charge for a certain number of months. Secretaries and librarians were also elected members but usually stayed in charge permanently. Treasurers were often also the vice-directors, but for this role, there was more variability among the provincial academies.

Finances. Finances often came from a combination of royal support, member fees, private donations, and sometimes bequests. Some academies received annual subsidies from the King (like the Paris Academy, Boissier (1907)), others only at the beginning of their activities, while others relied more heavily on private contributions to gain more independence from the central power.

- Italy

Official Recognition. Italian academies were often established informally before receiving official recognition from local rulers or the Pope. Official recognition was sometimes delayed, with some academies operating for several

[9] Sometimes honorary members were also limited to a specific number, but for this category, exceptions were applied more regularly than the rule itself.

[10] From here on, when I use the term 'hierarchical' structure, I am referring to the French-like organization, where specific figures are either elected or appointed for life or for a set term.

decades before receiving official status. For instance, Turin waited 26 years for the King of Savoy to officially recognize it. While many Italian academies were recognized by local rulers, the Pope's authority was significant, particularly for institutions like the *Istituto delle Scienze* in Bologna, which heavily relied on Pope Benedict XIV's donations.

Topics of Study. Italian academies were inspired by the "New Science" and its experimental approach, particularly in the early period, thanks to the influence of scholars like Galileo Galilei and his followers. Academies such as the *Accademia del Cimento* in Florence (founded by two students of Galileo) (Knowles Middleton, 1971; Maylender, 1930) and the *Accademia degli Investiganti* in Naples (Maylender, 1930) are examples of early Italian institutions focused on experimental research. Italian academies frequently focused on natural philosophy, physics, mathematics, and astronomy, but also explored literature, history of the homeland, and practical issues like agriculture. In Florence, the Georgofili academy closely worked with local authorities to reduce the impact of famines in 1791/1792, proving itself right and gaining credibility (Tabarrini, 1856).

Memberships and Meetings. Italian academies had various membership categories, including ordinary members, honorary members, and foreign correspondents, but in a much less centralized manner compared to their French provincial counterparts. Maximum thresholds are rarely seen in the *Statutes* of Italian academies. Meeting frequency varied significantly depending on the academy, with some meeting only once a month.

Governance. Governance structures were diverse, ranging from more to less democratic organizations. Some academies were overseen by a patron, while others had elected leaders and committees. The *Accademia ducale dei Dissonanti* of Modena had in its name the word "ducale" (i.e., literally "of the Duke"), explicitly indicating the Ducal patronage and his high influence over academic matters (Accademia Nazionale di Scienze, Lettere e Arti di Modena, 2023).

Finances. Italian academies relied on various sources of funding, mainly from patron support and member fees, but also from private donations and sometimes subsidies from the local or provincial church. Royal patronage was particularly important for some institutions, as mentioned above, but its generosity varied significantly from case to case.

- Germany

Official Recognition. For German academies, official recognition did not follow any specific pattern; it could come from local rulers or patrons, with the timing and type of recognition varying. For example, the academy of Göttingen was directly established as a "Royal Society" by King George II of Great Britain and Elector of Hanover (Niedersächsische Akademie der Wissenschaften zu Göttingen, 2024). The city of Mannheim saw the creation of two academies,[11] thanks to the Elector Palatine of Bavaria, Karl Theodor (Cassidy, 1985). Not obtaining recognition often meant more independence, as in the case of the academy of Görlitz, which did not obtain any official recognition, remaining a private society since its foundation in 1779 (Oberlausitzische Gesellschaft der Wissenschaften, 2024).

Topics of Study. German academies covered a wide range of subjects, including natural sciences, humanities, and applied sciences. There was a strong emphasis on experimental research and the use of empirical data, as seen in academies like the *Gesellschaft Naturforschender Freunde* in Berlin and the *Naturforschende Gesellschaft* in Jena. The former focused on producing original research on natural history thanks to their own data collections (Böhme-Kaßler, 2005). The latter aimed to supplement university lessons with more empirical applications through their collection of instruments and their own laboratory (Böhme-Kaßler, 2005).

Memberships and Meetings. German academies often had a mix of ordinary members, honorary members, and sometimes foreign correspondents. Meetings were generally regular, with weekly or bi-weekly gatherings being common.

Governance. Unlike France, governance structures in Germany were diverse, ranging from more informal and democratic to more hierarchical and patron-driven.

Finances. Finances were typically derived from a combination of member fees and donations, with patron support also being important alongside government subsidies. Patron support was particularly important in Germany, and the stability of the academy was highly dependent on it.

- Great Britain

Official Recognition. British academies were mostly informal, with only the Royal Society of London and the academy of Edinburgh obtaining official recognition. The timing differed significantly between the two: the Royal Society was recognized in 1662, around two years after its creation, while Edinburgh waited 52 years to obtain its royal charter in 1783.[12]

Topics of Study. British academies were primarily devoted to natural philosophy and scientific experimentation, taking the *Royal Society* as a model. Its motto *"nullius in verba"* is a clear statement of the will to use the experimental perspective to test and verify every fact and conclusion (The Royal Society, 2024). The experimental approach was central to their work, as demonstrated by institutions like the *Lunar Society* of Birmingham, which focused on applied science and its relevance to industry, with members like James Watt (mechanical engineer working on steam engines), Erasmus Darwin (natural philosopher,

[11] The *Academia Electoralis Scientiarum et Elegantiorum Literarum Theodoro-Palatina* created in 1763 and the *Societas Meteorologicae Palatinae* founded in 1780.

[12] Edinburgh presents a complex case: the 52 years are calculated from the founding of its predecessor, the *"Philosophical Society of Edinburgh"*. Although it was inactive for a period, it later resumed with only minor changes in its membership, which is why we regard both societies as a single academy, established in 1731.

poet, and grandfather of Charles), and Richard Lovell Edgeworth (grandfather of Francis Ysidro)[13] (Schofield, 1963).

Memberships and Meetings. British academies typically had various membership categories, including ordinary fellows, honorary members, and often foreign correspondents. However, for many British academies, including the Royal Society, it is impossible to distinguish between ordinary and correspondent members, as all members are called "fellows" in their lists. In our database, the category is identified only for specific years for which we know the list of foreign members as detailed in De Candolle (1885).

Meetings were generally regular, often weekly, with specific days designated for gatherings.

Governance. Most academies had a hierarchical structure, with presidents, secretaries, treasurers, and sometimes other elected officials.

Finances. From a financial point of view, British academies operated very similarly to those in other countries, with a combination of member fees and donations. Patron support and subsidies were rarer in Great Britain.

- Rest of Europe
  - **Russia.** The only Russian academy in my analysis is located in Saint Petersburg. It was created under the direct patronage of Tsar Peter the Great, who fully financed and controlled it by approving new memberships. This academy was devoted to advancing Russia through the study of sciences and mathematics, along with history and humanities. The educational aspect was much more significant for this academy than in the rest of Europe.
  - **North Europe.** In the Netherlands, Sweden, Ireland, Belgium, Denmark, and Norway, official recognition was much more widespread than in the rest of Europe, with only a few informal or private academies. Nevertheless, the timing of granting recognition could vary from almost no wait to 19 years. This was the case for the Royal Dublin Society, which originated from a previous society in 1731 and obtained its royal charter only on April 2, 1750 (Berry, 1915). The topics of research were very similar to the rest of Europe, ranging from natural science to practical applications to improve local society.
  - **East Europe.**[14] In the Czech Republic, both academies in Prague and Olomouc received official recognition, while in Switzerland the academies were mostly private societies (Kostlán, 1996; Zacek, 1968). Olomouc was peculiar for its open-minded atmosphere, where Catholics and Protestants collaborated and helped each other (Kostlán, 1996). The topics of study

[13] Francis Ysidro is considered the pioneer of utility theory with his development of indifference curves and the Edgeworth box.

[14] McClellan (1985) does not include any academy in Poland; however, the "Warsaw Society of Friends of Science" (*Towarzystwo Przyjaciół Nauk*) was established in 1800 and remained active until 1832. It is the earliest scientific academy recorded in Poland. Nevertheless, I will not include it in the analysis, as data collection has only recently begun.

focused on natural history and the efficiency improvement of agriculture, which was especially important for Switzerland (Rübel, 1947).

- **South Europe.** Both Spain and Portugal had one scientific academy each,[15] and both were officially recognized a year after their creation. Patronage was important for the financing of these societies as well (Teixeira Rebelo da Silva, 2015). The topics were similar, focusing on the advancement of the local region.

In addition to all the information described above, I also collected micro-level data on the founders of these academies. Analyzing the personal differences between those who established the institutions and those who were affiliated afterward provides interesting details, important to fully grasp where these academies come from. So far, I have collected information for about 93 out of 102 academies in my sample. Some academies were created directly by kings and will not appear in the statistics, such as the academy of Göttingen established by King George II of Great Britain and the academy of Naples established by King Ferdinand IV of Bourbon. Excluding these two academies and the few others for which our sources do not list the founders, I am able to select a total of 387 founders (i.e., an academy can be established by more than one founder). Table B1 shows the differences between these founders and the rest, the non-founders. It is clear that academies were created by personalities of higher individual quality (see Section 3 for the quality measurement) and were slightly older at death. The two groups seem to be appointed at approximately the same age, but founders remain active in the academy for a longer period. Interestingly, founders are much more local (i.e., they are born closer to the academy seat) and static (i.e., they die closer to the academy location).

In Appendix E, I list each academy individually, providing a brief summary of their establishment history. A more detailed table containing all the information provided in this section will be available online.

3 Data sampling

To study the relevance of the academy movement and human capital in the European economic path prior to 1800, I investigate the link between the presence of an academy, a university or both and the economic growth of cities. In this section, I explain the data I employ in my analyses.

Population data. Before the Industrial Revolution, population size is often used as a measure of income for pre-industrial societies. This lies on the hypothesis that the economy followed a Malthusian regime, meaning that

[15] I refer to the list in McClellan (1985), which includes only one Spanish and one Portuguese academy. However, we recently found the presence of other two scientific academies in Madrid. The oldest is *Real Academia de Matemáticas de Madrid* created in 1582 and hence out of the academy movement I study in this paper. However, it may be argued that it contributed to its origins. The other is the Royal Spanish Academy, founded in Madrid in 1713 and dedicated to the study of all sciences (Real Academia de Ciencias Exactas, Físicas y Naturales de España , 2024). Despite this, I cannot include these academies in my analysis, given we only started the search for reliable sources and data.

the higher the income, the bigger the population size of the city (Ashraf & Galor, 2011). Economic prosperity was strongly and positively correlated with the number of inhabitants. Furthermore, the lack of GDP data at city level during the pre-industrial era leads me to follow the previous literature in using population size to capture economic growth (Acemoglu, Johnson, & Robinson, 2005; Bairoch, 1988; Bosker et al., 2013; DeLong & Shleifer, 1993; Dittmar, 2011; Serafinelli & Tabellini, 2022; Squicciarini & Voigtländer, 2015). I use Buringh (2021), which provides population data for cities that reached 5,000 inhabitants at least once in the period between 700 and 2000. It is the updated version of Bairoch, Batou, and Pierre (1988). Buringh (2021) includes 2262 cities over a longer time frame. Buringh (2021) covers the period 700 - 2000, while Bairoch et al. (1988) have data between 800 and 1850. Buringh (2021) systematically imputes missing population data considering specific city and time characteristics and corrects previous miscalculations. However, errors are still possible especially in the first centuries of the time frame (for more details, see Buringh (2021)).

I focus on Europe; I exclude those countries that were part of the Ottoman Empire - I remove 161 cities in 11 countries.[16] There are also five cities that were initially independent settlements but later agglomerated into larger urban centres. To avoid missing values and ensure comparable estimates, I sum the available number of inhabitants of these smaller settlements to the population of the main city.[17] Finally, I have population data for 2096 cities over 19 time periods, between 700 and 2000 (every century until 1400, every 50 years from 1500). Appendix B.1 presents some descriptive statistics.

Universities and Academies. Population data is my main dependent variable, while the main independent variables capture the presence of higher educational institutions and, hence, the role of high-level knowledge in a specific city. I have access to a new and unique database on scholars described in de la Croix (2021), which I have expanded to better account for scientific academies. It lists information about individual quality (referred to as *"human capital"*) and mobility characteristics, such as birthplaces and death places with relative years, of more than seventy-six thousand scholars active in European universities and academies between 1000 and 1800. The database also includes affiliation data. The scholars can be affiliated to a university, an academy, or both. With this information, my project is able to track when a professor worked in both the university and the academy built in the same city. I firstly consider aggregate data; therefore, my main independent variables are dummies capturing the presence of an academy (ACAD), a university (UNI) or both institutions (UNIxACAD). This last case is what I call *interaction* (UNIxACAD): the dummy variable takes value 1 when both institutions were

[16] I exclude the countries listed in the following link: https://en.wikipedia.org/wiki/Outline_of_the_Ottoman_Empire (accessed in June 2023), but Hungary and Slovakia because only partially conquered by the Ottomans.

[17] Specifically, I sum the population size of Barmen and Elberfeld into Wuppertal (Germany), Rheydt became part of Mönchengladbach, Depford is now part of London (Buringh, 2021), and Pest merged with Buda to become Budapest in 1873.

open at the same time in the same city, 0 otherwise. The database is continuously updated and every covered institution with more than 100 scholars is (or will be) summarized in the *Repertorium Eruditorum Totius Europae*.[18]

The reach of this database is as massive as delicate, so I decided to select a subset of the most representative list of institutions. For universities, I consider those listed in *"A History of the University in Europe"* written by Frijhoff (1996). As a general rule, I include only institutions classified as a "typical" university and exclude those defined as convent-university, collegium, seminar-university, or those that never functioned.[19] I collect data about the location, the creation and the end date. I usually consider the information exactly as written in Frijhoff (1996), but for some cases I used additional and more precise sources.[20]

Individual data for university professors are already well-covered by the original database. I contribute to it by adding information about scholars active in academies.[21] I consider the academies listed in McClellan (1985)'s *"Science reorganized: Scientific societies in the eighteenth century"* because it includes only academies working with an experimental approach. Using this list, I directly exclude Renaissance academies from my sample because based on the same traditional and old perspective as universities. I examine both official and private academies in McClellan (1985) and exclude those for which no source exists and it was impossible to find any member.[22] For the creation and end dates, I use the exact information found in McClellan (1985) except for cases where more precise sources are available.[23]

In cities where more than one academy or more than one university were created I generally consider the oldest. For universities, it is the case only for four cities: Aberdeen in UK, Aix-en-Provence and Nimes in France, and Rome in Italy. For academies the situation is more complex, many cities have more than one academy and some cities had created even more than two academies, like Bologna, Edinburgh, Florence, Naples and Venice with three; London had four academies. In these cases I also consider the oldest, but for Bologna, Caen and Florence for which I consider the longest (the other academies in those cities lasted only a few years, with a small number of members).

[18] https://ojs.uclouvain.be/index.php/RETE/index

[19] I also exclude the *Angelicum* university in Rome founded in 1727, as it seems to be a minor institution in a city where there are other two relevant universities; and the university of Camerino founded in 1727 because the sources we consulted described it as marginal without mentioning any professor (Brizzi, 2001).

[20] The only case is for the University of Modena: I use the website of the university itself (https://www.unimore.it/ateneo/cennistorici.html) to include a more accurate creation date.

[21] I mainly use secondary sources, but for the Academy of Nimes we obtained the first handwritten registers.

[22] This is the case only in the list of McClellan (1985, p. 281) entitled "Notable Private and Semi-Private Scientific Societies: 1660 - 1793". Hence, I do not consider the Academy *Fisico-matematica* and *dell'Arcidiacono* in Bologna (Italy), the Society in Breman (Germany), the Society in Cuneo (Italy), the Academy *Clelia de' Vigilanti* in Milan (Italy).

[23] This is especially the case for creation dates. If the academy is considered as *official* by McClellan (1985), I use the year when it actually became *official* or when it was authorized/endowed by the local or ministerial power. However, when there is reliable evidence of strong activity even before that date, I decide to use the foundation year of the society, even if it remained only a *private* entity for a while.

Figure 1 shows the geographical distribution of these educational institutions between 1000 CE and 1800 CE. The yellow bubbles represent universities as classified in Frijhoff (1996) and the green triangles academies as in McClellan (1985). At the aggregate level, I define an interaction between these two educational institutions when they are both in the same city, which is captured by yellow bubbles overlapping green triangles. By 1800, almost every European country and city either had an academy or felt the effect of the academy movement and the experimental perspective (McClellan, 1985). It is a pooled set, meaning that it is only visible where the institution is created but not whether the institution closed before 1800. To provide more insights about the time dimension, two figures in Appendix B show the creation dates and the end dates (Figure B2 and B3, respectively). Figure B2 shows that universities have a more heterogeneous creation period compared to academies: universities were created since the 11^{th} century, while academies started to spread from the second half of the 17^{th} century. This heterogeneity over time is relevant for the empirical strategy I will present in Section 4. Figure B4 (in the Appendix) also visualizes the openings of universities and academies happening every 50 years between 1500 and 1800. At this point it is important to acknowledge the measurement error underlying the data: we only observe institutions that have somehow "survived", either by still being open today or by being deemed relevant enough to be recorded in historical sources.

Scholars. In the database, there is also individual information on scholars' Virtual International Authority File (VIAF), which includes the number of alternative names, countries, publishers, and titles available for each individual. Information from scholars' Wikipedia pages, such as their length (i.e., number of characters) and languages available, is collected as well. These data are used by de la Croix et al. (2023) to compute a quality index referred to as "human capital". The authors employ a principal component analysis to obtain a unique indicator of human capital (for the combination of weights see Curtis and de la Croix (2023a)). On this point, it should also be noted that a present bias affects this output measure of human capital since both VIAF and Wikipedia only reflect the importance of scholars as of today.

In addition to individual quality, we have information on scholars' age at death, age at appointment, period of activity in any institution, and the distance they travelled from their birthplace to the institutions where they were active, from their birthplace to their place of death, or again from their institution to their place of death. Table 2 shows some descriptive statistics at the individual level. It is evident that the sample of scholars affiliated with academies (column 1) is entirely different from the sample of university professors (column 2).[24] Interestingly, for the 'age at death' I find similar results to Stelter, de la Croix, and Myrskylä (2021), who shows that scholars of scientific academies benefited from lower mortality than their contemporary colleagues in universities. It is important to notice that in the sample of 33150 university

[24] I did not add the t-test for these two samples because the difference is clearly significant, as confirmed by the p-values that are all at 0.000.

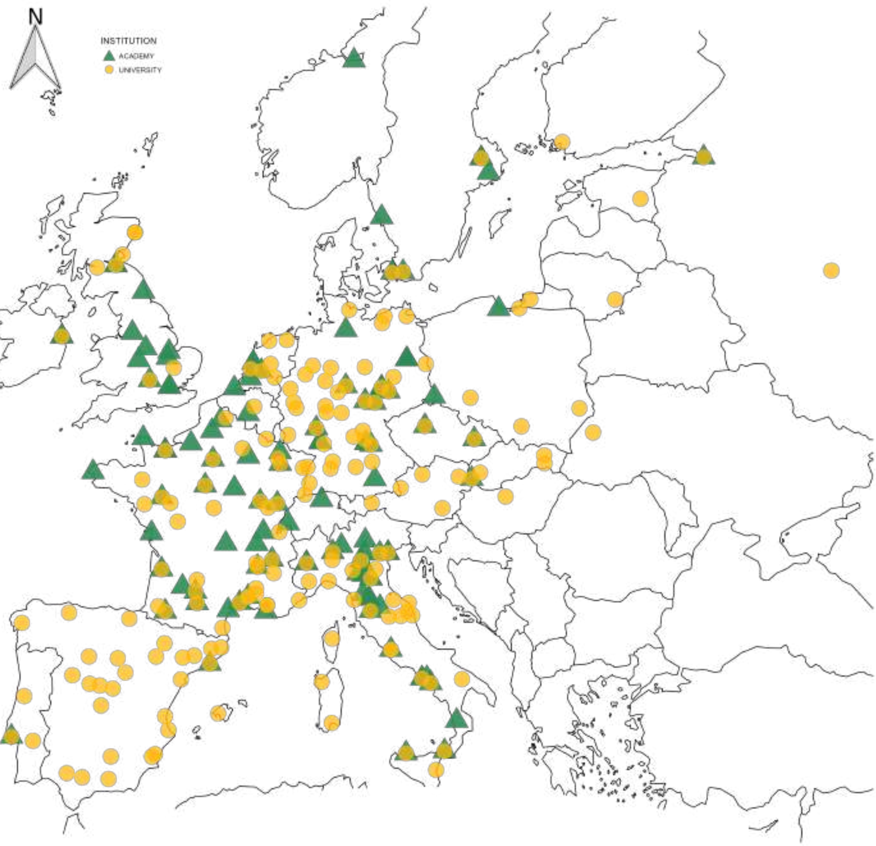


Fig. 1 Locations of higher educational institutions (1000 - 1800 CE): yellow bubbles represent universities, green triangles represent academies. When the two institutions are created in the same city there is an interaction, which is captured by the overlapping of the two shapes. Countries borders are those in the year 2000.

professors there are only scholars active from 1600 onwards - I exclude all the Medieval professors for a better comparison. Moreover, column 3 shows the means for the sample of scholars who were members of both one academy and one university, at least. I present the statistical differences between this last group of scholars and those affiliated only with an academy in column 4 and only with universities in column 5. It is clear that this 'interaction' group differs significantly from the other two subsets of scholars. The only similarity is in the distance between the institution and the place of death: the interaction group seems to die, on average, at the same distance from the institution as university professors.

University quality. Using the individual data on quality, I compute the aggregate level of quality for universities. I adopt the same index as utilized by de la Croix et al. (2023). They employ the human capital indicator of the top five professors who had been working in the institution during the 25 years

Table 2 Summary Statistics about ACAD and UNI members VS ACADxUNI scholars.

	(1) ACAD	(2) UNI	(3) ACADxUNI	(4) t-test vs ACAD	(5) t-test vs UNI
No. of scholars	16500	33150	1166		
	μ	μ	μ	p-value	
Quality	2.38	1.39	3.26	0.000	0.000
Age at Death	67	63	68	0.003	0.000
Age at Appointment	37	32	30	0.000	0.000
Activity Years*	16	12	30	0.000	0.000
Dist. Birth-Institution	344	193	226	0.000	0.027
Dist. Institution-Death	419	173	130	0.000	0.012
Dist. Birth-Death	363	257	250	0.000	0.741

*When interpreting the statistics on activity years, it is important to consider that if there is no precise time frame of activity in the database, academicians are considered active at the academy for their entire lifetime, whereas university professors are considered active for only 8 years (unless they pass away before the end of this period).

before the year when the quality index of the institution is computed (for more details see de la Croix et al. (2023)). I take the average of this index for every 50 years as dependent variable in Section 6.

Fields of study. Furthermore, universities and academies differ not only in terms of quality indexes but also in their fields of study. This distinction is visualized in Figure B5, which displays the number of institutions by main field of study (i.e., the subject studied by the majority of their members). As mentioned earlier, universities primarily focused on literary disciplines such as history, literature, philosophy, ethics, rhetoric, Greek, poetry, along with theology and law as depicted in Figure B5b. On the other hand, Figure B5a illustrates that most academies primarily specialize in the sciences, although 30 of them also engage in humanities studies. Figure B6 shows the partition of fields by country for academies (Figure B6a) and for universities (Figure B6b). Table B2 presents some descriptive statistics on both activity years and fields of study at the aggregate level, differentiating between academies and universities.

4 Empirical strategy

Using the data described in the previous section, this study examines the nexus between having an academy, a university, or both and the economic growth of European cities. The analysis focuses specifically on academies adopting an experimental approach, hence on the period from 1500 to 1900, which allows for the investigation of nine 50-years periods. This time frame includes approximately three periods before and after the creation of an academy. It is important to include periods after 1800 to track what happens after the initial establishments of higher educational institutions.

My empirical strategy proceeds as follows. Initially, simple Ordinary Least Squares (OLS) regressions are presented for different city samples providing preliminary correlations (Section 5.1). Subsequently, to mitigate endogeneity concerns, a difference-in-differences (DID) design is used. First, in Section 5.2, dynamic two-way fixed effects (TWFE) regressions are visualized through panel event studies, treating the creation of a higher educational institution as the event of interest. This approach allows for the examination of pre- and post-event estimates to assess the presence of pre-trends and anticipation effects. However, since this is a staggered setting with the event occurring at different periods in different cities, heterogeneity across time is likely to be present. The traditional TWFE estimator does not recognize heterogeneity and computes the average treatment effect with wrong weights leading to biased estimates (Goodman-Bacon, 2021). Therefore, it is necessary to account for heterogeneity in the treatment effects (Goodman-Bacon, 2021; Roth et al., 2023). As a result, advanced DID estimators developed by Sun and Abraham (2021) (Section 5.3) and by Callaway and Sant'Anna (2021); De Chaisemartin and d'Haultfoeuille (2024) (Section H) are employed to construct more appropriate counterfactuals and a more precise weighting process. The main differences between these estimators are also discussed.

Furthermore, I study the historical evidence that claims a positive effect of creating an academy on the quality of universities. Section 6 presents the analysis using the university quality as outcome variable and provides deeper insights into the interaction between these two types of higher educational institutions.

Finally, Section 7 presents additional analyses testing the Stable Unit Treatment Value Assumption (SUTVA). I also conduct sensitivity analyses by excluding one sample unit from the study and perform spillover effect analyses to examine whether the effects extend beyond the local urban areas.

Overall, this comprehensive approach aims to provide a robust understanding of the relationship between higher educational institutions and population growth of European cities in Early Modern time.

5 Results

5.1 OLS results

Table 3 presents the panel estimations obtained using ordinary least squares (OLS). The table shows the correlation between the natural logarithm of population and the presence of a university, an academy, or both types of higher educational institutions in a European city during the period of analysis (i.e., 1500–1900).

Panel A reports the estimates for the entire sample of 2,096 cities, while Panel B presents the results for a subset of 633 large cities, as defined by Bosker et al. (2013).[25] In my preferred specification, Column 4 in Panel A, I include city fixed effects (city FE) and time fixed effects (time FE). By considering the whole sample, I also capture the effects in smaller urban areas. However, there are no additional controls available for all the cities and periods covered in this analysis. To mitigate omitted variable bias, I include city FE in Columns 2 to 4 of both panels to control for time-invariant city-specific characteristics, although time-varying characteristics cannot be accounted for. Nonetheless, in Appendix C, I argue that including city and time FE already accounts for the most relevant information. I demonstrate this using the sample of big cities for which I have access to time-varying controls as in Bosker et al. (2013). Table C4 shows that including only city and time FE provides the same results as adding time-varying determinants.

Examining the estimates in Panel A, the coefficients associated with the presence of either a university or an academy in the city are positive and statistically significant. The magnitude of the ACAD coefficient is consistently larger than the coefficient for universities. Specifically, comparing Column 2 with Column 3 indicates that the creation of an academy correlates more strongly with economic growth than the creation of a university, providing initial evidence of the importance of these research-driven institutions. However, in Column 4, the interaction term between universities and academies is not significant. Interestingly, the coefficient for the interaction term (UNI:ACAD) has a negative sign, suggesting that adding an academy to a city with an existing university does not increase the correlation with the economic conditions of the local area. If anything, creating an academy appears to have a weaker link with growth in cities that already have a university. Nonetheless, the total correlation of having both educational institutions remains positive and significant. The results in Panel B exhibit a similar pattern. Specifications without city FE, but including country and time FE (Column 1 in both panels), yield stronger coefficients, but they do not control for city-specific characteristics, as reflected in the lower R-squared values.

5.2 Dynamic TWFE results

To reduce endogeneity concerns,[26] I first use dynamic two-way fixed effects (TWFE)[27] estimation and visualize the results using panel event studies (Bhalotra, Clarke, Gomes, & Venkataramani, 2023; Clarke & Tapia-Schythe, 2021; Jacobson, LaLonde, & Sullivan, 1993). This approach allows me to estimate the effect of the $EVENT$ (i.e., the creation of a university or an academy) occurring at different times across different cities. I divide the cities into two groups: the treated group consists of cities that experienced the creation of at least one higher educational institution, while the control group includes

[25] In Bosker et al. (2013), cities are included if they exceed the threshold of 10,000 inhabitants at least once between 800 and 1800 (633 European cities). In my sample, I include all cities that exceed the threshold of 5,000 inhabitants at least once between 700 and 2000 (2,096 cities).

[26] As discussed in the introduction, I can only mitigate reverse causality issues, acknowledging that endogeneity concerns cannot be fully addressed solely using a DID framework.

[27] Appendix D presents the static TWFE estimates.

Table 3 Results: OLS estimator

	Dependent Variable: ln pop in 1500-1900			
	Panel A: ALL cities			
	(1)	(2)	(3)	(4)
UNI	1.108***	0.162**		0.142**
	(0.078)	(0.071)		(0.056)
ACAD	1.745***		0.308**	0.319**
	(0.228)		(0.118)	(0.131)
UNI:ACAD	−0.999***			−0.060
	(0.323)			(0.224)
Obs.	2096	2096	2096	2096
R^2	0.444	0.805	0.805	0.801
	Panel B: BIG cities			
	(1)	(2)	(3)	(4)
UNI	0.737***	0.099		0.102*
	(0.086)	(0.061)		(0.061)
ACAD	1.256***		0.256**	0.346**
	(0.256)		(0.115)	(0.163)
UNI:ACAD	−0.510			−0.234
	(0.330)			(0.213)
Obs.	633	633	633	633
R^2	0.464	0.740	0.741	0.742
city FE	NO	YES	YES	YES
time FE	YES	YES	YES	YES
country FE	YES	NO	NO	NO

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors in parenthesis clustered at city level.

cities that did not have such institutions. The outcome variable used for the dynamic analysis is the growth rate of the natural logarithm of city population, denoted as $\Delta lnPOP_{ct}$, where c represents the city and t denotes the time period. The event-study specification is expressed as follows:

$$\begin{aligned}\Delta lnPOP_{ct} = \beta_0 + &\sum_{l=2}^{5} {\beta_l}^{lead} EVENT_c \times \mathbb{1}\{lead_t = l\} + \\ &\sum_{k=0}^{3} {\beta_k}^{lag} EVENT_c \times \mathbb{1}\{lag_t = k\} + \\ &\mu_c + \lambda_t + \epsilon_{ct}\end{aligned} \tag{1}$$

In equation 1, μ_c represents city fixed effects (city FE), λ_t represents time fixed effects (time FE), and ϵ_{ct} is the unobserved error term. There are no time-varying controls. The variable l denotes the number of leads (pre-event estimates), and k denotes the number of lags (post-event estimates) used to capture the impact of the events. The first lead is omitted as the baseline reference for comparing differences between treated and untreated cities.

It is important to note that, by design, the event-study approach assumes absorbing states, meaning that once a higher educational institution is created, it remains open until the end of the period considered. Consequently, the analysis focuses on the intention-to-treat (ITT) effect, examining the impact on local economic prosperity between 1500 and 1900 in cities where a university or an academy was created before 1800.

For the event-study estimates to be reliable, three key assumptions must hold: the *parallel trends assumption* (which posits that cities without higher educational institutions would have experienced the same growth rate evolution as treated cities), the *no anticipation effect assumption* (which suggests that no significant changes in the growth rate occurred immediately before the creation of a higher educational institution in treated cities), and the *Stable Unit Treatment Value Assumption* (SUTVA), which assumes that the population growth rate of one city does not depend on the growth rate of another city. The results using the dynamic TWFE specification are presented in Appendix F, confirming the first two hypotheses. Additionally, Section 7.2 provides further analyses to assess the validity of the SUTVA assumption and investigates whether the observed effects reflect local impacts (Berkes & Nencka, 2021; Butts, 2021).

5.3 Main findings: IW results

Recent literature on Difference-in-Differences (DID) designs has highlighted potential biases in classical dynamic Two-Way Fixed Effects (TWFE) estimates when events occur at different times in different cities, leading to heterogeneous effects (Goodman-Bacon, 2021; Roth et al., 2023). In my context, it is reasonable to expect that the impact of creating an academy in Oxford in 1651 differs from creating one in Turin in 1757, just as creating a university in Lund in 1666 may have a different effect than creating one in Seville in 1505. The presence of heterogeneity across cities is evident, and the dynamic estimates presented in the previous section suggest heterogeneity across periods as well.

In simple contexts, when the event happens only once (2x2 DID), there is no heterogeneity across time, which eliminates one of the main concerns of having negative weights, as explained below. I present these simple event studies in Appendix G, where I plot the coefficients of dynamic TWFE regressions, selecting only one period at a time for the creation of an academy or a university. As expected, the post-event effects are not constant over time and vary according to the year of creation, implying the presence of heterogeneity.

In more complex settings, where events occur in multiple periods across multiple units, the issue of heterogeneity becomes more pronounced. This is because dynamic TWFE estimates incorporate a weighted sum of all simple 2x2 DID estimates, sometimes with "wrong/negative" weights (Goodman-Bacon, 2021). These negative weights primarily arise in the 2x2 DID estimates between later- and earlier-treated units (Jakiela, 2021). To illustrate this, consider the case where the creation of a university increases the population growth rate in every city, but the effect is stronger when the university is created in 1700 (early-treated cities) compared to 1800 (later-treated cities). The simple 2x2 DID estimate between later- and earlier-treated cities would cancel out the positive effect on the later-treated cities because the control group (earlier-treated cities) would have already experienced faster growth. Consequently, this 2x2 DID estimate would be associated with a negative weight, despite both groups of cities showing positive growth.

In my research, I expect universities to be more susceptible to negative weights than academies, given their greater heterogeneity across time (Figure B2). This is also evident when comparing Figure G15 with Figure G16. Figure G15 shows that academies created later, in 1750 and 1800, mostly increase city populations, while universities created in 1700 have a larger impact than those created in 1800. I formally identify this issue by calculating the proportion of negative weights for both events: the $ACADEMY$ event does not exhibit negative weights, whereas the $UNIVERSITY$ event has negative weights amounting to 2.7% of the total weights. Although negative weights are detected for universities, it is reassuring that the percentage is not excessively large.

Using heterogeneity-robust estimators for staggered timing is a valuable approach to address biases in the dynamic TWFE estimator and obtain more reliable average treatment effect estimates in the presence of heterogeneity across time and space, even when negative weights are not a significant concern (De Chaisemartin & D'haultfœuille, 2023). In my analysis, I employ four of the new heterogeneity-robust estimators: Sun and Abraham (2021), De Chaisemartin and d'Haultfoeuille (2022), De Chaisemartin and d'Haultfoeuille (2020), and Callaway and Sant'Anna (2021). In brief, these estimators control for heterogeneity by constructing the counterfactual in more robust ways than the dynamic TWFE, leading to a more appropriate weighting procedure.

I am interested in the dynamic effects of creating an educational institution. Specifically, I aim to determine the average effect of opening an academy or a university in each period since its creation. In other words, I seek to obtain a coefficient summarizing the effect on city population for each cohort of cities, where a cohort (from here onwards) is defined as a group of cities where an educational institution was created in a specific period of time.

My main results are derived using the "interaction-weighted" estimator (IW estimator) developed by Sun and Abraham (2021). The authors propose a new regression-based approach in which they estimate a weighted average of the cohort-specific average treatment effect on the treated (CATT) for each period relative to the initial treatment. They provide interpretable and robust non-negative weights. The method is termed the "*interaction*-weighted" estimator because it interacts relative period l indicators with cohort e indicators. Once the control cohort is defined, the coefficient estimator consistently estimates CATTe, l via a two-way fixed effects specification. After estimating the reasonable weights as shares of sample cohorts e in relevant l periods, Sun and Abraham (2021) construct the IW estimator by taking the weighted average of the estimated CATTe, l.

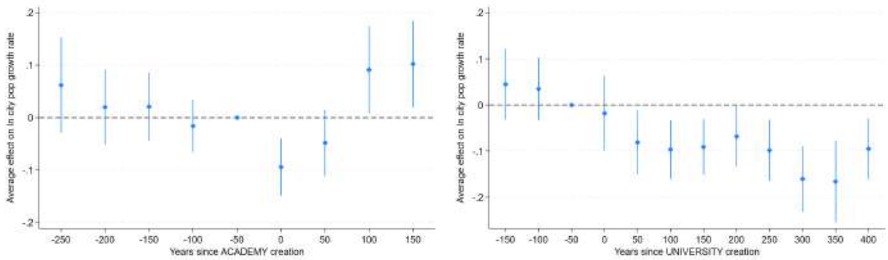
I have a group of cities that never hosted an academy or a university, so I define these never-treated cohorts as the control groups in the respective event study. In the following paragraph, I present the results using the IW estimator by Sun and Abraham (2021), which allows for a more unbiased understanding of the effects of creating academies and universities between 1500 and 1800 in my sample of European cities. I include outcome variables up to 1900 to ensure enough post-event periods, which is possible under the assumption that once a unit is treated, it remains treated (e.g., Intention To Treat). However, including the nineteenth century in the analysis increases the number of outliers—cities with a population growth rate higher than 200%—which I exclude from my event studies to obtain more conservative estimates.[28] The total number of observations is now reduced to 2,056, with 152 universities and 82 academies, as Saint Petersburg, with its university and academy, is part of the outliers.

Figure 2a presents the average treatment effect of creating an academy between 1500 and 1800. The plotted coefficients are relative to five periods prior and three periods after the creation, allowing for the estimation of effects on a sufficiently balanced number of units for each relative period. The first lead is omitted as the baseline period. The pre-trends assumption holds, and I observe an immediate negative impact, which is more than compensated for in the following century. Cities with an academy at a given point in time experience faster economic growth compared to cities without academies, especially after 100 years from their establishment. In general, the dynamics resemble the path seen in the classical dynamic TWFE regression in Figure F10a: a decline for the first 50 years (−9.4%, p-value: 0.005), followed by an increase in the next century (to around 10% on average, p-value: 0.05).

Figure 2b shows similar effects of creating a university between 1500 and 1800, also using Sun and Abraham (2021). In this case, I plot three pre-periods and eight post-periods to balance the number of treated units by period (i.e., frequencies). I do not find significant pre-trends, and there is a more or less consistent negative effect of creating a university from its establishment until 400 years later, compared to cities without universities. After 100 years, the negative effect is 9.6% (p-value: 0.013), and after 300 years, universities decrease city population by 16% (p-value: 0.000) on average. After

[28] Out of 40 outliers, only Bekescsaba (HUN), Cacares (ESP), Chaves (PRT), Kronslot (RUS), Le Creusot (FRA), Montceau-les-Mines (FRA), Orel (RUS), Rochefort (FRA), Saint Petersburg (RUS), Tameside (UK), Valletta (MLT), and Versailles (FRA) grew above 200% before (and including) 1800.

400 years, the decrease stabilizes around 9.5% (p-value: 0.018). These findings may seem surprising at first, but they may be also explained by the teaching style prevalent at universities. Adam Smith, in his book The Wealth of Nations (Book V), describes how professors at the University of Oxford would merely read ancient texts in foreign/dead languages, adding only occasional comments when they deemed necessary (Smith, 1776). This minimal approach to teaching, which required very little actual knowledge, might have represented a significant waste of resources. Consequently, this explains how universities could have such a negative influence on local economies.



(a) (b)

Fig. 2 Effect of creating (a) an academy and (b) a university between 1500 and 1900 estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: city population growth rate in logarithm.

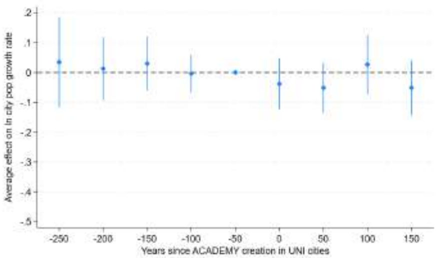


Fig. 3 Effect of creating an academy between 1500 and 1900 in cities that hosted a university at least once estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: city population growth rate in logarithm.

To investigate the interaction between universities and academies, I select only cities that had a university at least once at a certain point in time, and I apply Sun and Abraham (2021) to estimate the average effect of creating an academy in those cities. The sample reduces to 152 cities, decreasing the statistical power as well. Indeed, Figure 3 shows that there is no significant change in the economic growth of cities that hosted a university when an innovative academy is created, compared to cities that had only a university at least once. Again, there is a downward trend, implying a negative marginal effect of creating an academy in a city with a more traditional university. Only one coefficient (after 100 years) remains slightly positive but with an effect not significantly different from zero.

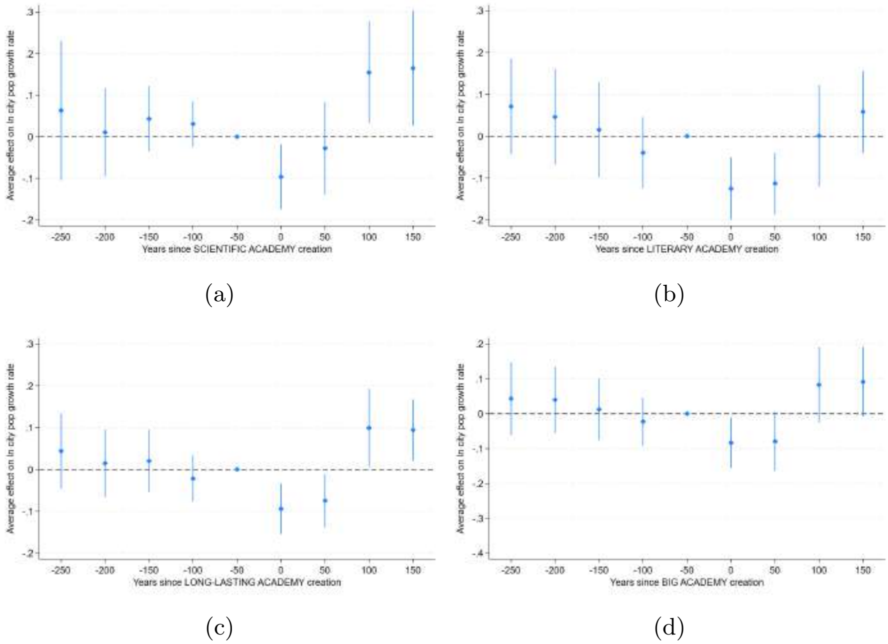


Fig. 4 Effect of creating (a) a scientific academy, (b) a literary academy, (c) a long-lasting academy (with more than 30 years of activity), and (d) a big academy (with more than 30 members) between 1500 and 1900 estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: city population growth rate in logarithm.

As with the dynamic TWFE in Appendix F, I further analyze the *ACADEMY* event by studying the field, the length of the activity period, and the size of the academies created. Figure 4 shows the estimated coefficients using Sun and Abraham (2021) for scientific, literary, long-lasting,[29] and big academies,[30] respectively. In each case, I consider five pre-periods and three post-periods to balance the frequencies and ensure consistency. The same pattern as in the general case is observed for long-lasting academies (Figure 4c), while big academies (Figure 4d) show less significance.

More interestingly, the field of study is the key factor that matters. Figure 4b shows the average effect of creating a literary academy, with no pre-trends or anticipation effect. The immediate negative effect in cities that created a literary academy is striking—these cities experience a lower growth rate of

[29]Recall that *long-lasting* academies are those that lasted more than 30 years.
[30]Recall that *large* academies are those with more than 30 members.

between 12.5% and 11.2% (p-value: 0.006 and 0.012, respectively) during the first 50 years relative to cities without a literary academy. This negative effect disappears in the next 50 years, with coefficients slightly positive but not statistically different from zero. While this result is challenging to interpret, it seems to support the idea presented by Murphy et al. (1991), suggesting that some occupations may be rent-seeking, using resources without generating economic returns, leading to a negative overall effect. Recent empirical literature also suggests that regions more involved in Catholic traditions grow more slowly than their counterparts due to a more religious and less technical education system (Squicciarini, 2020). Similarly, Curtis and de la Croix (2023b) shows that income per capita is negatively influenced by the presence of scholars studying law in the region.

It seems that scientific subjects are the ones that truly matter for long-term growth. When studying the creation of scientific academies in Figure 4a, I show that cities where the academy had more than 50% of its members studying science, applied science, and medicine experience faster economic growth—by 15% (p-value: 0.038) after 100 years relative to cities without a scientific academy. This faster growth persists until the end of the sample period, with cities hosting scientific academies growing 16.5% faster after 150 years from their establishment.

These results align with those found in Appendix F, confirming that the field of study matters, and specifically, that scientific subjects have a positive and significant effect on city population growth on average. Additionally, by using the entire sample of academies that adopted the scientific approach and experimental procedures, I can claim that critical thinking has the strongest effect when associated with scientific subjects, which are also more directly linked to the practical needs of local communities. This is further confirmed in Section 6 where I explain the connection between the creation of academies and the quality of universities.

In the appendix, I present alternative DID estimators following Callaway and Sant'Anna (2021), De Chaisemartin and d'Haultfoeuille (2020), and De Chaisemartin and d'Haultfoeuille (2022) as robustness checks. All the main results are confirmed, and I summarize them as follows. Using Callaway and Sant'Anna (2021), Figure H19 sshows that creating scientific academies significantly impacts population growth rates, increasing them by 22% (p-value: 0.006) 150 years after the academy's creation, with a total average post-treatment effect of 11.2% (p-value: 0.056). Employing De Chaisemartin and d'Haultfoeuille (2020) and De Chaisemartin and d'Haultfoeuille (2022), Figure H21a shows that population growth rates are 16.6% (SE: 0.075) higher 150 years after the creation of scientific academies compared to cities without scientific academies. On the other hand, literary academies have a significant negative impact on city population growth rates, decreasing by 12–13% during the first 50 years after their creation.

These findings align with the event study estimates, indicating that the field of study of an academy—whether scientific or literary—has a significant impact on population growth rates. Scientific academies have a positive effect, while literary academies have a negative effect, at least in the short term. Moreover, these results highlight the importance of collecting micro-level data to precisely assess the impact of high-level human capital before the Industrial Revolution.

6 Quality of Universities

Up to this point, my investigation has focused primarily on the direct link between educational institutions and the economic growth of cities. However, there are other avenues through which the establishment of academic institutions could impact local urban areas. I begin by exploring the effect of creating academies on the quality of universities.

In this section, I examine historical evidence on the role of academies in fostering university innovations and reforms. My dataset allows me to measure university quality over time, within the same period considered in Section 5.3. Thus, I can consistently apply the same identification strategy used thus far, relying on the DID design.

While exploring the connection between university quality and the establishment of academies provides insights into the direction of the effect, it does not fully resolve the underlying endogeneity issue present in the analysis. Nevertheless, defining the relationship between innovative academies and university quality remains of significant interest: it offers valuable insights into the modernization process that ultimately transformed European universities into modern, professionally-oriented institutions by the 19th century.

The computation of university quality is based on the aggregated quality of the top five professors who taught there in the preceding 25 years (for technical specifics, refer to de la Croix et al. (2023)). Using the information available in the database, I calculate the average university quality for every 50-year interval up to 1800. This approach enables me to replicate the same DID design employed in the previous section. Here, I present results using my preferred DID estimator Sun and Abraham (2021), while Appendix I.2 provides event studies generated through dynamic TWFE regressions. I consistently include only two lags in the analyses to balance event frequencies, as university quality data is available only until 1800. The last dynamic effects would otherwise imprecisely estimate the relative coefficients, considering only the first academy, the *Accademia degli Investiganti*, exactly founded in 1650.

Figure 5 illustrates the impact of academy establishment on university quality using the estimator outlined in Sun and Abraham (2021). The parallel trends are consistent, with no significant negative leads. Furthermore, similar to the main results, no significant effects are observed after the establishment of academies. The creation of an academy in cities that already have a university

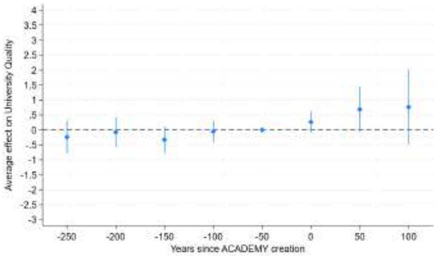


Fig. 5 Effect of creating an academy between 1500 and 1800 in cities that hosted a university at least once estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: quality of universities.

does not appear to improve the quality of the university compared to cities with universities but without academies.

The effect becomes evident only with the creation of purely scientific academies, as shown in Figure 6a. The effect is remarkably significant and positive after 50 years: the establishment of a scientific academy increases university quality by a coefficient of 1.84 (p-value: 0.02), representing an average increase of almost 60% compared to pre-treatment statistics ($\mu = 3.18$, $sd = 2.29$). Using the methodology of Callaway and Sant'Anna (2021), I observe a positive average treatment effect on the treated, with a coefficient of 0.83 (p-value: 0.067), and no indication of pre-trends. This general effect is driven primarily by the first lag. Thus, considering both the main results and those presented in this section, I demonstrate that the creation of a scientific academy has a significant impact on university quality in cities compared to those that experienced the establishment of a university but did not see the creation of a scientific academy.

In contrast, literary academies show no significant positive effects. While the parallel trend is still confirmed, the average treatment effect on the treated is negative but statistically insignificant. This suggests that the creation of a literary academy does not lead to an improvement in university quality, which aligns with the findings in the main text.

Finally, event studies examining long-lasting[31] and large academies[32] suggest a positive influence on university quality for the latter. Figure 6c and Figure 6d present the respective results.

In cities that had a university at least once, the establishment of long-lasting academies does not appear to affect university quality. The control group here includes cities with universities but without long-lasting academies. Placebo estimates are not significant, confirming the presence of parallel trends. Using Callaway and Sant'Anna (2021), I find a positive, though not significant, average treatment effect on the treated, with a coefficient of 0.44 (p-value: 0.124).

[31] Long-lasting academies are those that have been active for more than 30 years.
[32] Large academies are those with more than 30 members.

When examining the establishment of large academies in university cities, a positive and significant effect is observed over the 100 years following academy creation. The coefficients indicate an immediate average increase of 45%, growing to 63% after 100 years (pre-treatment stats: μ 2.71, *sd* 2.23). These results support the importance of large academies, whose role may have been underestimated in the main analysis. Average treatment effects using Callaway and Sant'Anna (2021) confirm both the absence of pre-trends and a significant post-treatment effect. Hosting a large academy has an average treatment effect on the treated of 0.71 (p-value: 0.04), indicating that the presence of such academies substantially improves the quality of universities in their respective cities.

These findings are particularly interesting because they not only confirm the relevance of scientific academies in improving university quality but also suggest that the size of the academy may play a crucial role in modernizing local universities.

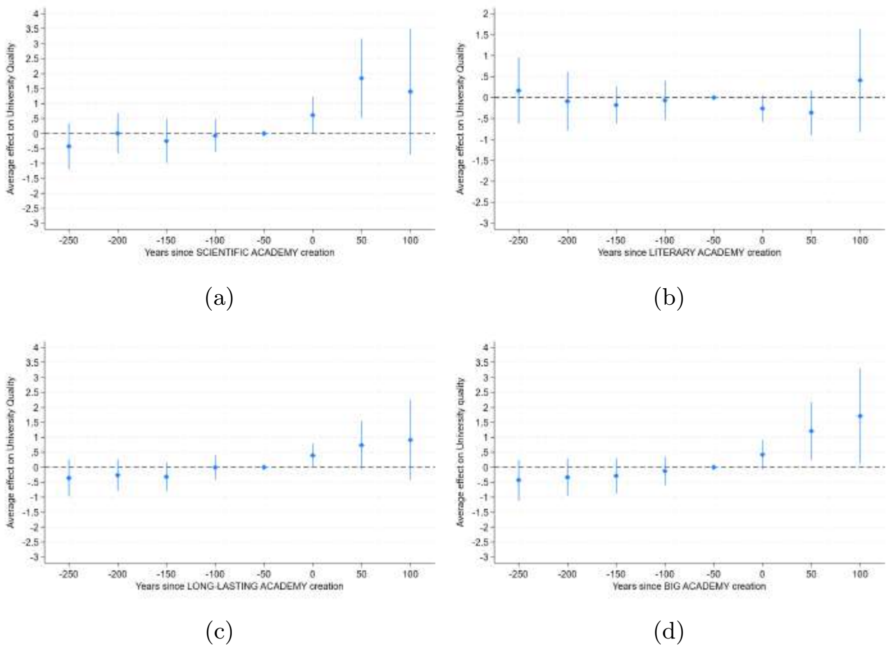


Fig. 6 Effect of creating (a) a scientific academy, (b) a literary academy, (c) a long-lasting academy (with more than 30 years of activity), and (d) a big academy (with more than 30 members) between 1500 and 1800 estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: quality of universities.

In addition, it is interesting to explore whether universities of higher quality have a different impact on the economic development of cities that either (i) do not have a university or (ii) do not have an outstanding university. In the following analysis, I examine these two cases. I define "top" universities as those institutions that achieve an average quality of at least 4.53 during any period of activity. This threshold corresponds to the third quartile of university quality in 1800, the final year of the analysis.[33]

I begin by presenting the results for the entire sample of cities, investigating the effect of a top university relative to cities without a university. The results using Sun and Abraham (2021) are provided in the Appendix. Figure I23a does not show highly significant effects, except for the period between 100 and 350 years after the university's creation (i.e., from the 2^{nd} to the 7^{th} lag), where the coefficients are slightly significant (p-value: 0.07 on average) and still negative, with an average magnitude of approximately -14%. Nevertheless, Figure I23 does indicate, if anything, an improvement compared to the main results in Figure 2b, where the creation of a university had a clearly negative impact on local economies compared to cities without universities. Figure I23b extends the analysis to the period between 1000 and 1900. The only significant and negative coefficients occur at 100 years (-10%, p-value: 0.05) and 300 years (-9%, p-value: 0.09); the other coefficients remain negative but are no longer significant.

In Figure I24, I present results for the creation of top universities, considering only cities that have had a (non-top) university as the control group. This increases the similarity between the control and treated groups, though it lowers the statistical power. Figure I24a examines universities founded between 1500 and 1800. It is notable that the negative effects are smaller after the creation of a top university, with coefficients approaching zero as the timeline extends to 450 years. Figure I24b, which goes back to the year 1000 to include more university creations, shows a more generalized zero effect, though with small magnitudes.

7 Additional analyses

In this section, I provide sensitivity analyses to better understand the specific effects of certain units of analysis. In Section 7.1, I examine the impact of excluding major cities such as London and Paris, as well as entire countries that host a large number of innovative academies, including France, Italy, Germany, and the UK.

Additionally, in Section 7.2 I explore the potential for spillover effects from nearby cities. It is possible that the creation of an academy in one city could be influenced not only by the characteristics of that specific urban area but

[33]Top universities selected using this criterion are located in the following cities: Alcala-de-Henares (SPA), Basel (CHE), Bologna (ITA), Cambridge (UK), Coimbra (PRT), Douai (FRA), Edinburgh (UK), Erfurt (DEU), Erlangen (DUE), Franeker (NLD), Frankfurt am Oder (DEU), Freiburg (DEU), Geneve (CHE), Giessen (DEU), Glasgow (UK), Göttingen (DEU), Greifswald (DEU), Halle (DEU), Heidelberg (DEU), Helmstedt (DEU), Iena (DEU), Ingolstadt (DEU), Kalingrad (RUS), Kiel (DEU), Copenhagen (DNK), Köln (DEU), Krakow (POL), Leiden (NLD), Leipzig (DEU), Leuven (DEU), Lund (SWE), Marburg (DEU), Montpellier (FRA), Napoli (ITA), Oxford (UK), Padova (ITA), Paris (FRA), Pavia (ITA), Pisa (ITA), Roma (ITA), Rostock (DEU), Salamanca (SPA), Strasbourg (FRA), Torino (ITA), T́ubingen, Turku (FIN), Uppsala (SWE), Utrecht (NLD), Valencia (SPA), Vilnjus (LTU), Wien (AUT), Wittenberg (DEU).

also by those of nearby cities, which could introduce bias into the DID estimator. I provide evidence showing that this is not a concern, demonstrating the coefficients for the unbiased local effect.

Finally, Section 7.3 presents the spillover effects obtained through "donut" regressions, where I allow for the influence of academies to extend beyond the immediate urban center. The interpretation of these results reveals interesting dynamics, which again depend on the academic fields studied at the institution.

7.1 Sensitivity analyses: leave-one-out

Maintaining a European perspective has the advantage of offering a comprehensive and general analysis. However, it is possible that certain specific units of analysis may heavily influence the results. For instance, cities hosting the most prominent academies, such as London and Paris, could disproportionately drive the findings. This effect could also occur at the country level, where one nation might dominate the outcomes discussed above. If this is the case, the effects cannot be attributed to Europe as a whole but rather to that specific unit. Therefore, I conduct a sensitivity analysis to determine whether certain cities or countries are driving my results.

I begin by excluding London and Paris from the analysis, followed by the four countries with the largest number of academies: France, Italy, Germany, and the UK. I exclude each unit one at a time to assess its individual impact, comparing the results to my main findings using the *IW* estimator from Sun and Abraham (2021).

Excluding London does not affect the results, as the coefficients from the event studies on academy creation remain largely unchanged, regardless of the type of academy analyzed. The same is true when Paris is excluded from the sample, where the coefficients slightly increase in magnitude but show no change in significance. Appendix J.1 and J.2 provide graphical representations of these results. Overall, the main findings remain consistent even when excluding the most renowned centers of scientific knowledge and innovation. This not only demonstrates the robustness of the analysis but also reduces concerns about endogeneity.

Maintaining a European perspective throughout the paper allows me to exclude an entire country while retaining enough statistical power to assess its relative importance compared to the entire sample. I begin by excluding France, which hosts the largest number of academies, followed by Italy, Germany, and the UK. France significantly affects the results, as it contains the most academies (30 out of 83) and universities (34 out of 153). In the main event studies, excluding France slightly reduces the significance of the negative coefficient found immediately after an academy's establishment.[34] Excluding

[34] With France, the coefficient was −9.4% (p-value: 0.005); without France, the magnitude remains at −10%, but the p-value rises to 0.015.

France also increases the positive effect observed at the 100-year mark; excluding French urban areas, cities hosting academies show a population growth rate 17% higher (p-value: 0.01) compared to cities without academies (previously 9% with a p-value of 0.07). Overall, excluding France only slightly alters the results, primarily by amplifying the positive impact of academy creation. Figure J31 displays these results. This effect can be explained by France's unique history: excluding the country removes the negative shocks it experienced during the 18th century. In 1793, the French Revolutionary Convention sought to sever all cultural ties with the *Ancien Régime*. On August 8th, 1793, the National Convention decreed the "suppression of all academies and literary societies licensed or endowed by the nation" (Taillefer, 1984). The second article of this decree mandated the closure of academies and the confiscation of all their materials, including "books, manuscripts, medals, machines, tables, and other objects," which were placed in storage. The buildings were also seized and sold as national property in the subsequent years (Taillefer, 1984).

Regarding other outcomes, I find similar effects with or without France when analyzing the creation of academies in cities that have ever hosted a university (Figure J31e)or when examining the impact of $ACAD$ on university quality (Figure J31b). MAdditionally, excluding France does not significantly alter the results concerning university creation (UNI), which remain negative and significant, and the same holds true when extending the time frame from 1000 to 1900 (Figure J31c and J31d).

The most challenging results to interpret arise when analyzing specific academies after excluding France, including purely scientific, literary, long-lasting, and large academies. Without France, the creation of scientific academies no longer has a negative impact on population growth within the first 50 years. Moreover, excluding French cities leads to a 19% faster growth rate for cities with scientific academies 100 years after their creation—a larger magnitude compared to the baseline. However, when testing the influence of scientific academies on university quality, excluding France lowers statistical significance while keeping the magnitude unchanged, suggesting that the regression's statistical power is insufficient to fully interpret the results(Figure J32a and J32b).[35] For literary academies, excluding France slightly mitigates the negative effects on population growth observed within the first 50 years (Figure J32c).As for university quality, literary academies in the rest of Europe remain insignificant, similar to the main findings (Figure J32d). Excluding France increases the positive impact of long-lasting academies on population growth after 100 years[36], without altering the results on university quality, which remain insignificant (Figures J32e and J32f). For large academies, excluding France has minimal impact on the results (Figure J32g and J32h).

Excluding other countries does not affect the results in the same way as excluding France. Removing Italy decreases the significance of the results: the

[35] France hosts 10 out of the 38 scientific academies in the sample.
[36] With France, long-lasting academies foster growth by 10%, while without France the effect rises to 19%.

ACAD event shows no strong positive effect, with only a slightly significant coefficient 100 years after academy creation (Figure J33a). However, the results on university quality remain unchanged. The main findings also hold when delving into the types of academies created: without Italy, scientific academies still have a significant positive effect after 100 years (+17%), increasing to 20% by the end of the sample period compared to cities without scientific academies (Figure J34a). These effects remain strong for university quality as well (Figure J34b). Appendix J.4 presents all event studies.

Excluding Germany delays the positive impact of the *ACAD* event (Figure J35a). This is driven by scientific, long-lasting, and large academies: when German cities are excluded, the positive effects of these academies become highly significant only after 150 years, rather than 100. This delay is explained by the fact that German academies were established around 1755, while the average creation date for the whole sample is 1741. Although the difference is only 15 years, it aligns with the cut-off point for sample periods, shifting the results by 50 years. All other findings, including those related to university quality, remain unchanged. The graphical representations are provided in Appendix J.5.

Excluding the UK does not significantly alter the baseline results on population growth: the *ACAD* event shows an immediate negative effect that is more than offset after 100 years. The analyses regarding field of study, academy size, and years of activity remain unchanged, as do the findings when university quality is used as the outcome variable. Appendix J.6 contains all relevant results.

7.2 Local effects

Up until now, I have assumed that the main event studies capture only the local effect of creating an academy. However, it is possible that the influence of such institutions extends beyond the boundaries of a single municipality, potentially affecting nearby cities. If this were the case, the treatment effects might violate the Stable Unit Treatment Value Assumption (SUTVA)—a key assumption for unbiased event studies. SUTVA requires that the effects depend solely on the status of treated cities and not on neighboring cities. To address this, a common strategy is to exclude nearby cities, thus accounting for potential spatial spillovers Butts (2021). This approach refines the construction of the counterfactual, ensuring that cities indirectly impacted by spillovers are excluded from the sample. By doing so, the analysis can provide a more accurate estimate of the local effect of creating an innovative academy within a particular city. The resulting estimator will yield unbiased coefficients, provided that all nearby cities potentially affected by the treatment are excluded from the sample.

Following the methodology of Johnson, Thomas, and Taylor (2023), who examine spatial spillovers for a historical period similar to the one considered in this paper, I exclude cities within a 50, 100, and 150 km radius of an academy.[37] If the primary results hold after this adjustment, the effects identified can be considered the unbiased local effects of creating an academy in a specific urban area. In this section, I focus solely on academies and do not analyze spatial spillovers for universities, given the zero effect found in the analysis of university creation.

When excluding cities within a 50 km radius from the nearest academy, the results remain consistent in terms of population growth rates. As expected, the significance diminishes due to the reduced sample size (now 1,642 cities, down from 2,056). However, excluding cities within 100 and 150 km produces slight changes: the magnitude of negative coefficients increases within the first 50 years, while the magnitude of positive coefficients—found after 100 years—diminishes until they are no longer relevant. Despite this, the positive coefficients related to university quality remain present, although they are not statistically significant, as in the baseline results. These findings are displayed in Figure K39.

Figure K40 shows the event studies for academy creation in cities that previously hosted a university. Once again, the trends are consistent with the main results.

In the analysis of spatial spillovers for specific types of academies—scientific, literary, long-lasting, and large academies—I exclude cities located near the respective academy type. I find no substantial variations compared to the main results when excluding cities within a 50, 100, or 150 km radius. Scientific academies (Figure K41) exhibit a positive effect on population growth rates since 100 years from their creation, reaching a 16.8% increase after 150 years, and they also enhance university quality by around 43% on average (pre-treatment stats: μ 3.18, *sd* 2.29), within the first 50 years. Literary academies (Figure K42) reduce population growth by around 12% within the first 50 years but have no significant effect on university quality within the same city. The results for long-lasting and large academies align with the main findings (Figure K43 and Figure K44, respectively): both types of academies initially have a negative impact on population growth in the first 50 years but experience a strong recovery in the following century. Additionally, large academies significantly improve university quality during this period.

7.3 Spillover effects

In this section, I examine potential spatial spillover effects from the creation of different types of academies. This complements the previous section, where I estimated the local effect. Now, I assess the impact on cities located further away from the treated cities, applying a standard spatial analysis technique (Butts, 2021; Keller & Shiue, 2021). Specifically, I create "donuts" around the treated city—the academy-hosting city—using cities within these donuts as treated groups and those further away as controls. To focus on spillover effects,

[37] I do not extend the radius beyond 150 km in order to maintain sufficient statistical power.

the treated city itself is excluded. Due to statistical power constraints, the maximum radius for these donuts is 25 kilometers: I analyze areas 0-25 km, 25-50 km, and 50-75 km from the treated city.[38]

The findings reveal a consistent pattern for cities within the 0-25 km donut: while cities further away experience no immediate effects (with insignificant coefficients at time 0), they show a positive and significant impact roughly 50 years after the academy's creation. This positive effect, however, trends downward over time, with coefficients turning insignificant by 100 years and eventually becoming negative (though still insignificant) in later periods.[39]

This pattern—significant positive effects at 50 years followed by a decline—persists, particularly for scientific and larger academies. Cities within 25 km seem to benefit earlier (from 0 to 50 years) compared to the host cities, which only see positive effects between 50 and 100 years after the academy's creation. However, while the hosting cities retain long-term benefits, the positive effect fades for the surrounding cities. This might reflect the hosting cities absorbing the upfront costs of establishing the academy, while nearby cities benefit from spillover effects without incurring those costs. In the long run, however, the hosting cities continue to benefit while the spillover effects dissipate in surrounding areas.

For cities within the 25-50 km and 50-75 km donuts, I find no evidence of positive spillovers. After excluding the nearest cities (i.e., those hosting academies and those within 25 km or 50 km), these cities do not experience significant impacts within the first 50 years. Over time, they show a slightly significant negative effect, with the 25-50 km donut exhibiting more significant results than the 50-75 km one. This suggests that cities may bear some costs of not having an academy close enough. This pattern is most evident for larger academies, while for scientific academies, the effects in these two donuts remain flat.

For long-lasting academies, there is no significant spillover effect; the general pattern holds.

The results for literary academies differ. For the 0-25 km donut, statistical power is insufficient to draw robust conclusions.[40] However, in the 25-50 km and 50-75 km donuts, a progressively negative impact emerges: cities within the 25-50 km donut experience slower growth, with a 4% reduction initially and an 11% reduction after 100 years. A similar but slightly more significant effect is observed for cities in the 50-75 km donut.

As discussed in the main analysis, literary academies negatively impact host cities during the first 50 years. However, the negative effect on surrounding cities appears to persist over time. This could be explained by resource allocation toward low-return activities: resources drawn from surrounding areas

[38] I explored spillovers up to 150 km, but beyond 100 km the results became random due to limited statistical power.

[39] Note that for the last lag, I used fewer frequencies, which should be considered when interpreting the results.

[40] The maximum number of frequencies for the first donut is 58, compared to 186 and 388 for the other two.

may slow growth locally, while the benefits of producing capable professionals, like lawyers or historians, are confined to the hosting cities. Thus, while these cities eventually recover, the surrounding cities continue to experience diminished growth.

8 Conclusions

The primary goal of this paper is to explore the long-term role of higher educational institutions in economic development. Using advanced econometric techniques, I provide new insights into the economic impact of Early Modern academies across European cities from 1500 to 1800. This research contributes to several key strands of the existing literature, offering fresh perspectives on the relationship between educational institutions and economic growth, especially in the period before the Industrial Revolution.

At the heart of this study is a unique dataset of academicians and university professors, comprising over 76,000 scholars from more than 380 institutions. With this comprehensive database, I developed a robust difference-in-differences (DID) design to analyze the establishment and evolution of higher educational institutions. The individual-level information within the dataset proved crucial in addressing contentious issues in the literature and refining our understanding of the economic impact of these institutions.

When evaluating economic growth directly through population growth rates, my findings reveal that academies had a delayed positive effect, with an initial decline. Notably, academies focused on scientific disciplines exhibited a strong and persistent positive impact: cities hosting these institutions experienced approximately 15% higher population growth after 100 years. In contrast, literary academies had a temporary negative effect on population growth during the first 50 years. These results highlight the nuanced relationship between education and economic dynamics in historical contexts.

Turning to universities and selecting those with higher quality, my research aligns with previous studies, finding no significant impact on population growth rates. This suggests that universities of the time were less influential than the innovative scientific academies in fostering economic development.

One of the most intriguing findings arises when considering other pathways through which academies may have influenced growth. When analyzing the quality of universities as the dependent variable, I observe a strong positive effect from the establishment of academies, especially scientific ones. After 50 years, the creation of a scientific academy is associated with a remarkable 60% increase in the quality of the city's university, on average. This supports the argument that scientific academies promoted innovative thinking, also elevating the overall quality of educational institutions. Conversely, literary academies showed no significant impact on university quality.

These results emphasize the importance of innovation and experimental approaches to education in driving economic growth, consistent with the literature on "useful knowledge" (Mokyr, 2005b). By providing empirical evidence on the historical evolution of educational institutions, particularly universities, this paper demonstrates how scientific thinking and practical innovations have shaped their modernization. Moreover, this study highlights the continued relevance of investing in innovative and scientific education for shaping societal progress, even when faced with potential initial costs.

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Appendix A Marat's pamphlet

English translation: **Modern Charlatans, or Letters on Academic Charlatanism**

"It [i.e., the Academy of Sciences] took a radiant sun as her symbol and this modest epigraph as its motto: *Invenit et perfecit*, not that it ever made any discovery or that it has never perfected anything, because all that came out of its heart was a heavy collection of aborted memoirs, which sometimes serve to fill a void in the great libraries. On the other hand, it has assembled 11,409 times, it has published 380 praises, it has given 3,965 approvals, both on new recipes for makeup, hair pomades, plasters for corns, ointments for bedbugs, as well as on the most advantageous form of false toupees, wig heads, syringe cannulas, and on a thousand other objects of similar importance; glorious works, well done to console us for the immense sums it costs us annually.[6] Taken collectively, it must be regarded as a society of vain men, very proud to gather together twice a week, to chat at ease over the fleur-de-lys, or, if you like it better, as a brotherhood of mediocre men, knowing very little and believing they know everything, mechanically given over to the sciences, judging on their word, incapable of delving into anything, attached by self-esteem to old opinions and almost always at odds with common sense."

[6] The budget of the Academy of Sciences, in 1790, amounted to 83,458 pounds.

Original version: **Les charlatans modernes, ou Lettres sur le charlatanisme académique**

"Elle [Académie des Sciences] a pris, dit-il, pour symbole un soleil radieux et pour devise cette modeste épigraphe : Invenit et perfecit, non qu'elle ait jamais fait aucune découverte ou qu'elle ait jamais rien perfectionné, car il n'est sorti de son sein qu'une lourde collection de mémoires avortés, qui servent quelquefois à remplir un vide dans les grandes bibliothèques. En revanche, elle s'est assemblée 11 409 fois, elle a publié 380 éloges, elle a donné 3 965 approbations, tant sur de nouvelles recettes de fard, de pommades pour les cheveux, d'emplâtres pour les cors, d'onguens pour les punaises, que sur la forme la plus avantageuse des faux toupets, des têtes à perruque, des canules de seringues, et sur mille autres objets de pareille importance ; travaux glorieux, bien faits pour nous consoler des sommes immenses qu'elle nous coûte annuellement. [6] Prise collectivement, elle doit être regardée comme une société d'hommes vains, très fiers de se rassembler deux fois par semaine, pour bavarder à l'aise sur les fleurs de lys, ou, si tu l'aimes mieux, comme une confrérie d'hommes médiocres, sachant fort peu de choses et croyant tout savoir, livrés machinalement aux sciences, jugeant sur parole, hors d'état de rien approfondir, attachés par amour-propre aux anciennes opinions et presque toujours brouillés avec le bon sens."

[6] Le budget de l'Académie des Sciences, en 1790, montait à 83 458 livres.

Source: Boissier (1907), p.725-726

Appendix B Descriptive Statistics

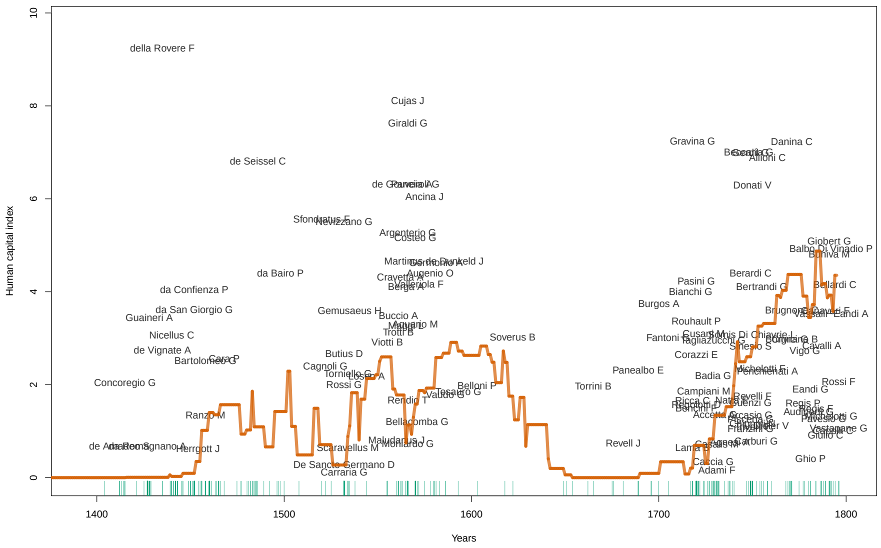


Fig. B1 Ordinary member at the University of Turin with a non-negative individual quality index. Vertical green lines show their distribution over time considering also scholars with a zero quality index. The orange like displays the dynamic of the aggregate quality of the university. Figure taken from Zanardello (2022).

Table B1 Summary Statistics ACAD Founders VS not Founders:

	Founders	**Not Founders**	**t-test**
Obs.	387	16244	
	μ	μ	p-value
Quality	2.9	2.4	0.004
Age at death	68.5	66.7	0.033
Age at Appointment	37.4	37.4	0.973
Activity Years	21	16.4	0.000
Dist. Birth-ACAD	130.3	337.4	0.000
Dist. ACAD-Death	228.1	414.5	0.002
Dist. Birth-Death	258.2	365.7	0.058

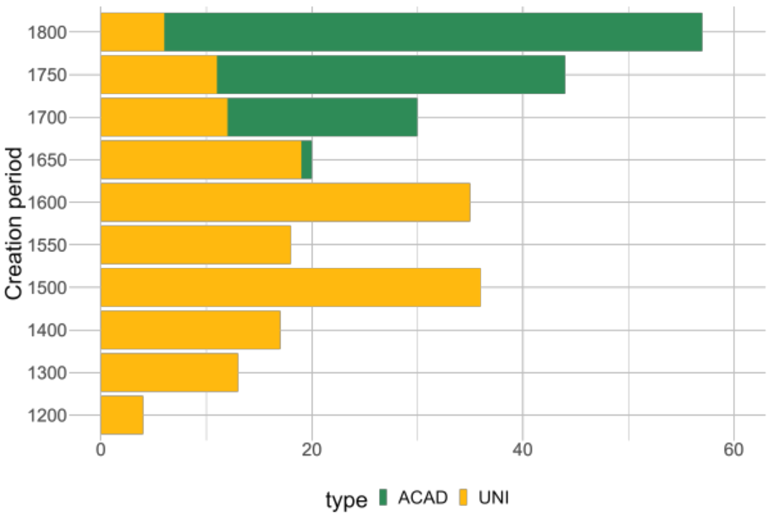


Fig. B2 Number of institutions created in the period before the year indicated in the y-axis. It shows that universities have a more heterogeneous creation dates compared to academies: universities were created since the 11^{th} century, while academies started to spread from the second half of the 17^{th} century.

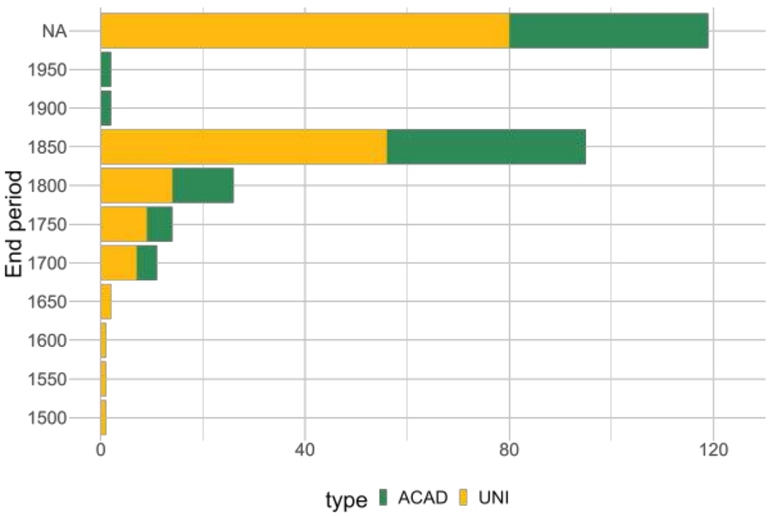


Fig. B3 Number of institutions closed in the 50 years before the year indicated in the y-axis. *NA* indicates institutions that never closed. It is clear that most institutions remained open before 1800, many closes between 1800 and 1850 but most of them are still open today.

(a) 1500 - 1550

(b) 1550-1600

(c) 1600 - 1650

(d) 1650 - 1700

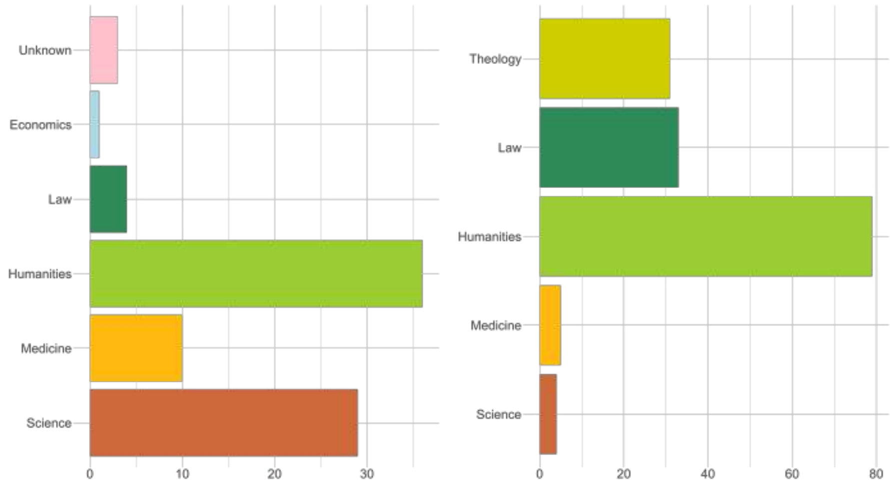
(e) 1700 - 1750

(f) 1750 - 1800

(g) 1800 - 1850

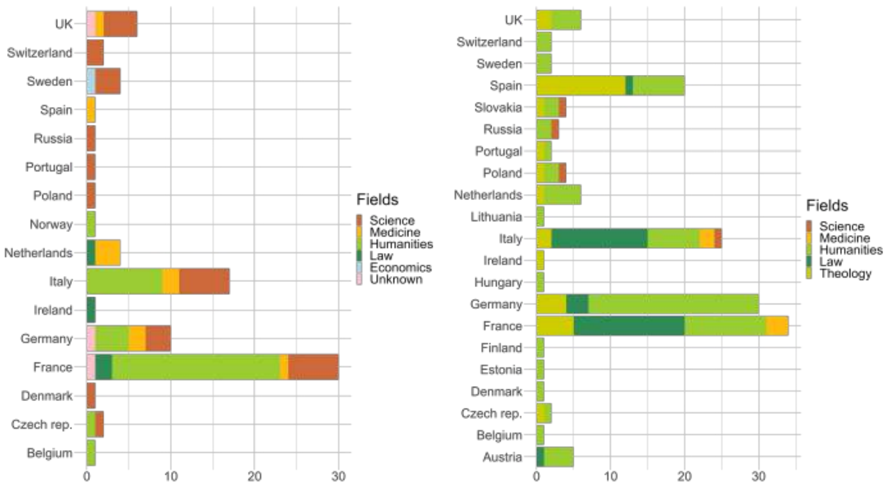
(h) 1850 - 1900

Fig. B4 Educational institutions location (1500 - 1900 CE): yellow bubbles represent universities, green triangles represent academies. When the two institutions are created in the same city there is an interaction, which is captured by the overlapping of the two shapes. Countries borders as in 2000.



(a) Academies (b) Universities

Fig. B5 Number of institutions by main field of study – *main field of study* being the field studied by the majority of members in the institution. In (a) the "unknown" field means that we do not track the fields of study for the majority of the scholars in the academy.



(a) Academies (b) Universities

Fig. B6 Number of institutions by major field of study per country. For major field of study, I mean the field most studied in the institution, without considering any specific threshold. In (a) the "unknown" field means that we do not track the fields of study for the majority of the scholars in the academy.

Table B2 Summary statistics at aggregate level, divided by academies and universities

	ACADEMIES					UNIVERSITIES				
	Mean	**Med**	**Min**	**Max**	**Obs**	**Mean**	**Med**	**Min**	**Max**	**Obs**
Total activity years	134	75	2*	372**	103	370	359	3*	936**	171
Creation Date	1740	1750	1650	1793	103	1516	1548	1088	1781	171
End Date	1875	1794	1667	2024	103	1885	1811	1460	2024	171
Total size	122	38	0†	1611‡	103	141	68	0†	835‡	171
% SCIENCE	52.7%	50.0%	0.0%	100.0%	103	20.7%	19.1%	0.0%	100.0%	171
% LITERARY	43.1%	43.1%	0.0%	100.0%	103	74.4%	77.2%	0.0%	100.0%	171
% UNKNOWN	3.2%	0.0%	0.0%	55.4%	103	2.7%	0.0%	0.0%	35.7%	171
Size in 1650-1700	219	30	1	1611‡	17	87	40	1	246°	12
% SCIENCE	60.7%	60.0%	18.8%	100.0%	17	19.3%	17.8%	0.0%	40.0%	12
% LITERARY	36.9%	40.0%	0.0%	77.1%	17	77.0%	76.1%	60.0%	100.0%	12
% UNKNOWN	2.4%	0.0%	0.0%	14.0%	17	3.7%	0.2%	0.0%	16.7%	12
Size in 1700-1750	141	71	4	873⊕	33	64	26	1	353⊕	11
% SCIENCE	49.2%	47.4%	0.0%	100.0%	33	28.9%	19.1%	0.0%	70.0%	11
% LITERARY	49.4%	51.7%	0.0%	100.0%	33	69.6%	81.0%	16.7%	100.0%	11
% UNKNOWN	1.4%	0.0%	0.0%	12.9%	33	1.5%	0.0%	0.0%	13.3%	11
Size in 1750-1800	80	34	0†	480•	53	26	20	1	67•	6
% SCIENCE	52.4%	50.0%	0.0%	100.0%	53	34.6%	34.5%	0.0%	80.0%	6
% LITERARY	41.1%	41.0%	0.0%	100.0%	53	65.2%	65.5%	20.0%	100.0%	6
% UNKNOWN	4.6%	0.0%	0.0%	53.4%	53	0.2%	0.0%	0.0%	1.5%	6

* Refer to *Accademia della Traccia* in Bologna (ITA, 1665), and to *Corte University* in France (1765).
** Refer to *Leopoldina Academy* in Halle (DEU, 1652), and to the *University of Bologna* in Italy (1088).
† Refer to *Société Académique* in Cherbourg (FRA, 1755), and to the universities in Burgo-de-Osma (ESP, 1555), Genova (ITA, 1471), Onate (ESP, 1540), and Palma (ESP, 1483). These are the institutions for which we did not find any member yet.
‡ Refer to the *Royal Society* in London (UK, 1660), and to the *University of Paris* in France (1200).
° Refer to the *University of Lund* in Sweden (SWE, 1666).
⊕ Refer to the *Prussian Academy* in Berlin (DEU, 1700), and to the *University of Göttingen* in Germany (1734).
• Refer to the *Erfurt Academy* in Germany (DEU, 1754), and to the *University of Moscow* in Russia (1755).

B.1 Statistics on city population

Table B3 presents descriptive statistics including the median and third quantile, for population levels in different subsets of cities. These subsets consist of cities that ever had a university (columns 3 and 4) or an academy (columns 5 and 6) for at least one period, compared to the entire sample of cities (columns 1 and 2) and cities with no higher educational institutions at all (columns 7 and 8). The city samples remain constant over time. The results indicate that even prior to the relevant period of analysis (1000-1400), cities with higher educational institutions were experiencing faster population growth. Specifically, when comparing larger cities in the general sample (column 2) to the median city with a university at a certain point in time (column 3), it becomes evident that while the general sample did not experience significant growth after 1200, cities that had universities showed continuous growth over time. This pattern is even more pronounced when examining cities with an academy at a certain point in time (column 5). Figure B7 and Figure B8 depict the median logarithmic population growth rate for cities with academies or universities, respectively, compared to cities with no higher educational institutions at all. These figures reveal that higher educational institutions were established in cities that were experiencing faster growth prior to the Black Death, and although the difference temporarily diminished afterward, it began to grow again towards 2000. Further investigation into the presence of pre-trends will be conducted.

Table B3 Descriptive statistics of city population

cities	**ALL**		**UNI**		**ACAD**		**NO INST.**	
N. cities	2096		153		83		1902	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Period	**Med**	**75%**	**Med**	**75%**	**Med**	**75%**	**Med**	**75%**
1000	1	2	2	5	3	6.5	1	2
1100	1	2	3	7	3	8.5	1	2
1200	2	3	4	10	5	12	1	3
1300	2	3	7	15	8	18	2	3
1400	1	3	5	12	6	17	1	2
1000 - 1400	1	3	4	10	5	11	1	2
1500	2	4	7	17	9	25	2	4
1600	3	6	11	25	16	39.5	3	5
1700	4	6	13	27	20	41.5	4	6
1800	6	10	19	33	30	73.5	6	9
1900	16	33	54	108	85	295.5	15	28
1500 - 1900	5	10	15	33	24	55	5	9

Note: Inhabitants in 000-s in every column. The sample of cities do not change over the time periods.
Med is the median, 75% is the third quantile.

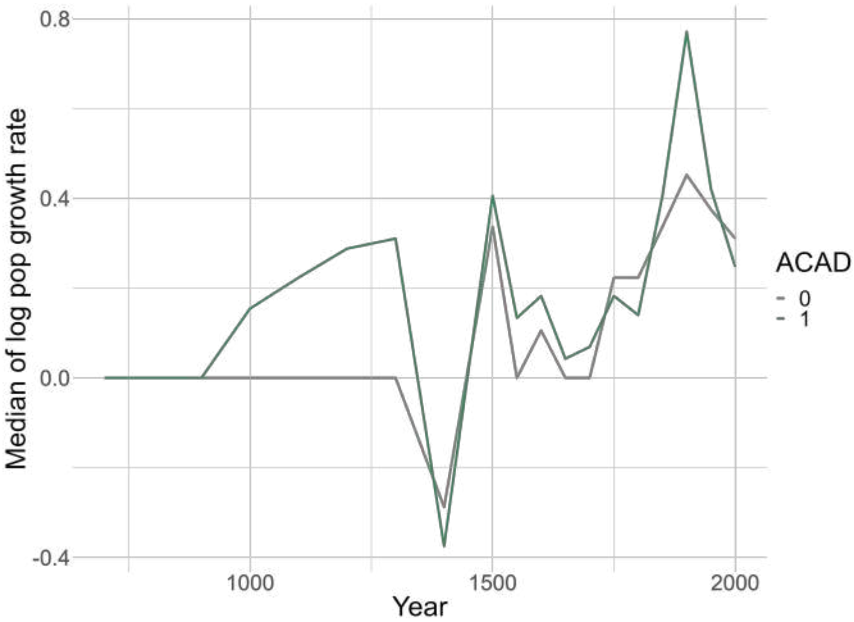


Fig. B7 Median of the growth rate for the natural logarithm population by year, between 700 and 2000. The green line is for cities that hosted an academy at least in one period of time, the grey line for cities with no institutions at all.

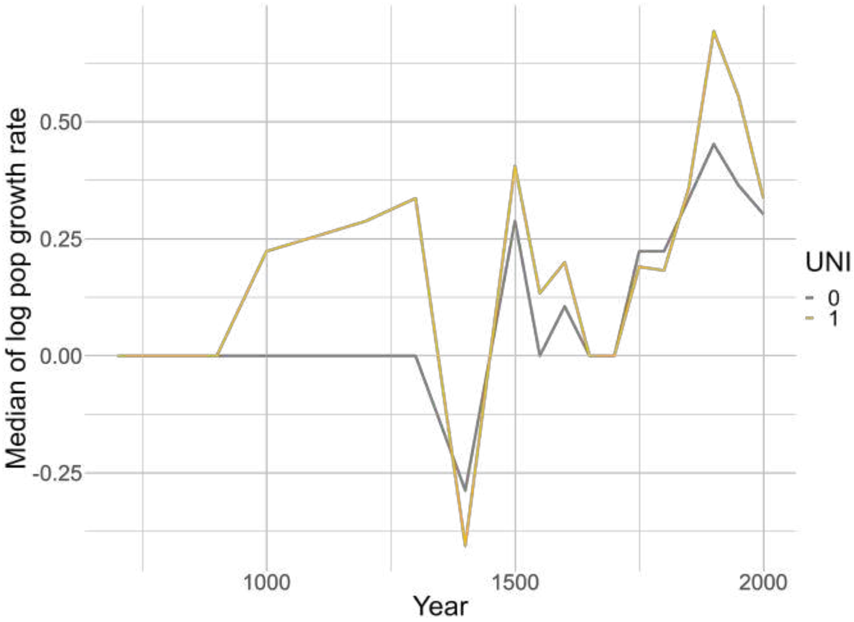


Fig. B8 Median of the growth rate for the natural logarithm population by year, between 700 and 2000. The yellow line is for cities that hosted a university at least in one period of time, the grey line is for cities with no institutions at all.

Appendix C Additional OLS results: time-varying controls

In the main text (Section 5.1), I consider the whole sample of cities in Buringh (2021) for which I do not have time-varying controls. This arises omitted variable concerns. Therefore in this section, I prove that city and time FE already provide the most important piece of information by showing that results do not change by adding time-varying controls.

I can do this only for the sample of big cities for which I have time-varying controls until 1800 from Bosker et al. (2013). I first select the time variant characteristics from Bosker et al. (2013) by looking at the dynamic of every independent variable available in the dataset (Figure C9). It is clear that many cities had been *plundered* different number of times depending on the year considered. In addition, Bruges (Belgium) and Seville (Spain) stopped having a direct access to the *sea* between 1500 and 1900, some cities became/ceased to be a *bishop*, an *archbishop* or a *capital* in this period. Again, *Muslim* and *Christian urban potential* (defined as in Bosker et al. (2013) to be a "distance-weighted sum of the size of all other Muslim or Christian cities" (p.1423), for the formula check p.1423 in Bosker et al. (2013).) changes for most cities over the period. Granada ceased to host a *Madrasa* between 1500 and 1600 (Madrasa being a higher educational institution in the Arab world). Finally, some cities became or ceased to be influenced by *Muslim* religion. All the other determinants present a stable dynamic: distances to Rome, to Mecca, to Byzantium, the quality of the soil,[41] the logarithm of the elevation above the see in meters, the logarithm of the standard deviation of the elevation of the terrain in a 10km radius in meters, having direct access to a river, to a Roman road, or to more than two Roman roads, and being a Christian holy city.

City FE will certainly capture these time-invariant characteristics but they may not consider the information provided by time-varying controls. Nonetheless, this is not a concern here, given that the OLS estimates do not vary much when I include time-varying determinants in Table C4: any coefficient is not significant, and only the coefficient associated with the presence of the university change sign but also remains very close to zero - all the other coefficients have the same sign with (column 1) or without (column 2) time-varying controls.

[41] Bosker et al. (2013) utilize the composite indicator of Ramankutty, Foley, Norman, and McSweeney (2002). For more details refer to p.1422 in Bosker et al. (2013).

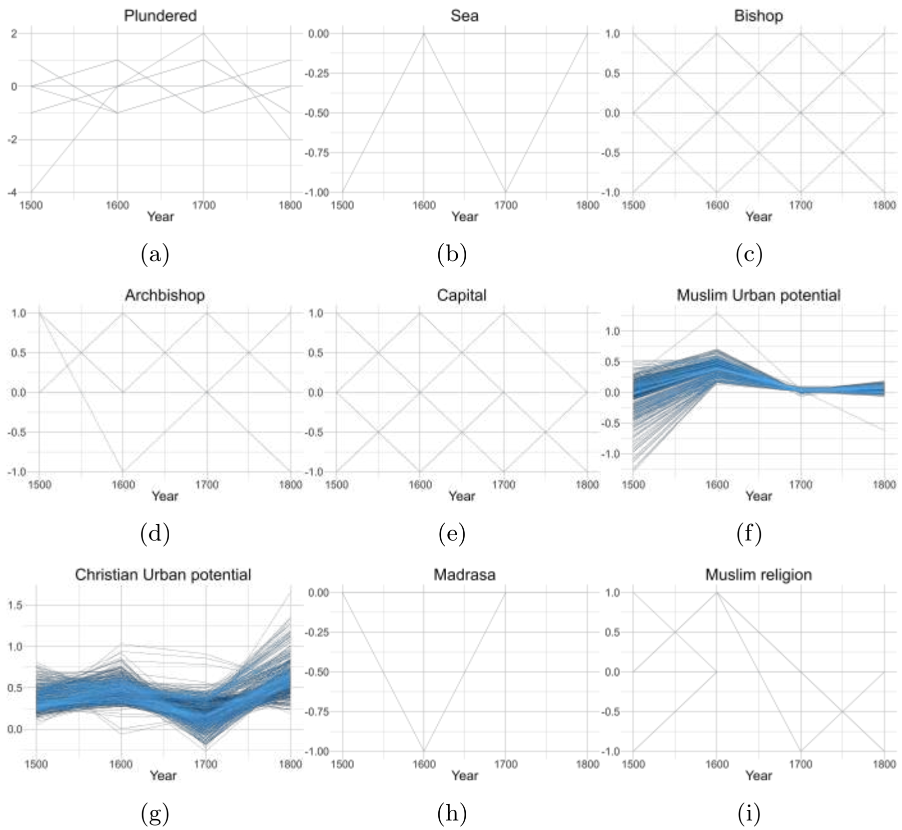


Fig. C9 Time-varying variables by cities as in Bosker et al. (2013). Year in the x-axis, variation between subsequent periods in the y-axis.

Table C4 OLS estimator - BIG cities

	ln pop in 1500-1800	
	(1)	(2)
UNI	0.005	−0.05
	(0.063)	(0.061)
ACAD	0.190	0.177
	(0.127)	(0.157)
UNI:ACAD	−0.048	−0.104
	(0.173)	(0.206)
Obs.	633	633
R^2	0.795	0.752
Δ*time* controls	YES	NO
city FE	YES	YES
time FE	YES	YES
country FE	NO	NO

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors in parenthesis clustered at city level. Time varying (Δtime) controls are having direct access to the sea, having a bishop or an archbishop, being a capital city, having a madrasa, being plundered n. times, Muslim or Christian urban potential, and being a Muslim city.

Appendix D Static TWFE

In this section, I present the estimate of a traditional static Two-Way-Fixed-Effects specifications as follows:

$$lnPOP_{ct} = \beta_0 + \beta_1 EVENT_c \text{x} Post_{ct} + \mu_c + \lambda_t + \epsilon_{ct} \tag{D1}$$

where μ_c and λ_t are city and time FE respectively, and ϵ_{ct} is the unobserved error term. $lnPOP_{ct}$ is the logarithm of the population size of city c at time t, and it is the outcome variable in these specifications. $Post_{ct}$ is an indicator variable taking value 1 the periods after the creation of an ACAD or a UNI in city c (e.g., $EVENT_{ct}$). The coefficient of interest is β_1 and should identify the average increase in cities' population size after the creation of a higher educational institution relative to cities with no higher educational institutions. Static TWFE models shows conservative estimates because they underweight long-run effects favouring short-run effects. Nonetheless, I cannot claim the main assumption of homogeneity across time and space, which makes the identification through static TWFE not possible. I present the single coefficient estimates only for completeness, while more robust dynamic TWFE and new DID estimators are also presented in the main text.

Table D5 Effect of creating an academy (ACAD) or a university (UNI) on log city population

	ln pop in 1500-1900	
	(1)	(2)
ACAD x Post	0.244**	
	(0.101)	
UNI x Post		0.119
		(0.091)
Constant	1.277***	1.274***
	(0.009)	(0.009)
Obs.	2096	2096
R^2	0.632	0.631
city FE	YES	YES
time FE	YES	YES

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors in parenthesis clustered at city level.

Appendix E Academies' establishments

- **Acad Agen.** The *"Société des Sciences, arts et belles lettres"* was created in Agen (FRA) on January 1, 1776 and officially recogniez in 1788. The main goal was to provide a forum for intellectual discussion. It was focused on advancing knowledge in various fields, including arts, sciences, and belles-lettres (Lauzun, 1900).
- **Acad Amiens.** The *"Académie des Sciences, belles lettres et arts"* was founded in Amiens (FRA) in February 1746 and officially recognized in 1750. It was initiated by Chauvelin German Louis (lawyer), Gresset Jean-Baptiste (poet), and d'Albert d'Ailly Michel Ferdinand (governor and scientist). It aimed to cultivate the spirit and shape taste through perfecting language, art, and knowledge. It had a structured governance with a hierarchy and specific tasks for its members (Académie des sciences, des lettres et des arts d'Amiens, 1901).
- **Acad Angers.** The *"Académie des sciences, belles lettres et arts d'Angers"* was founded in Angers (FRA) on March 31, 1684, and received official recognition through patent letters from Luis XIV in June 1685. It was established under the proposition of the mayor of Angers, Jacques Charlot (Bois, 2021).
- **Acad Arras.** The *"Académie Royale de belles lettres"* was founded in Arras (FRA) on May 22, 1737, but received official recognition with patent letters in 1773. It was founded by the writer Pierre Antoine de La Place, the military engineer Victor-Hyacinthe d'Artus, and the counsellor Galhaut de Lassus. The academy sought to advance knowledge in literature and the arts. It had a structured governance with different categories of members and a protector. Maximilien de Robespierre joined the Academy of Arras in 1783, highly increasing the academy reputation (Académie des Sciences, Lettres et Arts d'Arras, 2024).
- **Acad Arrezo.** The *"Accademia Aretina"* was established in Arezzo (ITA) in 1787. It was founded by a group of 22 scholars to revitalize the intellectual atmosphere that was lacking scientific and literary discussions following the closure of two previous academies (Maylender, 1930, Vol 1). It is still active today.
- **Acad Auxerre.** The *"Académie des Sciences, arts et belles lettres"* was founded in Auxerre (FRA) in April 1749 with the permission of the King and support from M. de Caylus, the bishop of Auxerre. The academy aimed to advance knowledge in various fields, including ecclesiastical, civil, and natural history, physics, and agriculture. Arts and literature were also included in their pursuits. It had a director and a perpetual secretary, similar to the Paris Academy (des Barres, 1851).
- **Acad Barcelona.** The *"Reial Acadèmia de Ciències i Arts de Barcelona"* was founded in Barcelona (ESP) on January 18, 1764, and officially recognized on December 17, 1765. It was established by 15 founders, led by Francesc Subiràs i Barra, the first director. The academy sought to spread scientific and technical knowledge to the city. It is still active today (Reial Acadèmia de Ciències i Arts de Barcelona, 2024).

- **Acad Berlin.** The *"Gesellschaft Naturforschender Freunde zu Berlin (GNF)"* was founded in Berlin (DEU) on July 9, 1773. It was established by the doctor and natural scientist Friedrich Heinrich Wilhelm Martini. The academy aimed to recruit and train young scientists, popularize science, and enhance the experimental study of natural history. It has a structured governance, including ordinary, honorary, and extraordinary members, and is still active today. The Prussian State was financing its activities (Böhme-Kaßler, 2005).
- **Acad Besançon.** The *"Académie des Sciences, belles lettres et arts"* was founded in Besancon (FRA) in 1748, and in 1752 officially recognized with patent letters from Luis XV. It was established by Pourroy de Quinsonas (president of the Franche-Comte Parliament), the duc de Tallard (governor of Comte du Bourgogne), and Moreau de Beaumont (intendant of Franche-Comte). The academy sought to create a lasting and organized forum for advancing knowledge in the sciences and arts. It had a structured governance with a protector and 40 titular members (Defrasne et al., 2002).
- **Acad Beziers.** The *"Académie des Sciences et belles lettres"* was founded in Beziers (FRA) on August 19, 1723, and became a Royal Academy in 1766 with the receipt of patent letters. It was established by the lawyer Antoine Portalon, the physicist Dortous de Mairan, and the doctor Jean Bouillet (Académie de Béziers, 2024).
- **Acad Birmingham.** The *"Lunar Society of Birmingham"* was founded in Birmingham (GBR) in 1766, following the "Lunar Circle" that formed in 1765. It primarily focused on science, both pure and applied, particularly as it related to industrial problems. Its members were mainly "provincial manufacturers and professional men." (Schofield, 1963, p.3) The academy did not have a structured governance. It was known for its monthly meetings held near the full moon (Schofield, 1963).
- **Acad Bologna.** The *"Istituto delle Scienze di Bologna"* was founded in Bologna (ITA) in 1714, although it had informal roots dating back to 1711 and a predecessor, the Inqueti Academy, established in 1690. The academy was founded by Count Luigi Ferdinando Marsili and Eustachio Manfredi, with papal patronage. It was established to foster reforms within the University. The academy's focus was on experimental sciences, medicine, physics, chemistry, and mathematics. It was the first Italian academy to have academicians employed and paid by public funds (Ercolani, 1881).
- **Acad Traccia.** The *"Accademia della Traccia"* was founded in Bologna (ITA) in 1666. It was established by Abate Carlo Sampieri, following the influence of Geminiano Montanari, a professor at the University of Bologna and a corresponding member of the Cimento Academy. The academy was created as an imitation of the Cimento Academy and focused on experimental physics (Maylender, 1930, Vol 5).
- **Acad Bordeaux.** The *"Académie royale des sciences, belles-lettres et arts"* was founded in Bordeaux (FRA) in 1712, through letters patent issued on September 5th. The academy's aim was to advance knowledge across a

spectrum of disciplines, including belles-lettres, sciences, and arts. Natural history gained prominence with the establishment of the Société d'Histoire Naturelle in 1796. It had a structured governance with ordinary members, associate members, directors, secretaries, and a treasurer (Courteault, 1912).

- **Acad Bourg-en-Bresse.** The *"Académie des Sciences, belles lettres et arts"* in Bourg-en-Bresse (FRA) was initially established in 1755 and then reconstructed in 1783. It was founded by a group of notables to foster intellectual pursuits and the exchange of knowledge. The society focused on science, agriculture, letters, and social issues. It had a structured governance, with a Director, Vice-Director, and a perpetual Secretary (Allombert, 1899).
- **Acad Brest.** The *"Académie Royale de Marine"* was founded in Brest (FRA) in 1750 and officially recognized on July 30, 1752. It received royal status in 1769. It was founded by Sébastien Bigot de Morogues, a naval officer and scholar. The academy sought to study everything related to the navy, including naval officer training, shipbuilding techniques, research in mathematics, physics, arts, and natural history, and the compilation of a "Dictionary of Marine." It had a structured governance with honorary academicians, free/associate academicians, correspondents, ordinary academicians, and adjunct academicians (Académie Royale de Marine, 2024).
- **Acad Bruxelles.** The *"Académie Royale et Imperiale des Sciences et belles lettres"* was founded in Bruxelles (BEL) in 1769 as an informal society and officially recognized as a society with patent letters from Maria Theresa in 1772. It was founded by Count Cobenzl, who was inspired by the advice of Professor Schoëfflin. The academy aimed to revive interest in literature in the Austrian Netherlands, which was seen as declining. It had a structured governance with honorary members and ordinary academicians (Hasquin, 2009).
- **Acad Caen 1.** The *"Académie de physique de Caen"* was founded in Caen (FRA) in 1652, but received patent letters in 1705. It was established by Moisant de Brieux, de Grentemesnil, de Prémont, Halley, Vicquemand, and Bochart. The academy's initial focus was on literature and philosophy, but shifted to scientific matters after the creation of the Royal Society and the Academy of Sciences. It had a structured governance, with a director, a secretary, and a permanent reader (de Pontville, 1997).
- **Acad Caen 2.** The *"Académie des arts et belles lettres"* was founded in Caen (FRA) in 1662. It was never officially recognized by the King but the ministry Colbert expressed the royal approval. It was established by Pierre-Daniel Huet, who was inspired by the mostly literary works of other academies. The academy focused on physical and mathematical sciences. It had a structured governance and a clear set of objectives for its research (de Pontville, 1997).
- **Acad Châlons-en-Champagne.** The *"Académie des Sciences, arts et belles lettres"* was founded in Châlons-en-Champagne (FRA) in 1750, officially recognized in 1753, and received patent letters in 1775. Its motto was

"L'Utilité," emphasizing practical applications of knowledge. It sought to cultivate belle-lettres, arts, sciences, and research in natural history. It had a structured governance with honorary academicians, titular academicians, "Agrégés pour les Arts," and associate free members (Menu, 1869).

- **Acad Cherbourg.** The *"Société Académique"* was founded in Cherbourg (FRA) on January 14, 1755, and officially recognized in 1775. It was established by Jean-François Delaville and other 5 scholars to share knowledge and improve the reputation of the city. It was focused on the history of the local region and archeology, and naval matters also entered into its discussions. It had a structured governance similar to the Paris Academy(Académie De Cherbourg, 2024).
- **Acad Cimento.** The *"Accademia del Cimento"* was founded in Firenze (ITA) in 1651 as an informal society and officially established in 1657. It was founded by Grand Duke Ferdinando II and his brother Leopoldo, who advocated for the free application of the "New Science." The academy focused on experimental physics, meteorology, and astronomy. It was considered innovative in its methodology (Knowles Middleton, 1971).
- **Acad Florence 2.** The *"Accademia Botanica"* was founded in Firenze (ITA) in 1733 and officially recognized in 1739. It was established by Vincenzo Capponi as secretary of the earlier Botanic Society. It focused on scientific research and studies, with a particular interest in botany and the management of the botanic gardens in Florence (Maylender, 1930, Vol 1).
- **Acad Florence 3.** The *"Reale accademia dei Georgofili"* was founded in Firenze (ITA) in 1753. The creation of the academy was prompted by an essay by Abbot Ubaldo Montelatici, who also incorporated the previous Botanic Academy of Florence in 1783. It was established to promote research in agronomy, especially to address issues with famine and food shortages in Italy. It had a structured governance (Tabarrini, 1856).
- **Acad Clermont Ferrand.** The *"Académie des Sciences, arts et belles lettres"* was founded in Clermont-Ferrand (FRA) in 1747, officially recognized in 1750, and granted patent letters in 1780. The academy was established by Rossignol, Dufraisse de Vernines, and Queriau, with the aim of promoting science and society through research in natural history and literature. The academy had a structured governance (Mège, 1884).
- **Acad Copenhagen.** Founded in Copenhagen (DNK) on November 13, 1742, and granted royal status in 1743, the *"Det Konelige Danske Vidensakkernes Selskab"* was established by Johan Ludvig Holstein, Hans Gram, Erik Pontoppidan, and Henrik Henrichsen. The academy aimed to strengthen the position of science in Denmark and promote interdisciplinary understanding. It had a structured governance with a president and a secretary (Lomholt, 1950).
- **Acad Cosenza.** The *"Accademia dei Pescatori Cratilidi"* was founded in Cosenza (ITA) in 1753, inaugurated in 1756, and officially approved in 1758. It was established by Gaetano Greco, who wanted to create a new academy following the decline of the previous "Cosentina" academy. The academy's

name derived from the Crati river and its motto was "Grandia ab exiguo" (i.e., "from small to large") (Maylender, 1930, Vol 4).

- **Acad Dantzig.** The *"Danziger Naturforschenden Gesellschaft"* was founded in Danzig (POL) on January 2, 1743. It was established during an informal gathering, with Daniel Gralath proposing the idea. The academy aimed to advance the understanding of natural phenomena through empirical investigation. It had a structured governance with different types of members and a permanent location (Schumann, 1893).
- **Acad Derby.** The *"Derby Philosophical Society"* was founded in Derby (GBR) in February 1783. It's heavily implied that Erasmus Darwin was a driving force behind the society, he was also member of the Lunar Society of Birmingham. The academy aimed to promote knowledge and discussion of natural philosophy and provide access to scientific literature through its library (Sturges, 1978).
- **Acad Dijon.** The *"Académie des Sciences, Arts et Belles-Lettres de Dijon"* was founded in Dijon (FRA) in 1725, established through the will of Hector-Bernard Pouffier (dean of the Parliament of Burgundy) and officially recognized by the King in 1740. It primarily focused on scientific subjects like medicine, natural sciences, and applied sciences, but also included a quarter of its members working in the humanities. It had a structured governance and was supported by the regional State of Burgundy (Milsand, 1871).
- **Acad Dublin.** The *"Philosophical Society and Medica-Philosophical Society"* in Dublin (IRL) evolved from a previous academy and became the RDS (Royal Dublin Society) on June 25, 1731. It received royal recognition on April 2, 1750. The Dublin Society focused on improving the economy and the lives of the Irish people by promoting husbandry, manufactures, and useful arts. It had a structured governance with ordinary, honorary, and life members, and received funding through member subscriptions and parliamentary grants (Berry, 1915).
- **Acad Irish.** The *"Royal Irish Academy"* was founded in Dublin (IRL) in 1785 and granted a royal charter in 1786. This academy, the first in Ireland to balance research in both sciences and humanities, aimed to promote and investigate the sciences, polite literature, and antiquities. It had a structured governance with scientific and literary members, plus a rotating president (Royal Irish Academy, 2024).
- **Acad Edinburgh.** The *"Royal Society of Edinburgh"* was officially founded in Edinburgh (GBR) in 1783, with its first meeting on June 23, 1783. It received a Royal Charter on March 29. Many members of the earlier Philosophical Society became members of the RSE. It aimed to advance learning and useful knowledge, focusing on natural philosophy and literature. It had a structured governance (Emerson, 1981).
- **Acad Erfurt.** The *"Academia electoralis moguntina scientiarum utilium"* was founded in Erfurt (DEU) on July 19, 1754. Its creation was supported by its patron, the Elector of Mainz, Johann Friedrich Carl. The Academy aimed

to promote useful sciences, like including natural sciences, mathematics, law, history, and the arts (Kiefer, 2004).

- **Acad Gorlitz.** The *"Oberlausitzischen Gesellschaft der Wissenschaften"* was founded in Gorlitz (DEU) on April 21, 1779. It was established by Karl Gottlob Anton, who proposed the idea to Adolf Traugott von Gersdorf. The academy aimed to promote the study of natural science and history in Upper Lusatia and foster scientific research and scholarship (Oberlausitzische Gesellschaft der Wissenschaften, 2024).
- **Acad Goteborg.** The *"Kungl. Vetenskaps-och Vitterbets Samhallet"* was founded in Goteborg (SWE) in the 1770s and obtained the royal title from King Gustav III in 1778. It was established by Johan Rosen, a schoolmaster, and later by Martin Georg Wallenstrale and Carl Fredrik Scheffer. The society aimed to promote scientific exchange among different disciplines and to foster the study of sciences for the benefit of the local community.
- **Acad Göttingen.** The *"Akademie der Wissenschaften zu Göttingen"* was established in Göttingen (DEU) in 1752 as the *"Königliche Societät der Wissenschaften"* (Royal Society of Sciences). It was founded under the patronage of King George II of Great Britain and Elector of Hanover. The academy aimed to advance learning and knowledge (Krahnke, 2001).
- **Acad Grenoble.** The *"Académie Delphinale"* was founded in Grenoble (FRA) in 1772, received patent letters in 1780, and formally adopted its name in March 1789. It was established by a group of enlightened and noble men who purchased books following the death of the bishop of Grenoble. The academy focused on enhancing humanities like history, letters, and arts, but also included sciences and technical matters (*Lettres Patentes*, 1790).
- **Acad Haarlem.** The *"Hollandsche Maatschappij der Wetenschappen"* was founded in Haarlem (NLD) in 1752. It was established by seven leading citizens of Haarlem with the aim of promoting science. The academy has a twofold structure, with social members (representing society's interest in science) and scientific members (a group of scientists). It is still active today (Hollandsche Maatschappij der Wetenschappen, 2024).
- **Acad Tweede.** The *"Teylers Tweede Genootschap"* was founded in Haarlem (NLD) in 1756 and officially opened in 1778. It was established based on the will of Pieter Teyler van der Hulst. The academy aimed to promote science and the arts through discussion and prize competitions.
- **Acad Bad-Homburg.** The *"Société patriotique de Hesse-Hamburg pour l'encouragement des connaissances et des moeurs"* was founded in Bad-Homburg (DEU) in 1775, with statutes adopted in 1777. The academy aimed to promote "knowledge and morals" (from the name of the academy) and therefore focused on intellectual and ethical development (1777).
- **Acad Investiganti.** The *"Accademia degli Investiganti"* was founded in Napoli (ITA) in 1650 by Cornelio Tommaso and di Capua Leonardo. It was inspired by the Lincei academy in Rome, and sought to study and investigate "things of nature." It primarily focused on natural philosophy before 1735 and on literary matters after that (Maylender, 1930, p.369, Vol3).

- **Acad Naples.** The *"Reale Accademia della Scienze e Belle-Lettere"* was founded in Napoli (ITA) in 1778 and officially established in 1780. It was established by King Ferdinando IV of Borbon to advance public education, progress, and human conviction. It had a structured governance with a president, vice-president, treasurer, fiscal lawyer, and secretary, and received financial support from a royal annuity (Maylender, 1930, Vol 5).
- **Acad Jena.** The *"Naturforschende Gesellschaft zu Jena"* was founded in Jena (DEU) in 1793 by August Johann Georg Karl Batsch. The academy aimed to support members in choosing a career through natural-historical studies and to contribute to their moral advancement (Böhme-Kaßler, 2005).
- **Acad La Rochelle.** The *"Académie Royale des Belles lettres"* was founded in La-Rochelle (FRA) in 1730 and officially recognized in 1744. It was founded by Jean-Jacques Franc de Pompignan, who was considered the soul of the academy. The academy focused on the study of literature and eloquence, specifically poetry. It had a structured governance with a director and a permanent secretary (Flouret, 2009).
- **Acad Lausanne.** The *"Société des sciences physiques"* was founded in Lausanne (CHE) on March 10, 1783. It aimed to cultivate interest in natural history and to study all that concerns the sciences, arts, agriculture, industry, commerce, and the local patrimony 1789.
- **Acad Leipzig.** The *"Fürstlich Jablonowskische Gesellschaft"* was founded in Leipzig (DEU) in 1768. Further sources have been asked to the current academy.
- **Acad Leopoldina.** The *"Deutsche Akademie der Naturforscher Leopoldina"* was founded in Halle (DEU) on January 1, 1652, and officially recognized by the Emperor Leopold I in August 1677. It was established by four physicians: Bausch, Fehr, Metzger, and Wohlfahrth. The academy aimed to explore nature for the glory of God and the good of mankind. It had a structured governance and received special privileges from the Emperor Leopold I (Deutsche Akademie der Naturforscher Leopoldina, 2024).
- **Acad Halle.** The *"Gesellschaft der Naturforschenden Freunde"* was founded in Halle (DEU) in 1779 by some theology students with the support of Friedrich-Wilhelm von Leysser, who became the first president. The academy aimed to increase acceptance and interest in natural history among students (Böhme-Kaßler, 2005).
- **Acad Lisbon.** The *"Academia real das ciencias de Lisboa"* was founded in Lisboa (PRT) in 1779 and officially recognized by the King in 1780. It was established by the Duke of Lafões, who provided significant financial support. The academy aimed to promote scientific knowledge and cultural development within Portugal. It had a structured governance and was primarily funded through royal patronage and private donations (Teixeira Rebelo da Silva, 2015).
- **Acad Lund.** The *"Kungl Fysiografiska Sallskapet"* was founded in Lund (SWE) in 1772, and officially recognized by King Gustav III in 1788. It was

established by Theologian Hesselen, doctor in Medicine Barfort, and Magistrat Retzius. The academy aimed to encourage a passion for science in youth and to associate those who shared this passion to produce useful findings for the general public. It was devoted to natural history and economics (Gertz, 1940).

- **Acad Lyon.** The *"Académie Royale des Sciences, belles-lettres et arts de Lyon"* was founded in Lyon (FRA) in 1700, and officially recognized with patent letters in 1724. It was established by Claude Brossette and other notable citizens, aiming to promote the advancement of science, art, and literature in Lyon and the region. It had a structured governance with a director and a vice-director (Académie Royale des Sciences, belles-lettres et arts de Lyon, 2024).
- **Acad Manchester.** The *"Literary and philosophical society"* was founded in Manchester (GBR) in 1781. The academy was established by Thomas Percival and a group of men who sought to improve the living standards of the city, especially for the working class. It aimed to improve the local society and bring it towards more unity and progress (1896).
- **Acad Mannheim 1.** The *"Academia Electoralis Scientiarum et Elegantiorum Literarum Theodoro-Palatina"* was founded in Mannheim (DEU) on October 15-20, 1763. The academy was established by Karl Theodor, the Elector Palatine of Bavaria, after the advice of Johann Daniel Schopflin. The academy aimed to promote science and the humanities. It had a structured governance with honorary members (Cassidy, 1985).
- **Acad Mannheim 2.** The *"Societas Meteorologicae Palatinae"* was founded in Mannheim (DEU) on September 5, 1780. It was established by Karl Theodor, the Elector Palatine of Bavaria. The academy focused on meteorology, aiming to connect international meteorological stations with similar instruments to compare measurements. It had a structured governance with members and received financial support from Karl Theodor (Cassidy, 1985).
- **Acad Mantua.** The *"Accademia Virgiliana"* was founded in Mantova (ITA) in 1686. It took the name *"Royal Academy of Sciences, Lettres, and Arts"* in 1768. It was established by the co-regnant Maria Teresa and Giuseppe II, with the aim of continuing intellectual development in the Austrian Lombardy. It initially focused on theology and letters, but later expanded to include sciences useful to society. It had a structured governance with members and a patron (Maylender, 1930, Vol 5).
- **Acad Marseille.** The *"Académie des belles-lettres, sciences et arts"* was founded in Marseille (FRA) in August 1726 and officially recognized by King Luis XV with patent letters in 1766. The academy's primary goal was to promote French language and literature in the region. It had a structured governance (Académie des Sciences Lettres et Arts de Marseille, 2024).
- **Acad Messina.** The *"Accademia Peloritana dei Pericolanti"* was founded in Messina (ITA) in 1728. It was established by Paolo Aglioti and others, following the death of Pietro Guerriera who had initially pushed for a similar academy. The academy focused on Letters, Moral and Natural Philosophy

but also on Mathematics, Geography,and Duel and Knights subjects. After 10 years of activity, it focused primarily on scientific matters. It had a structured governance (Accademia Peloritana dei Pericolanti, 2024).

- **Acad Metz.** The *"Société Royale des Sciences et Arts"* was founded in Metz (FRA) in April 1757 and received patent letters in July 1760. The Marshal-Duke Charles Louis Auguste Fouquet de Belle-Isle was its founder and protector. The academy aimed to advance sciences, letters, and arts to make them useful to the local society of Metz.
- **Acad Middelburg.** The *"Zeeuwsch Genootschap der Wetenschappen"* was founded in Vlissingen (NLD) in 1765 and officially founded in 1769. It was established to provide a local organization for scientific practice and to promote the ideas of the Enlightenment (Zeeuwsch Genootschap der Wetenschappen, 2024).
- **Acad Modena.** The *"Accademia ducale dei Dissonanti di Modena"* was founded in Modena (ITA) in 1680 and formally active in 1684. It was established by the citizens of Modena to ask for the reopening of the University and the creation of the Academy. The academy was initially active only in humanities and letters, but added a scientific section in 1790 (Accademia Nazionale di Scienze, Lettere e Arti di Modena, 2023).
- **Acad Rangoniana.** The *"Accademia Rangoniana"* was founded in Modena (ITA) in 1783. It was established by Gherardo Aldobrandino Rangone, who was already financing and hosting scientific experiments of Michele Rosa, who worked on blood transfusions among animals. The academy focused on scientific experiments, mechanics, and physics (Maylender, 1930, Vol 4).
- **Acad Montauban** The *"Académie des belles lettres"* was founded in Montauban (FRA) in 1730 and officially recognized in 1744. The soul of the academy was Jean-Jacques Franc de Pompignan. The academy focused on literary subjects, particularly poetry and letters (Forestié, 1888).
- **Acad Montpellier** The *"Société Royale des Sciences"* was founded in Montpellier (FRA) in 1706. The King wanted to reassure his domain into the Mediterranean coast during the Spanish Succession. It was initially focused on mathematics, anatomy, chemistry, botany, and physics. It played a role in compiling the Encyclopédie of Diderot and d'Alembert (Dulieu, 1975; Société Royale des Sciences, 2024).
- **Acad Munich** The *"Bayerische Akademie der Wissenschaften"* was founded in Munchen (DEU) on October 12, 1758 and officially recognized on June 25, 1759. It was established by Johann Georg von Lori and aimed to advance all useful sciences in Bavaria (Bayerische Akademie der Wissenschaften, 2024).
- **Acad Nancy** The *"Société des Sciences et belles lettres - Académie Stanislas"* was founded in Nancy (FRA) on December 28, 1750, and received patent letters on December 27, 1751. It was founded by Stanislas Leszczynski, the king of Poland and duke of Lorraine and Bar. It aimed to enhance the study of sciences and literature and culture. It created a public library too (Stanislas, 2024).

- **Acad Nimes** The *"Academie Royale de Nimes"* was founded in Nimes (FRA) on March 28, 1682, and received patent letters in August 1682 from Luis XIV. It was established by Jules de Fayn, and aimed to enhance the local patrimony by studying antiquities and the local language (Nicolas, 1854).
- **Acad Nuremberg** The *"Cosmographical Society"* was founded in Nurnberg (DEU) in 1747.
- **Acad Olmouc.** The *"Societas Eruditorum Incognitorum"* was founded in Olomouc (CZE) in 1747 by Josef Petrash, who had traveled the world as a soldier and poet. The academy aimed to free higher education from the influence of Jesuits. It sought to cultivate the fine sciences and liberal arts (Kostlán, 1996).
- **Acad Orleans.** The *"Académie Royale des Sciences, arts et belles lettres"* was founded in Orleans (FRA) on April 23, 1781, and received patent letters on March 20, 1784. The academy was established by a group of 10 scholars. It aimed to promote physics and natural sciences (Nicolas, 1908).
- **Acad Oxford.** The *"Oxford Philosophical Society"* was founded in Oxford (GBR) in 1645 as an informal society and formally established in 1651 by John Wilkins and other natural philosophers. It was inspired by the London group of natural philosophers, and the remnants of William Harvey's circle at Oxford. The academy focused on magnetic experiments, dissections, antiquities, astronomy, and geometry (Applebaum, 2000; Gunther, 1925).
- **Acad Padua.** The *"Accademia dei Ricovrati/Accademia di Scienze, lettere ed Arti"* was founded in Padova (ITA) in 1599, which is still considered a Reinassance Academy (McClellan, 1985). It became the "Accademia di Scienze, lettere ed Arti" in 1779, when the Venetian Senate ordered its fusion with the *Accademia di Arte Agraria.* It was founded by Federico Cornaro, and Galileo was a founding member of the earlier Ricovrati Academy. The academy aimed to promote the study of humanities and science via the experimental approach (Maggiolo, 1983). The academy enter into my analysis only from 1779.
- **Acad Palermo.** The *"Accademia Palermitana"* was founded in Palermo (ITA) in 1718, though it only received recognition in 1752. It was established by Pietro Filangieri and other enlightened men. The academy aimed to tell Sicily's story and advance letters and sciences (Maylender, 1930, Vol 1).
- **Acad Palma.** The *"Accademia Boreliana"* was founded in Palmi (ITA) in 1673 by Gio. Alfonso Borelli. It focused on physics and natural history, especially on the respiration moto (Maylender, 1930, Vol 1).
- **Acad Pau.** The *"Académie Royale des Sciences et beaux arts"* was founded in Pau (FRA) in 1718.
- **Acad Prussia.** The *"Königlich-Preußische Akademie der Wissenschaften"* was founded in Berlin (DEU) on July 11, 1700, and immediately officially recognized. It was established by Gottfried Wilhelm von Leibniz, with sponsorship from the noble Hohenzollern family. The academy aimed to advance

both humanities and natural sciences (de la Croix, Eisfeld, & Ganterer, 2021; Königlich-Preußische Akademie der Wissenschaften, 2024).

- **Acad Prague.** The *"Regia Societas Scientiarum Bohemica"* was founded in Praha (CZE) in 1769 and officially recognized in 1790. The academy was established by count Frantisek Josef Kinsky and Ignac Born. It aimed to diffuse the experimental approach and critical thinking but also Bohemian History (Zacek, 1968).
- **Acad Reggio d'Emilia.** The *"Accademia degli Ipocandriaci"* was founded in Reggio-Emilia (ITA) in 1746. It was established by Achille Crispi, the captain of the Duke Francesco III. The academy had a structured governance (Maylender, 1930, Vol 3).
- **Acad Roma.** The *"Accademia di Fisico-Mathematica"* was founded in Roma (ITA) on July 6, 1677. It was established by Giovanni Giustino Ciampini, who provided the academy with tools and machines for scientific experiments. The academy focused on natural sciences and experiments, including anatomy, physics, mathematics, and mechanics (Maylender, 1930, Vol 3).
- **Acad Rotterdam.** The *"Battafsch Genootschap der Proefonderwindelijke Wijsbegeerte"* was founded in RotterdamNLD on May 14, 1769 (Lieburg, 1985).
- **Acad Rouen.** The *"Académie Royale des Sciences, belles lettres et arts"* started informally in Rouen (FRA) in 1736 and formally with patent letters from Luis XV on June 17, 1744. It was established by Fontanelle and Le Cornier de Cideville, and focused on botany (Gosseaume, 1985).
- **Acad Rovereto.** The *"Imperiale Regia Accademia degli Agiati"* was founded in Rovereto (ITA) in 1750, officially recognized in 1753. It was established by Giuseppe Valeriano Vannetti and other four important local scholars. The academy was initially focused on letters, history, and science, but later expanded to include agricultural research (Accademia Roveretana degli Agiati di Scienze, Lettere ed Arti, 2024).
- **Acad Paris.** The *"Académie Royale des Sciences"* was founded in Paris (FRA) in the spring of 1666. The academy was established by Minister Colbert under Luis XIV, who fully funded its creation and operations. The academy was a symbol of royal patronage. Its focus was on natural philosophy, mathematics, and the application of the laws of nature to practical reforms (Académie Royale des sciences, 2024).
- **Acad Siena.** The *"Reale Accademia della scienze di Siena"* was founded in Siena (ITA) in 1690. It was established by Pirro Maria Garieli, a professor at the University of Siena. The academy focused on natural science, philosophy, medicine, and poetry (Maylender, 1930, Vol 3).
- **Acad Stockholm.** The *"Kungliga Vetenskapsakademien"* was founded in Stockholm (SWE) on June 2, 1739. It was modelled after the Royal Society of London and the Académie Royale des Sciences in Paris. The

academy was created as an independent, non-governmental scientific society. It was primarily focused on natural sciences and mathematics (Kungliga Vetenskapsakademien, 2024).

- **Acad St Petersburg.** The *"Academia Scientiarum Imperialis Petropolitanae"* was founded in Saint-Petersburg (RUS) in 1724. It was established by Peter the Great, who was inspired by academies in Europe. The academy aimed to bring the Russian Empire into the modern era. It was initially focused on mathematics, physical sciences, and humanities, and included training in scientific subjects (de la Croix & Doraghi, 2021; Gordin, 2000).
- **Acad Toulouse.** The *"Académie Royale des Sciences, inscriptions et belles lettres"* was founded in Toulouse (FRA) in 1640-1645/1665-1685 as an academic conference and officially recognized in 1746. It was established by Sage Antoine, Carrière, and Gouazé Pierre. The academy aimed to advance sciences, inscriptions, and belles-lettres. It had a structured governance (Taillefer, 1984).
- **Acad Trondheim.** The *"Det Kongelige Norske Vienskabers Selskab"* was founded in Trondheim (NOR) in 1760 and received royal recognition in 1767. It was established by Bishop Johan Ernst Gunnerus, rector Gerhard Schoning, and councilor Peter Friderich Suhm to create an institutional space for enhancing and spreading the New Science (Schmidt, 1960).
- **Acad Turin.** The *"Accademia delle scienze di Torino"* was founded in Torino (ITA) in 1757 and officially recognized in 1783. It was founded by Joseph-Louis Lagrange, Giuseppe Francesco Cigna, and Giuseppe Angelo Saluzzo. The academy aimed to advance scientific research that could not find enough space within the university of the city (Accademia delle Scienze di Torino, n.d.).
- **Acad Filopatria.** The *"Accademia Filopatria"* was founded in Torino (ITA) on July 2, 1782. It was established by a group of enlightened men in the city of Turin. The academy focused on antiquities and the history of the homeland, including letters, poetry, and moral values but also on public economics, and sciences (Campori, 1887).
- **Acad Uppsala.** The *"Societatis Regiae Scientiarum Upsaliensis"* was founded in Uppsala (SWE) in 1710. It was reorganized in 1719, and received royal recognition on November 11, 1728. It was founded by the librarian Eric Benzelius. The academy initially focused on scientific discussions and later established a scientific journal (Karlberg, 1977).
- **Acad Uppsala.** The *"Cosmographiska sällskapet"* was founded in Uppsala (SWE) in 1758 by Anders Akerman and other enlightened men. The academy focused on cosmography, constructing globes for the earth and the sky.
- **Acad Utrecht.** The *"Provinciaal Utrechtsh genootschap van Kunsten en Wetenschappen"* was founded in Utrecht (NLD) in 1773 and officially founded in 1778. It was established by Mr. J. van Haeften and L. Praalder. The academy aimed to preserve local heritage, modern art, and publications, as well as to develop and improve science (Singels, 1923).

- **Acad Valence.** The *"Société Académique et Patriotique"* was founded in Valence (FRA) in 1784, receiving King's Letters Patent in December 1786. The academy aimed to advance sciences, arts, and belles-lettres. It had a structured governance and it organized 3 prizes every year (de Colonjon, 1866).
- **Acad Venice.** The *"Accademia dei Planomaci"* was founded in Venezia (ITA) circa 1740. It was established by the abate D. Meodoro Rossi. The academy published the *"Novelle Letterarie,"* a journal of reviews and critiques of new works. It had a structured governance with a protector (Maylender, 1930, Vol 4).
- **Acad Verona.** The *"Societa Italiana delle Scienze"* was founded in Verona (ITA) in 1766 and officially established in 1782. It was founded by Antonio Mario Lorgna. The academy focused on scientific matters and published the periodical *"Memorie accademiche"* (Maylender, 1930, Vol 1).
- **Acad Zurich.** The *"Naturforschende Gesellschaft"* was founded in Zurich (CHE) in 1745 and formally established in 1746. It was established by Johanes Gessner. The academy aimed to provide a space for students and personalities who studied abroad to return home and share their knowledge. It had a structured governance and relied heavily on member contributions (Rübel, 1947).
- **Royal Society.** The *"Royal Society of London"* was founded in London (GBR) in 1660 and officially established in 1662. It was established by John Wilkins and other polymaths. The academy focused on natural philosophy and experiments, including trade, manufacture, and crafts, as well as scientific experiments. It had a structured governance with a president, a treasurer, and two secretaries (The Royal Society, 2024).
- **Acad Botanical.** The *"Botanical Society"* was founded in London (GBR) in 1721. It was established by Johann Jakob Dillen and John Martyn to increase knowledge of and spread interest in minerals, plants, and animals.
- **Acad Linnaus.** The *"Linnean Society of London"* was founded in London (GBR) in 1788 by James Edward Smith, Samuel Goodenough, and Thomas Marsham. The academy was named after Carl Linnaeus, who is considered the father of taxonomy. The academy was devoted to natural history, focusing on the evolution theory and biological taxonomy.
- **Acad London.** The *"Temple Coffee House Botany Club"* was founded in London (GBR) in 1689. It was established by Hans Sloane and his friends, and focused on natural history and botany.

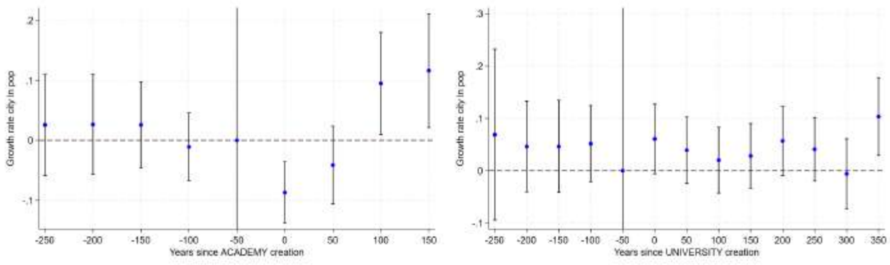
Appendix F Dynamic TWFE results

In the following discussion, I focus on the main results using dynamic TWFE estimations and address the two main assumptions of parallel trends and no anticipation effect. Section 7.2 provides further analyses to assess the validity of the SUTVA assumption and investigate possible spatial spillover effects (Berkes & Nencka, 2021; Butts, 2021).

Figure F10 presents the main event studies analysing the impact of the creation of educational institutions between 1500 and 1900. Each period represents a 50-years interval: Panel F10a illustrates the impact of creating an academy in city c at time t, while Panel F10b depicts the impact of creating a university. The first two assumptions (no pre-trends and no anticipation effect) hold in both panels.[42]

In Panel F10a, the results indicate a downward trend in the first 50 years and a positive effect in the following century that compensate the initial negative impact. This indicates that there should be a positive impact on population growth rates between cities with and without innovative academies after 100 years from the establishment.

On the other hand, Panel F10b shows no significant effect of creating a university. This result is consistent with previous studies indicating that the effect of a university on local economic growth is not significantly different from zero (Serafinelli & Tabellini, 2022; Squicciarini & Voigtländer, 2015). It is worth noting that analyzing the creation of universities within the period 1500-1900 may not be the most appropriate approach, as many universities were established before 1500 (see Figure B2). Figure F11b displays the event study for the creation of universities, extending the analysis back to the year 1000. As expected, the parallel trend assumption no longer holds, as the placebo estimates (i.e., the leads) become significant. This suggests the presence of a potential reverse causality issue, as mentioned in Appendix B.1. Nevertheless, when expanding the time frame for the $ACADEMY$ event as well, the parallel trend assumption continues to hold (Figure F11a).



(a) (b)

Fig. F10 Event Studies for the creation of (a) an academy or (b) a university between 1500 and 1900.

To investigate the interaction between universities and academies, I focus on cities that hosted a university at least once and analyze the impact of the $ACADEMY$ event on this subset of cities. Furthermore, since it is likely that the university was established before the academy, this subset accounts for

[42] To be noted that looking at possible pre-trends is only a partial test for the parallel trends assumption. Future stages of the paper will include the "Honest DID" by Rambachan and Roth (2020).

more similar cities allowing to better investigate the direction of the interaction term, $UNI : ACAD$. However, this sample has a much lower statistical power than the main one given it includes only 153 cities. Figure F12 displays the results for the period 1500-1900 in panel F12a and for 1000-1900 in panel F12b. In both cases, the parallel trend assumption holds, indicating a comparable growth pattern between treated and untreated cities before the creation of an academy. However, there are no significant effects observed after the creation of an academy in cities that had a university at least once. Interestingly, the lag periods exhibit a downward trend in both panels, which aligns with the negative sign found in the OLS results presented in Table 3 (main text). This suggests that the presence of an academy in cities with a previous university may have, if anything, a marginal negative impact on the local economic development although the total effect does not change.

In order to further investigate the $ACADEMY$ event, I examine specific groups of academies based on their size, period of activity, and field of study. In future stages, I plan to also consider the quality of academies.

First, I analyze the event study for the creation of big academies, defined as those with more than 30 members,[43] as shown in Figure F14a. However, the size of the academy does appear to have an immediate negative impact on the population growth rate of the city and only after 150 years there is a positive and significant effect (+15% p-value: 0.03). Next, I explore the event study for long-lasting academies, defined as those active for more than 30 years.[44] Figure F14b indicates that the duration of the academy's activity period does affect negatively the population growth rate: only the first two lag are negative and significant.

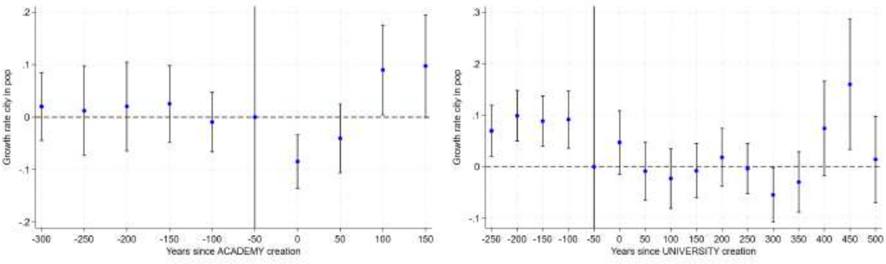
Moving on to the subject of academies, I distinguish between literary and scientific academies based on the composition of their members. Academies are defined as *scientific* when more than 50% of their members studies science, applied science, and medicine.[45] Academies are defined as literary when more than 50% of their members deals with literary disciplines (history, letters, poetry, arts) but also deals with theology, law and social sciences (e.g. economics and political science). In Figure F13, Panel F13a presents the event study for scientific academies. The results show a positive and highly significant effect on the population growth rate of the city after 100 years, persisting for the next 50 years too. Specifically, the growth rate increases by 28% (p-value: 0.000) after 150 years in cities with a scientific academy with respect to cities without scientific academies. Hence there is a positive and significant impact of creating a scientific academy. The immediate negative impact is more than compensate in the long term. In panel F13b of Figure F13, I present the event study for literary academies, defined as those with more than 50% of members studying humanities, theology, law, and social sciences.[46] Interestingly, there

[43]It is the case of 55 academies in my sample.
[44]It is the case of 70 academies in my sample.
[45]It is the case of 38 academies in my sample.
[46]It is the case of 37 academies in my sample.

is a negative and significant impact observed in the first 50 years after the creation of a literary academy. The growth rate of the population decreases by 13% (p-value: 0.001) immediately and by 11.7% (p-value: 0.012) after 50 years from the establishment of a literary academy with respect to cities without literary academies.

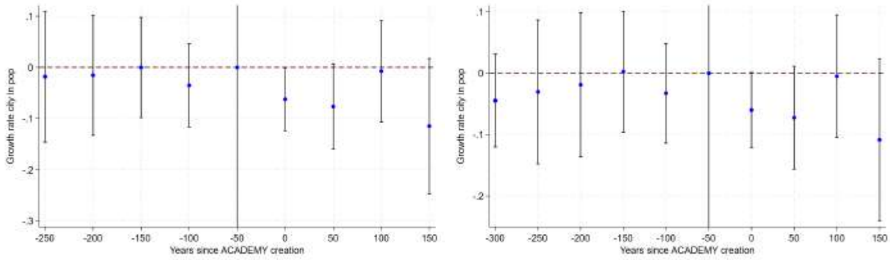
These findings suggest that micro-level data about the field of study of scholars are essential. It is the subject dealt at academies, rather than their size or duration that plays a crucial role in their impact on the population growth rate of cities. Scientific academies positively contribute to economic prosperity, while literary academies initially have a negative effect before stabilizing around a zero-effect in the long term. It appears clear that the experimental approach and innovative thinking have the strongest effect when linked to scientific subjects.

Nonetheless, event study estimates require not only the parallel trends and no anticipation effect hypothesis to hold, but also the Stable Unit Treatment Value Assumption - SUTVA. To test for it I build buffer zones of 50, 100 and 150 km around the cities with an academy, excluding them from the sample. If the results do not change then the estimates capture the local unbiased effect, meaning that nearby cities do not influence treated urban areas. In Section 7.2 I show how the results do not change much with respect to the main ones, confirming the SUTVA and showing the unbiased local effect of having an educational institutions n the city.



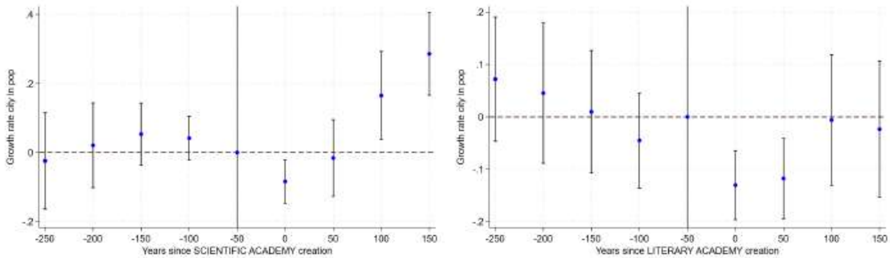
(a) (b)

Fig. F11 Event Studies for the creation of (a) an academy or (b) a university between 1000 and 1900.



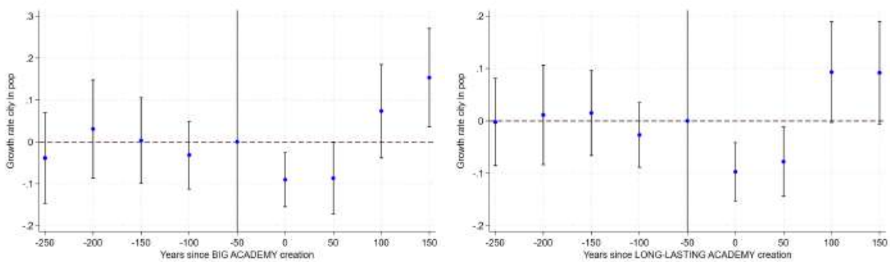
(a) (b)

Fig. F12 Event Studies for the creation of an academy (a) between 1500 and 1900 (b) and between 1000 and 1900 in cities that hosted a university at least once.



(a) (b)

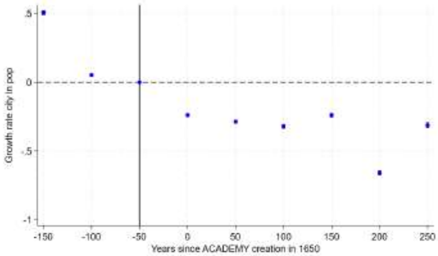
Fig. F13 Event Studies for the creation of (a) a scientific academy or (b) a literary academy between 1500 and 1900.



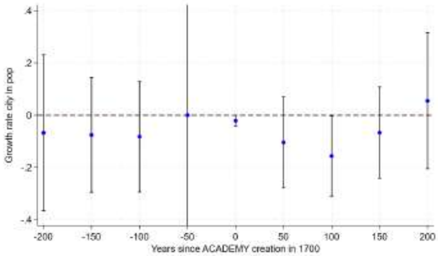
(a) (b)

Fig. F14 Event Studies for the creation of (a) a big academy or (b) a long-lasting academy between 1500 and 1900.

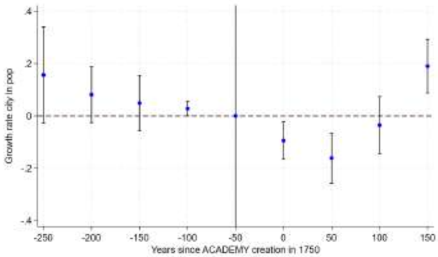
Appendix G 2x2 Event Studies



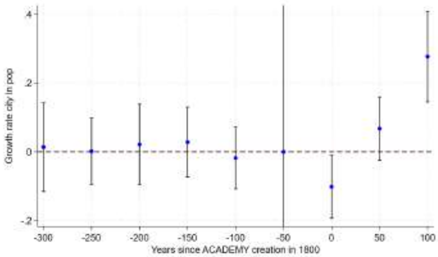
(a)



(b)

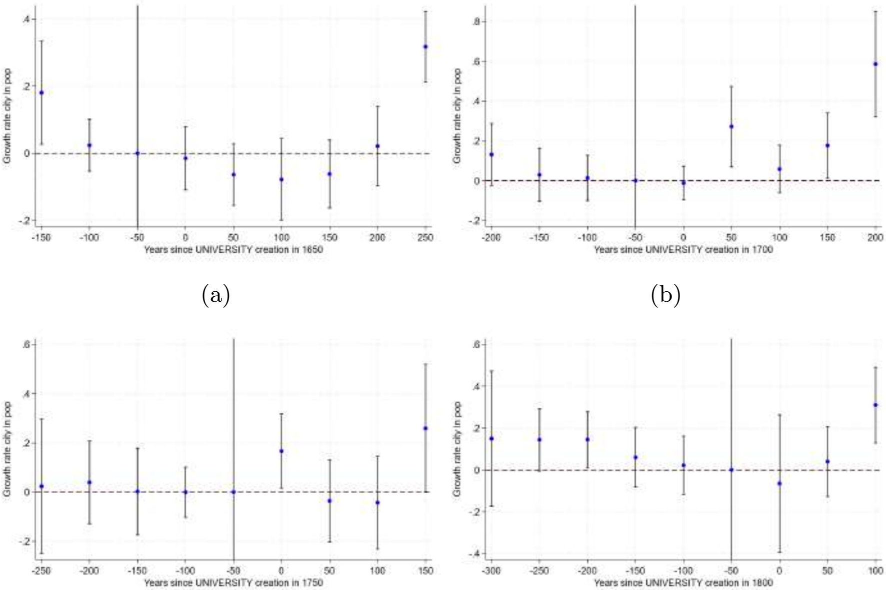


(c)



(d)

Fig. G15 Event Studies for the creation of an academy in a specific period of time. Note that (a) in 1650 only Investiganti Academy in Naples was created. (b) In 1700 13 academies were opened. (c) In 1750 29 academies were created and (d) in 1800 40 academies were opened.



(a) (b)

(c) (d)

Fig. G16 Event Studies for the creation of a university in a specific period of time. Note that (a) in 1650 14 universities were created, (c) in 1700 11 universities were opened, (d) in 1750 8 universities were created, and (e) in 1800 6 universities were opened.

Appendix H Alternative DID estimators

H.1 *CSDID* results

As in Sun and Abraham (2021), also Callaway and Sant'Anna (2021) focuses on the average treatment effect for cohorts, i.e. groups of cities g experiencing the creation of an educational institution for the first time at time t. $CSDID$ estimator by Callaway and Sant'Anna (2021) is pretty similar to the IW estimator by Sun and Abraham (2021) which I use to obtain my main findings in Section 5.3.

Callaway and Sant'Anna (2021) is more general and flexible, it allows for different types of average treatment effects' aggregations. It also allows to use not-yet-treated cities as controls (i.e., cities that will experience the creation of an educational institution only after time t). However, these alternative ways to represent and compute the estimates are less of interest in my setting given and I prefer to focus on balancing the frequencies through the event-studies specifications proposed by Sun and Abraham (2021). Nonetheless, given the similarities between the two estimators, I present the results obtained with Callaway and Sant'Anna (2021) as a robustness check.

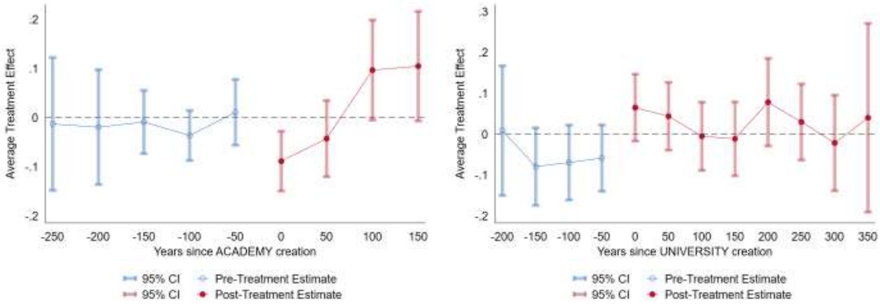
Figure H17 presents the event-study specifications plotting the dynamic effects of creating an educational institution. It visualizes how the effect of creating an academy (Figure H17a) or a university (Figure H17b) changes depending on the amount of periods the institution has been created. I show the specification with balanced time frame, with five pre- and three post-periods, to be consistent with the main results.

When studying the creation of an academy, Figure H17a shows statistic significant coefficients at 90% level, with a general dynamic similar to Sun and Abraham (2021). Callaway and Sant'Anna (2021) also allow to compute the pre-treatment average effect to partially test for pre-trends being this coefficient not significant (-1.4%, p-value: 0.44). However, when looking at the average treatment effect on the treated, I find it not significant and close to zero, with a coefficient of 0.004 (p-value 0.8). This implies that the results on creating an academy may not be that strong and when using Callaway and Sant'Anna (2021) there is no relevant difference in the population growth rate of cities experiencing the creation of an academy with respect to cities without any academy.

In addition, $CSDID$ allows the interpretation of every single calendar time effects. In Naples (the only city experiencing the creation of an academy in 1650), the population growth rate is estimated to be 23.9% (p-value: 0.000) lower on average between 1650 and 1700 than it would have been if the academy was not been created. It is only after 1900 that a positive and significant change in the population growth of 21% (p-value: 0.000) on average is seen, with respect to a situation where no academy was created.

When analysing the creation of a university, the situation is similar. Figure H17b shows no significant results and a dynamic resembling Sun and Abraham

(2021). The pre-treatment average effect is slightly significant and negative (−4.5%, p-value: 0.048), implying some pre-trends. With pre-trends no causal interpretation is usually possible, and anyway also the post-treatment average effect is not relevant, with a coefficient of 0.027 (p-value: 0.5).



(a) (b)

Fig. H17 Dynamic average effects of creating (a) an academy and (b) a university between 1500 and 1900 estimated with Callaway and Sant'Anna (2021). Control group: never-treated. Dependent variable: city population growth rate in logarithm.

Figure H18 plot the event-study specification visualizing the dynamic effects of creating an academy in cities that had a university at least once. This allows the investigation of the interaction between universities and academies, which follows the same dynamic found in Figure 3. There are no pre-trends (0%, p-value: 0.9), but also no statistically significant post-treatment effect on average (−6.2%, p-value: 0.12).

Figure H19 presents the event-study specification for the dynamic effects of creating different types of academies relative to the fields of study, years of activity, and size. As seen in Section 5.3, creating scientific academies increase population growth rate of cities after 100 years by 16.6% (p-value: 0.03) on average with respect to cities without scientific academies. There are no pre-trends (−1.2%, p-value: 0.67) but the post-treatment average effect falls slightly below the threshold of significance (7%, p-value: 0.1). However, the last two calendar time effects tell that after 1850 the population growth rate is on average 13% (p-value: 0.03) higher in cities with a scientific academy, and after 1900 the growth rate reaches 31%.

On the other hand, creating a literary academy (Figure H19b) would lower the population growth rate on average by 6% with respect to cities without a literary academy, however the p-value falls slightly below the threshold of significance. There are also some pre-trends (4.8%, p-value: 0.07). In addition, almost all single calendar time effects are statistically significant and negative, the only positive exception is after 1900 when the growth rate increases by 10% on average but not significantly (p-value: 0.21).

Creating an academy that would last more than 30 years or with more than 30 members do not bring much to the hosting cities. Figure H19c shows the results for long-lasting academies and Figure H19d for big academies. There are no pre-trends but not average post-treatment effect either.

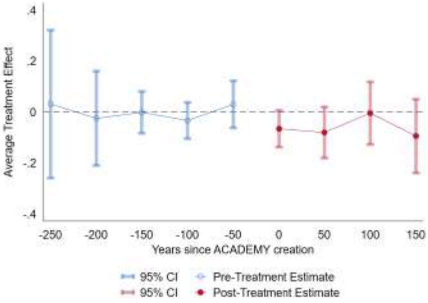


Fig. H18 Dynamic average effects of creating an academy between 1500 and 1900 in cities that hosted a university at least once estimated with Callaway and Sant'Anna (2021). Control group: never-treated. Dependent variable: city population growth rate in logarithm.

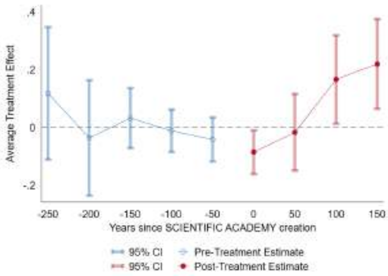
H.2 DID_l results

The De Chaisemartin and d'Haultfoeuille (2024) estimator, referred to as DID_l, estimates the effect of creating an academy or a university l periods ago for the first time. It compares cities that are currently experiencing the creation of a higher educational institution for the first time with cities that have not yet experienced the creation of such institutions. This estimator provides insights into the effects of the initial creation of institutions after a specific l period. It can be used also with continuous treatments, which is the main innovation developed in this last estimator.[47]

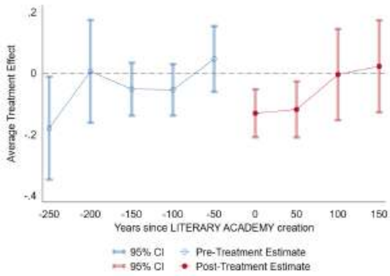
In the following sections, I present the results for this estimator DID_l, which estimates the long-difference placebos and does not allow to include more leads than lags, so I always have to include three leads and only three lags. Nevertheless, this last estimator allow me to obtain a more nuanced understanding of the effects of creating academies and universities in my analysis, and represent a great opportunity for the next steps of this project.

Figure H20 presents the treatment effects of creating an academy between 1500 and 1900 using the DID_l estimator. The dynamic is very similar to the baseline results, with an immediate negative impact followed by a positive effect after 100 years from the creation of the academy. The same is seen when

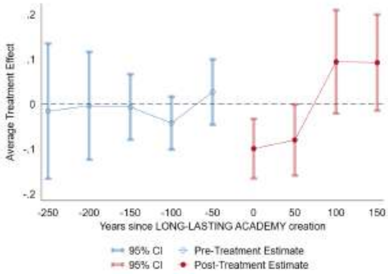
[47] Previous drafts of the current project used the previous estimator developed in De Chaisemartin and d'Haultfoeuille (2022) which produced very similar results to the current ones. I also compared the results with De Chaisemartin and d'Haultfoeuille (2020), which calculates the instantaneous treatment effect by estimating the impact of creating an academy or a university on the population growth rate in cities that are currently experiencing the creation of a higher educational institution. This estimator effectively cancels out cities without any institutions and cities that have already had an institution since 1500, focusing solely on cities where the treatment status changes. Again, the results are very similar but - obviously - for the placebo estimates, given that it was the only difference with respect to De Chaisemartin and d'Haultfoeuille (2022).



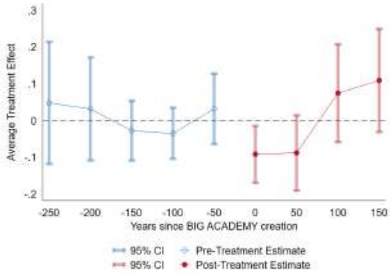
(a)



(b)



(c)



(d)

Fig. H19 Dynamic average effects of creating (a) a scientific academy, (b) a literary academy, (c) a long-lasting academy (with more than 30 years of activity), and (d) a big academy (with more than 30 members) between 1500 and 1900 estimated with Callaway and Sant'Anna (2021). Control group: never-treated. Dependent variable: city population growth rate in logarithm.

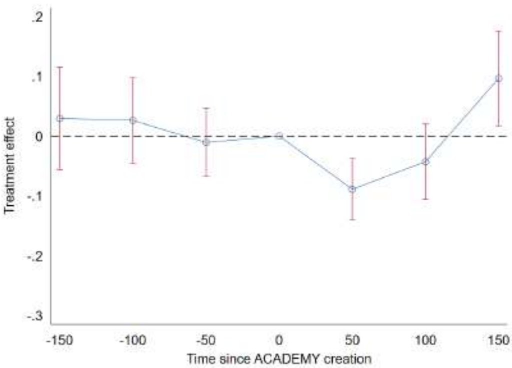
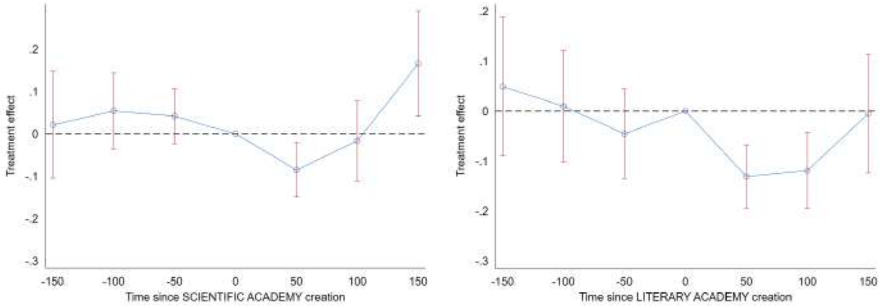


Fig. H20 Effect of creating an academy estimated with DID_l – De Chaisemartin and d'Haultfoeuille (2024) – between 1500 and 1900.

investigating the creation of scientific academies, which bring cities hosting them to grow 16% faster after 100 years - confirming the baseline results. Also the findings about literary academies are confirmed with the first 50 years having a negative impact on the population growth rate. These academies are the only ones to have a (negative) significant average cumulative total effect per treatment city. Figure H21 shows these results.

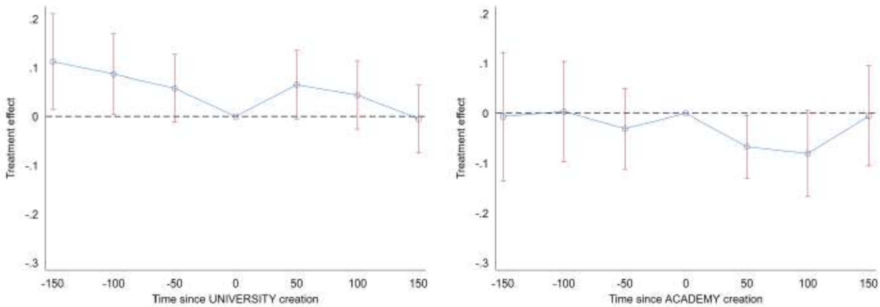
Figure H22a presents the event study for the creation of universities, which is not significant and present some pre-trends too even if the joint test of nullity of the placebo is not rejected. Figure H22b shows the dynamic of creating an academy in cities that hosted a universities at least once, confirming the same patterns as the baseline findings.

These findings align with the event studies estimates, indicating that the field of study of the academy (scientific or literary) has a significant impact on the population growth rate. Scientific academies have a positive effect, while literary academies have a negative effect at least in the short term.



(a) (b)

Fig. H21 Effect estimated with DID_l – De Chaisemartin and d'Haultfoeuille (2024) of creating (a) a scientific academy and (b) a literary academy between 1500 and 1900.

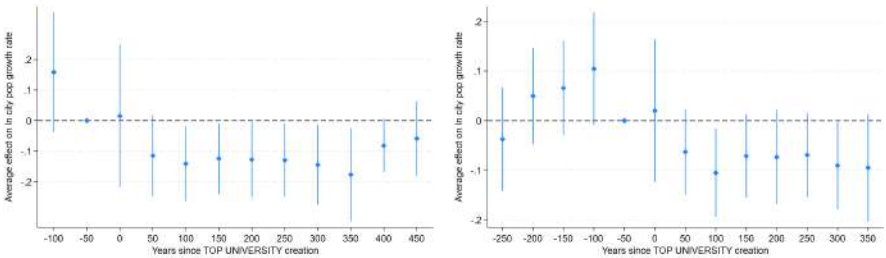


(a) (b)

Fig. H22 Effect estimated with DID_l – De Chaisemartin and d'Haultfoeuille (2024) of (a) of creating a university and (b) an academy in cities that hosted a universities at least once between 1500 and 1900.

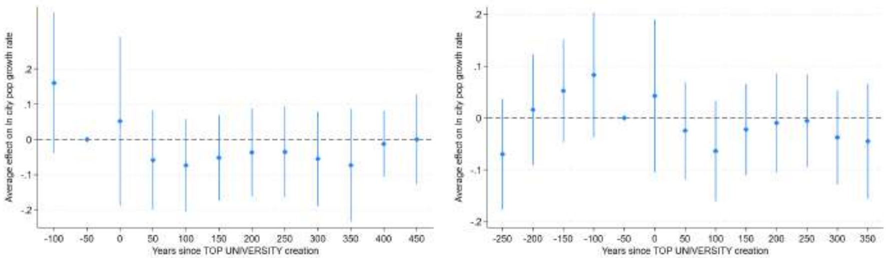
Appendix I Quality of universities

I.1 Top universities as event



(a) (b)

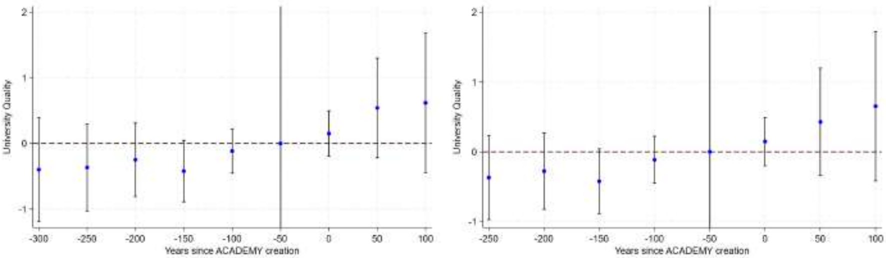
Fig. I23 Effect of creating a TOP university - which reached an average quality of 4.53 at least once between 1000 and 1800 in European cities estimated with Sun and Abraham (2021). Panel (a) considers the period between 1500 - 1900, Panel (b) considers the period 1000 - 1900. Control group: cities that never had a university at all. Dependent variable: population growth rate.



(a) (b)

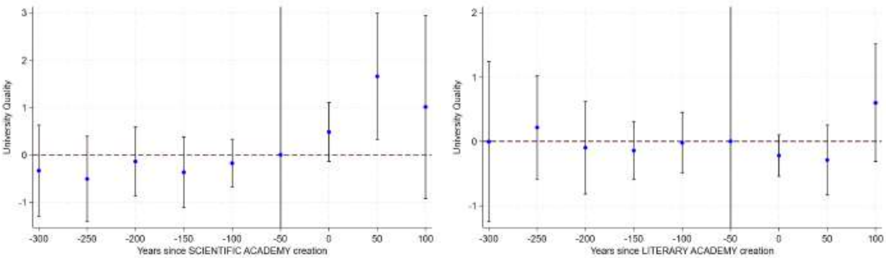
Fig. I24 Effect of creating a TOP university - which reached an average quality of 4.53 at least once between 1500 and 1800 in European cities estimated with Sun and Abraham (2021). Panel (a) considers the period between 1500 - 1900, Panel (b) considers the period 1000 - 1900. Control group: cities that had a university but not a top one. Dependent variable: population growth rate.

I.2 Dynamic TWFE: quality of universities as outcome variable



(a) (b)

Fig. I25 Dynamic TWFE: Event Studies for the creation of an academy between (a) 1500 and 1900 and between (b) 1000 and 1900 on the quality of universities.



(a) (b)

Fig. I26 Dynamic TWFE: Event Studies for the creation of (a) a scientific academy and (b) a literary academy between 1500 and 1900 on the quality of universities.

Appendix J Sensitivity analyses: leave-one-out

Table J6 Types of ACAD by country

	(1) **ACAD**	(2) **ACAD SCIENCE***	(3) **ACAD LIT****	(4) **ACAD LONG**	(5) **ACAD BIG**
Europe	82	37	37	69	54
France	30	8	18	24	15
Italy	17	8	9	15	11
Germany	10	5	4	9	7
UK	6	5	0	5	5
Belgium	1	1	0	0	1
Czech Rep.	2	1	1	1	1
Denmark	1	0	1	1	1
Ireland	1	0	1	1	1
Netherlands	4	2	1	4	3
Norway	1	0	1	1	1
Poland	1	1	0	1	1
Portugal	1	0	0	1	1
Spain	1	1	0	1	1
Sweden	4	3	1	4	3
Switzerland	2	2	0	1	2

*An ACAD is considered scientific if at leat 50% of the members studies science, applied science, or medicine.
**An ACAD is considered literary if at leat 50% of the members theology, law, humanities, or social sciences
Note: Column (2) and (3) should sum up to (1), if not it means that for some academies none of the two categories threshold is reached. Column (4) and (5) are independent from each other.

Table J7 Pre-treatment Statistics per *EVENT* by outcome variable

EVENT	Obs	Mean	Std. Dev.	Min	Max
Outcome variable: $\Delta lnpop$ 1500-1900, 50-years interval					
ACAD	82	0.199	0.303	−0.318	1.139
UNI*	83	0.125	0.245	−0.434	1.099
ACAD SCIENCE	37	0.182	0.304	−0.318	1.139
ACAD LIT	37	0.217	0.302	−0.236	1.099
ACAD LONG	69	0.216	0.295	−0.318	1.099
ACAD BIG	54	0.233	0.336	−0.318	1.139
Outcome variable: *AvgQ* 1500-1900, 50 years interval					
ACAD	41	2.430	2.295	0	6.748
ACAD SCIENCE	20	3.184	2.287	0	6.748
ACAD LIT	18	1.586	2.081	0	6.534
ACAD LONG	36	2.554	2.266	0	6.748
ACAD BIG	27	2.714	2.229	0	6.748

*There are 152 universities in total (St. Petersburg is excluded), 69 open before 1500, which is the beginning of my main sample period, so the statistics are computed on only 83 observations.

J.1 Leaving London out

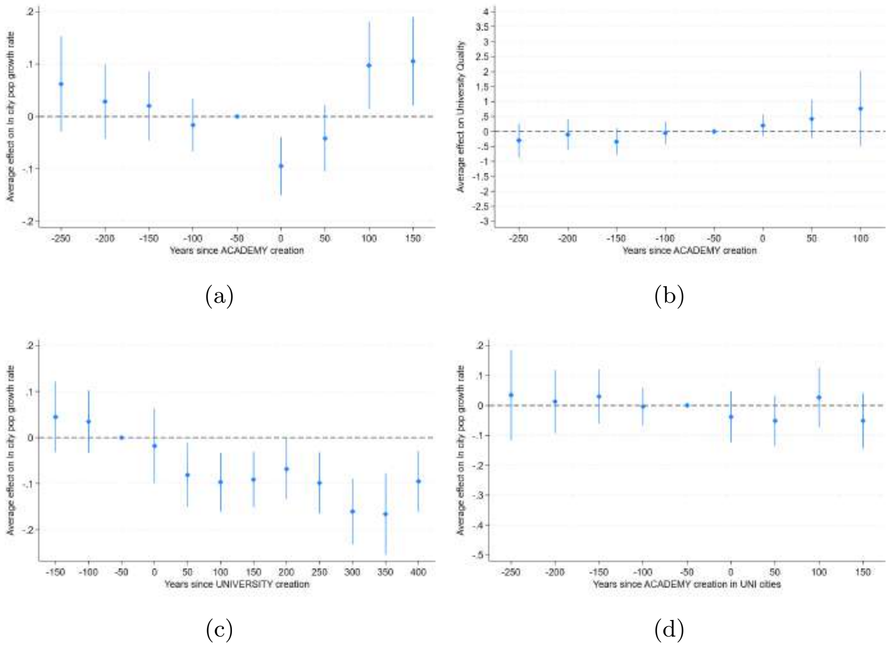
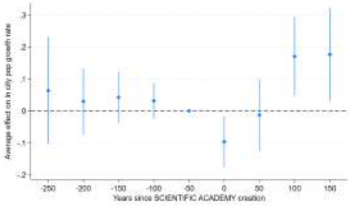


Fig. J27 Effect of creating (a) an academy on population growth rate, (b) an academy on the quality of universities, (c) a university on population growth rate, and (d) an academy in cities that hosted a university at least once; estimated with Sun and Abraham (2021). Control group: never-treated. Leaving London out from the sample.



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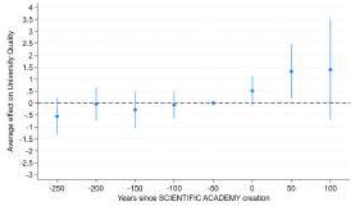

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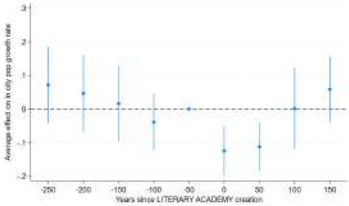

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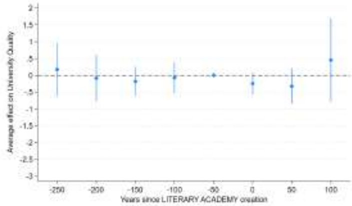

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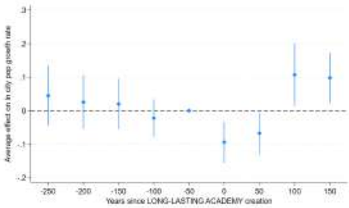

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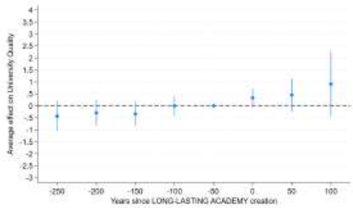

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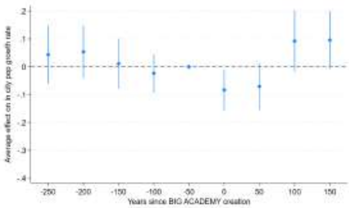

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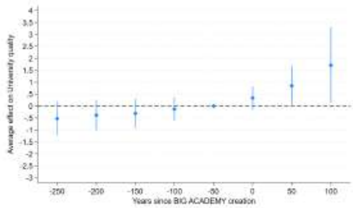


(h)

Fig. J28 Effect of creating (a - b) a scientific academy, (c - d) a literary academy, (e - f) a long-lasting academy, and (g - h) a big academy; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate on the left column, and quality of universities on the right column. Leaving London out from the sample.

J.2 Leaving Paris out

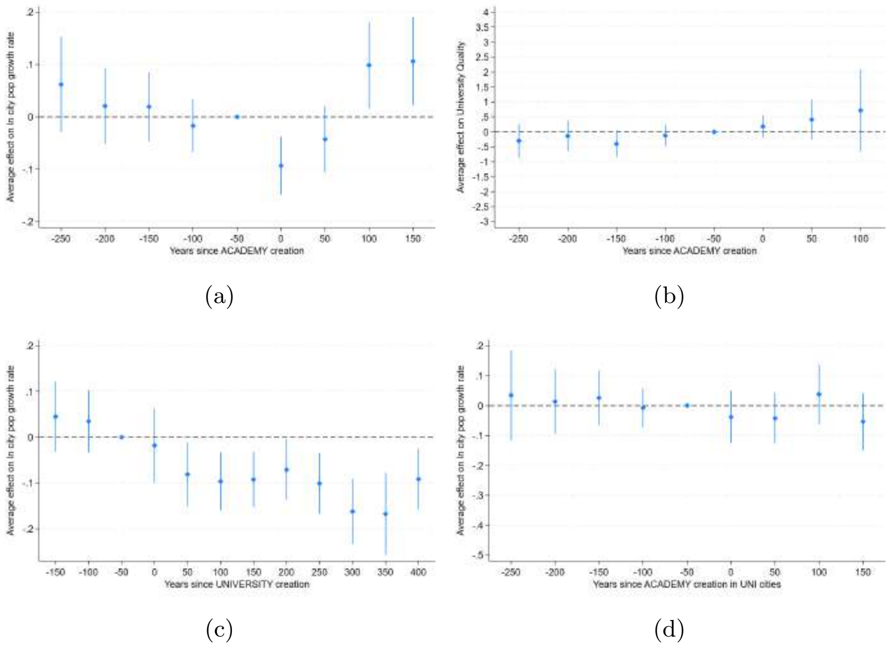
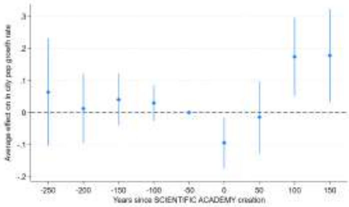


Fig. J29 Effect of creating (a) an academy on population growth rate, (b) an academy on the quality of universities, (c) a university on population growth rate, and (d) an academy in cities that hosted a university at least once; estimated with Sun and Abraham (2021). Control group: never-treated. Leaving Paris out from the sample.



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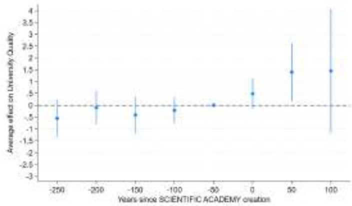

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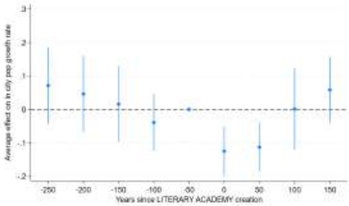

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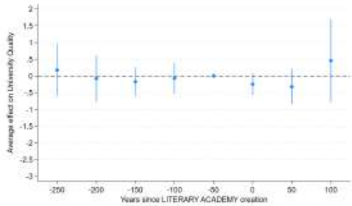

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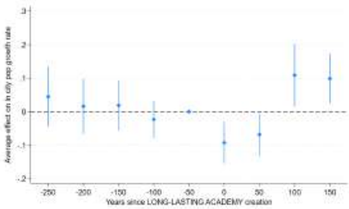

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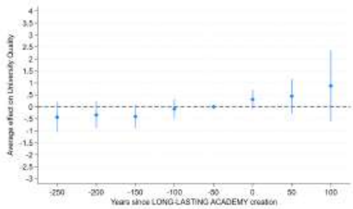

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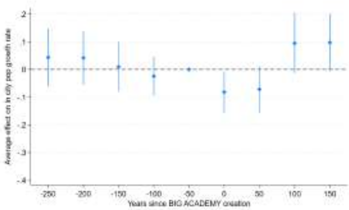

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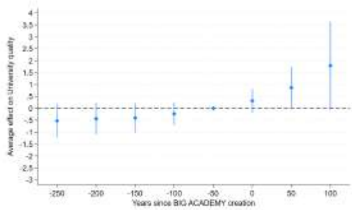
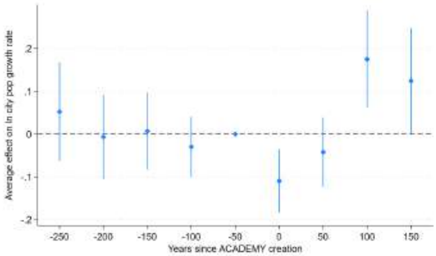


(h)

Fig. J30 Effect of creating (a - b) a scientific academy, (c - d) a literary academy, (e - f) a long-lasting academy, and (g - h) a big academy; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate on the left column, and quality of universities on the right column. Leaving Paris out from the sample.

J.3 Leaving France out



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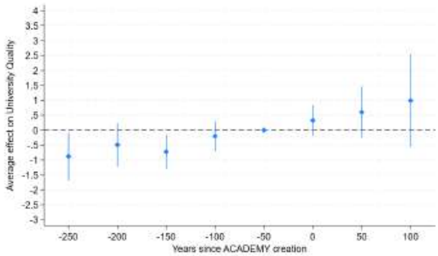

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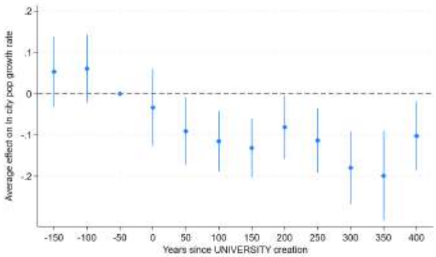

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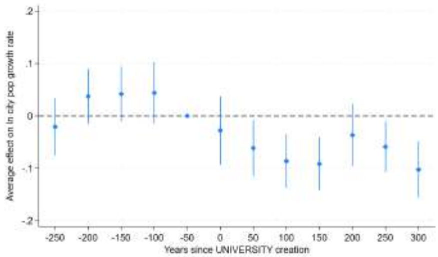

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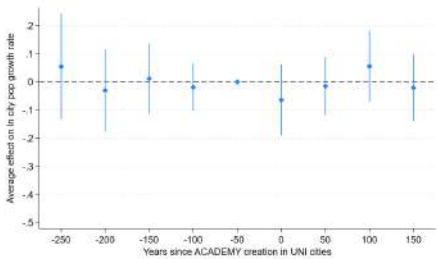


(e)

Fig. J31 Effect of creating (a) an academy on population growth rate, (b) an academy on the quality of universities, (c) a university on population growth rate, and (d) an academy in cities that hosted a university at least once; estimated with Sun and Abraham (2021). Control group: never-treated. Leaving France out from the sample.

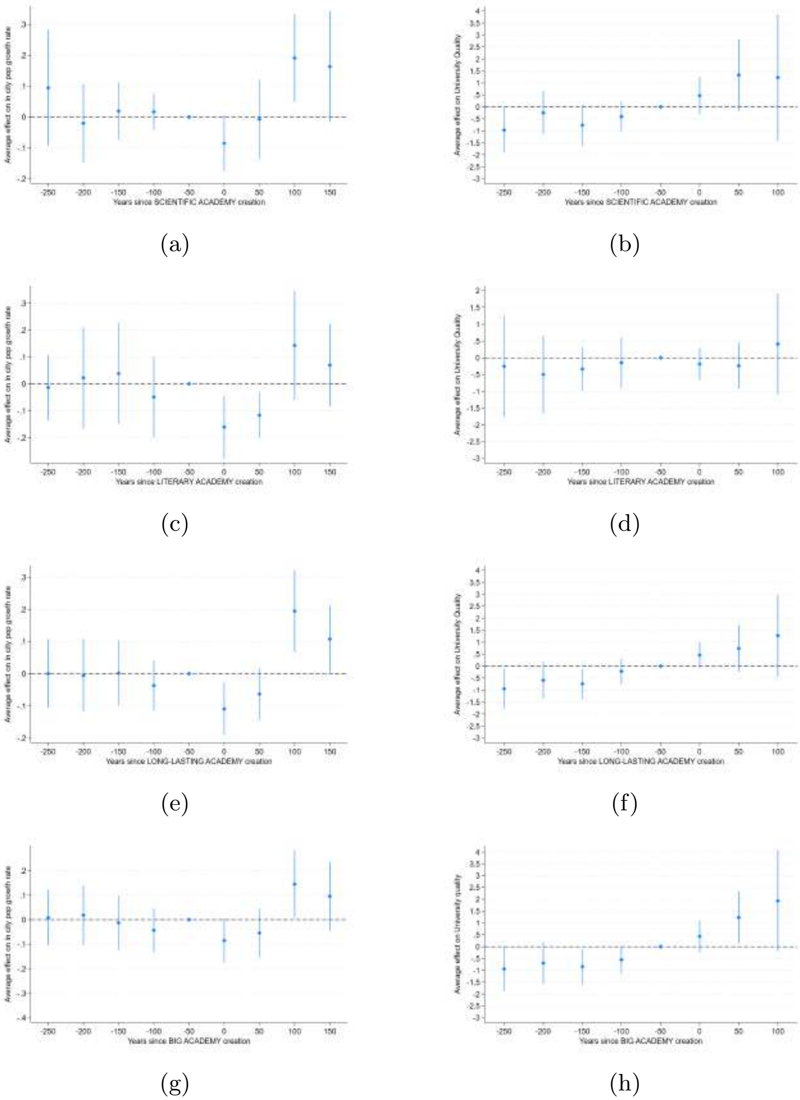
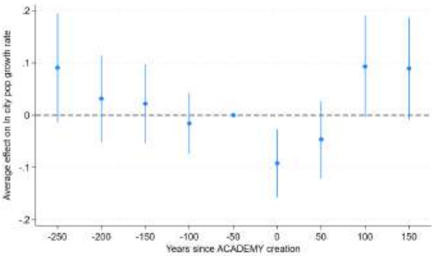
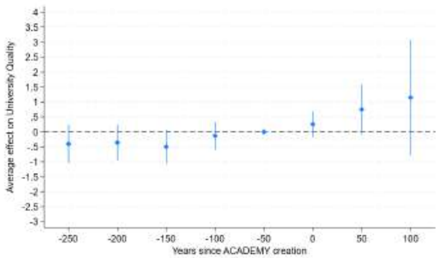


Fig. J32 Effect of creating (a - b) a scientific academy, (c - d) a literary academy, (e - f) a long-lasting academy, and (g - h) a big academy; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate on the left column, and quality of universities on the right column. Leaving France out from the sample.

J.4 Leaving Italy out



(a)



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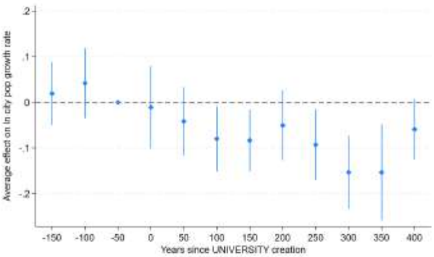

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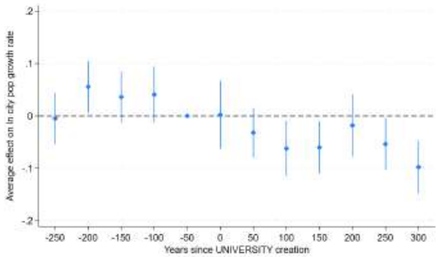

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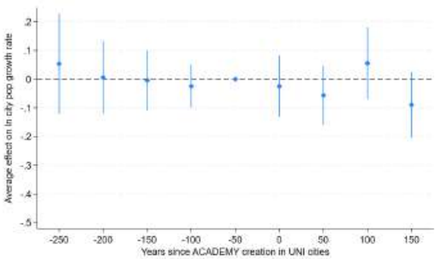
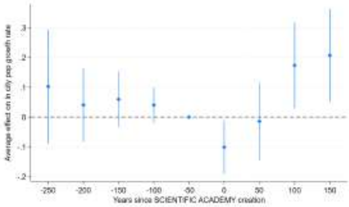


(e)

Fig. J33 Effect of creating (a) an academy on population growth rate, (b) an academy on the quality of universities, (c) a university on population growth rate, and (d) an academy in cities that hosted a university at least once; estimated with Sun and Abraham (2021). Control group: never-treated. Leaving Italy out from the sample.



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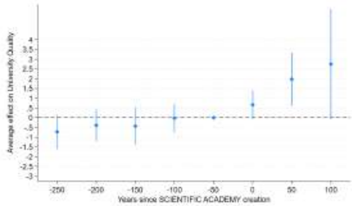

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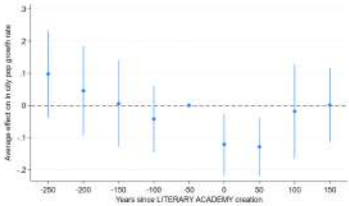

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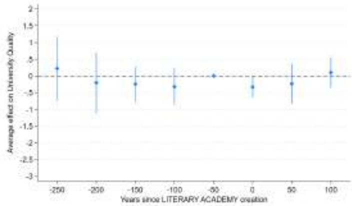

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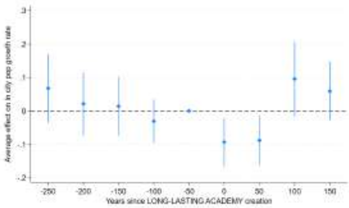

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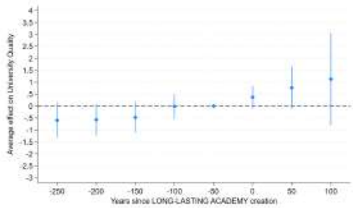

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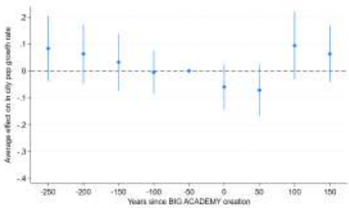

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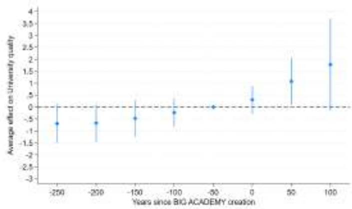
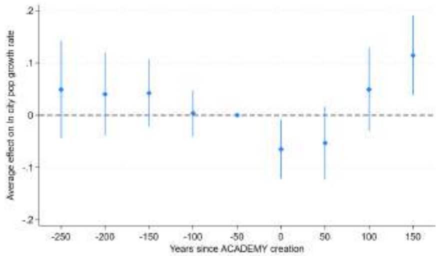


(h)

Fig. J34 Effect of creating (a - b) a scientific academy, (c - d) a literary academy, (e - f) a long-lasting academy, and (g - h) a big academy; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate on the left column, and quality of universities on the right column. Leaving Italy out from the sample.

J.5 Leaving Germany out



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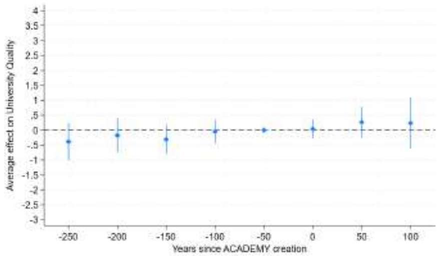

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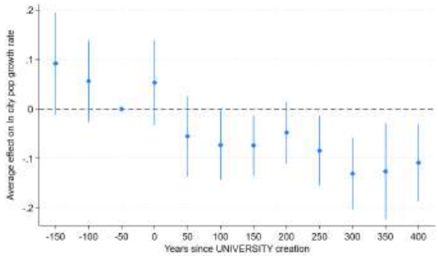

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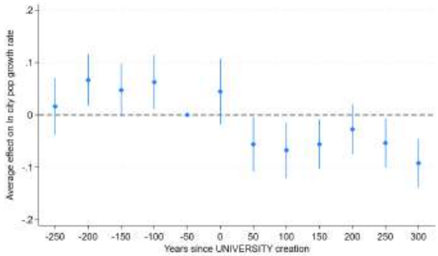

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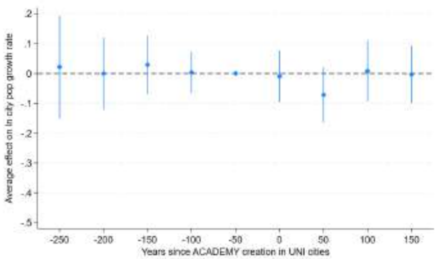


(e)

Fig. J35 Effect of creating (a) an academy on population growth rate, (b) an academy on the quality of universities, (c) a university on population growth rate, and (d) an academy in cities that hosted a university at least once; estimated with Sun and Abraham (2021). Control group: never-treated. Leaving Germany out from the sample.

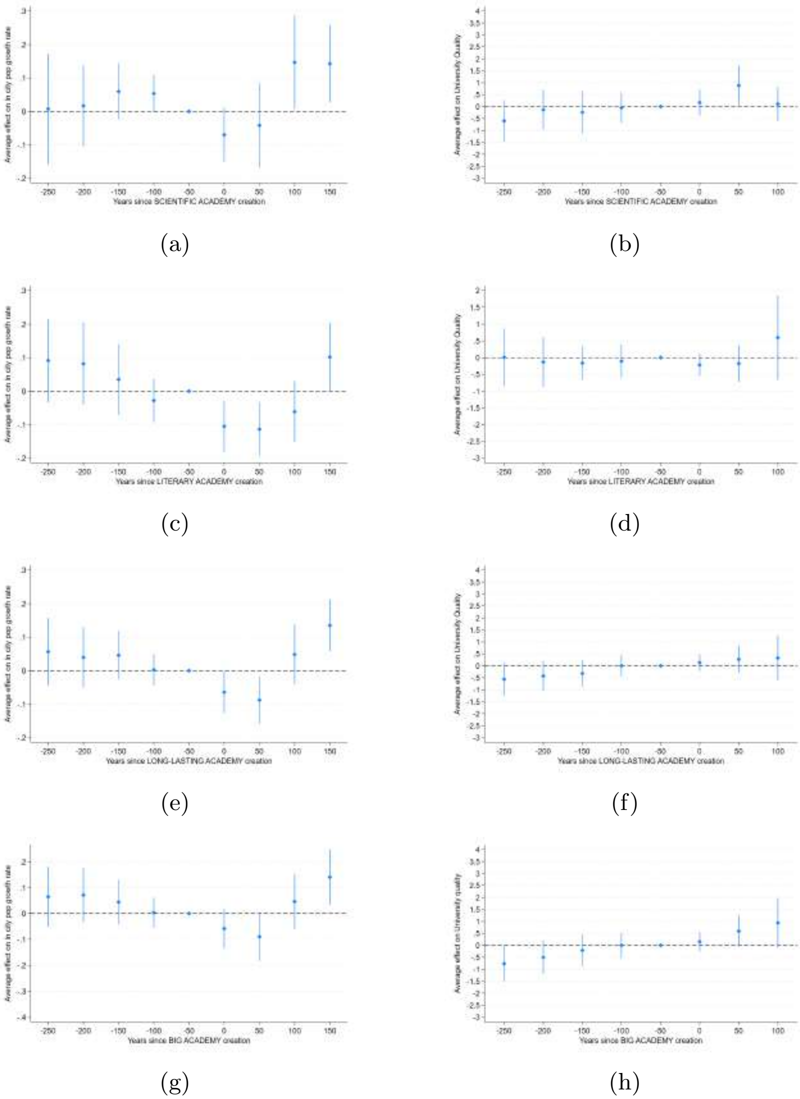
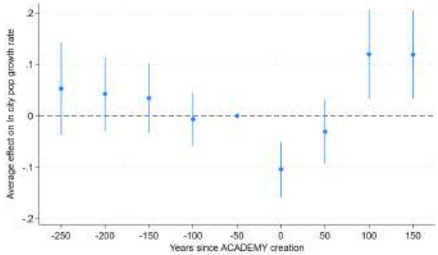


Fig. J36 Effect of creating (a - b) a scientific academy, (c - d) a literary academy, (e - f) a long-lasting academy, and (g - h) a big academy; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate on the left column, and quality of universities on the right column. Leaving Germany out from the sample.

J.6 Leaving UK out



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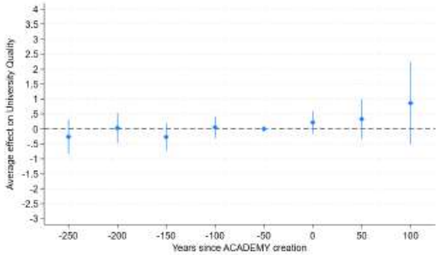

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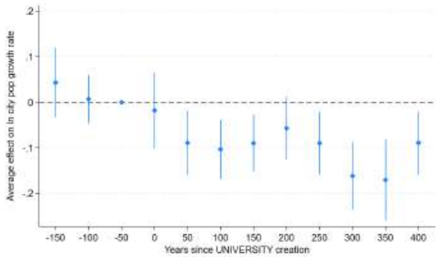

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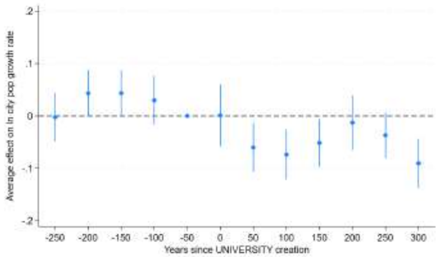

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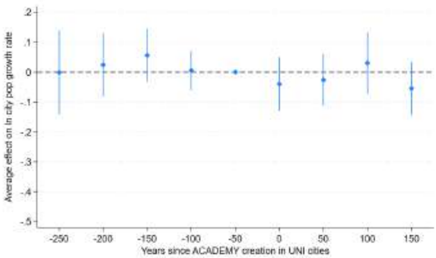
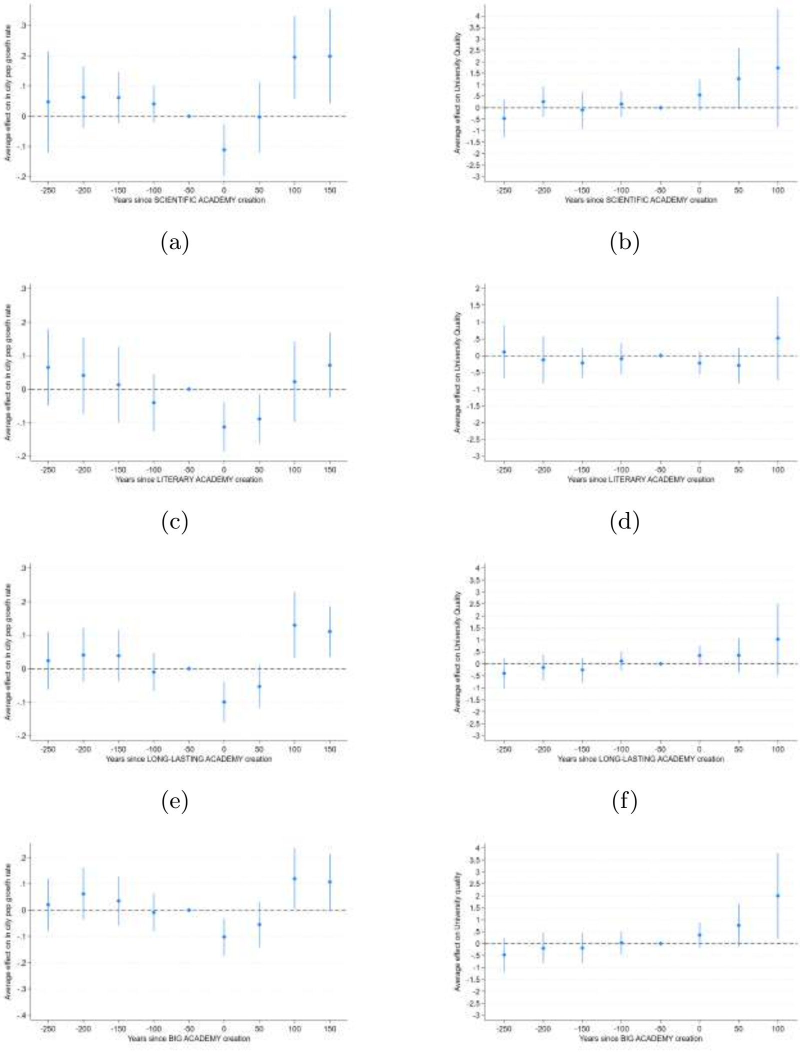


(e)

Fig. J37 Effect of creating (a) an academy on population growth rate, (b) an academy on the quality of universities, (c) a university on population growth rate, and (d) an academy in cities that hosted a university at least once; estimated with Sun and Abraham (2021). Control group: never-treated. Leaving UK out from the sample.



(a) (b)

(c) (d)

(e) (f)

(g) (h)

Fig. J38 Effect of creating (a - b) a scientific academy, (c - d) a literary academy, (e - f) a long-lasting academy, and (g - h) a big academy; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate on the left column, and quality of universities on the right column. Leaving UK out from the sample.

Appendix K Local effects: dropping cities within 50-100-150 km radius

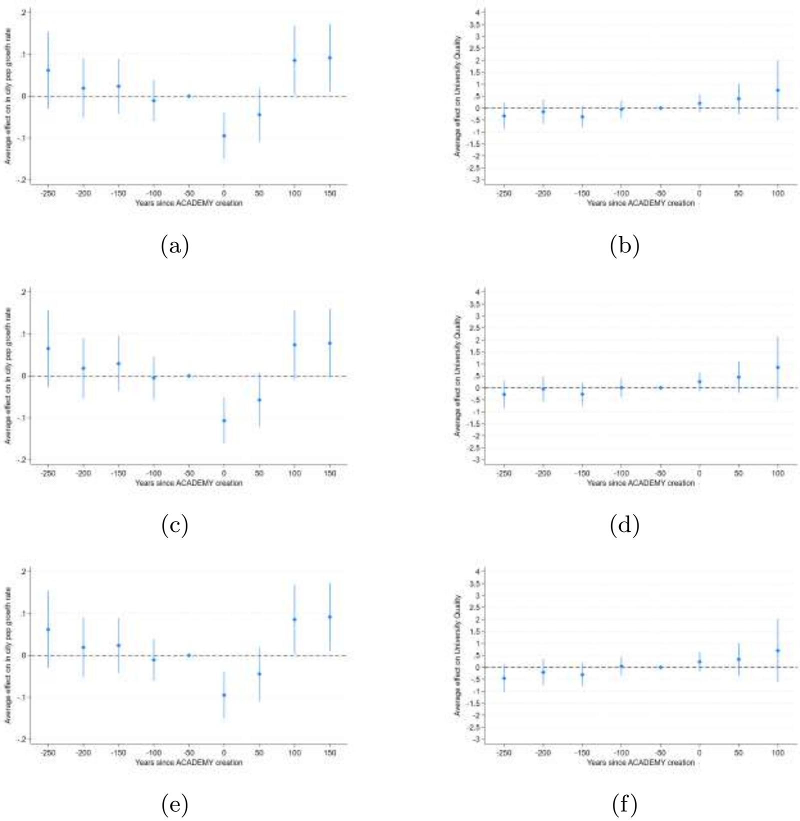
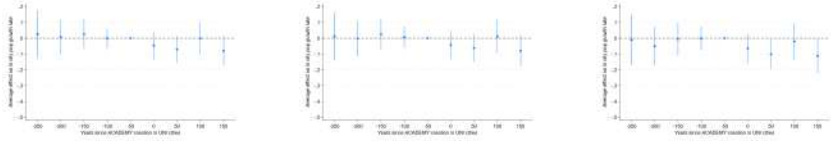
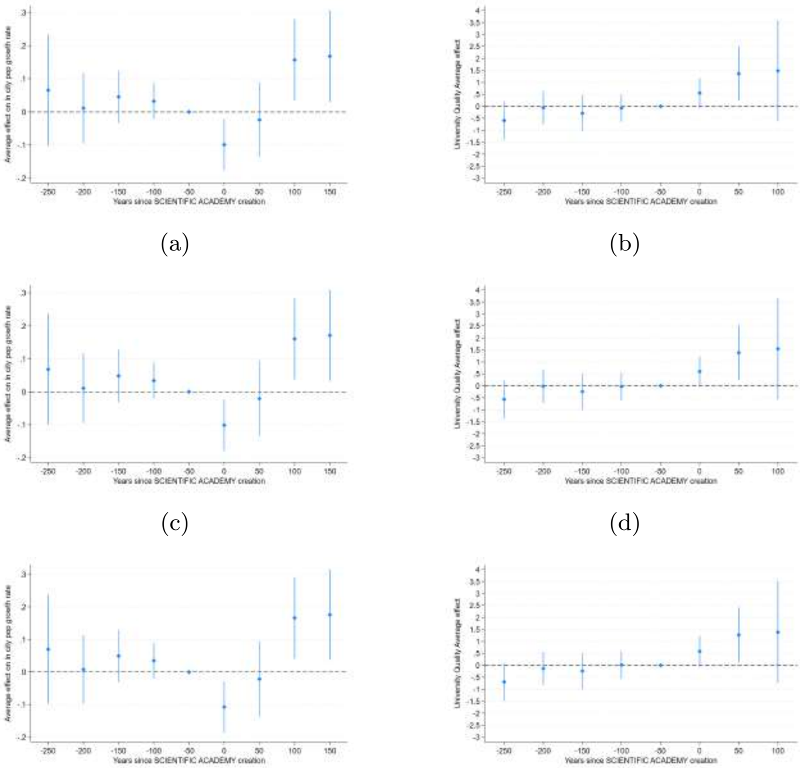


Fig. K39 Effect of creating an academy excluding cities (a - b) within 50 km, (c - d) within 100, (e - f) within 150km; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate on the left column, and quality of universities on the right column.



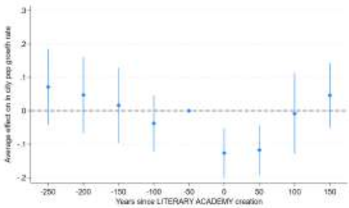
(a) (b) (c)

Fig. K40 Effect of creating an academy in cities that ever had a university, excluding cities (a) within 50 km, (b) within 100, (c) within 150km; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate.

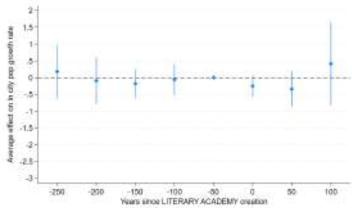


(a) (b) (c) (d) (e) (f)

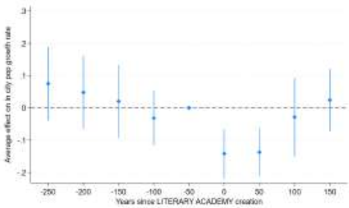
Fig. K41 Effect of creating a scientific academy excluding cities (a - b) within 50 km, (c - d) within 100, (e - f) within 150km; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate on the left column, and quality of universities on the right column.



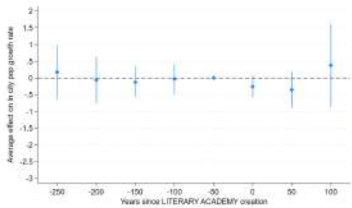
(a)



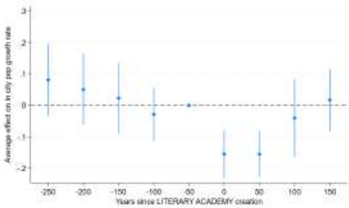
(b)



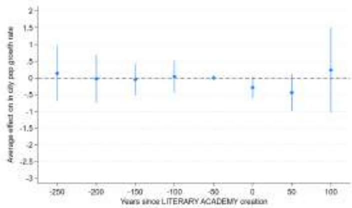
(c)



(d)

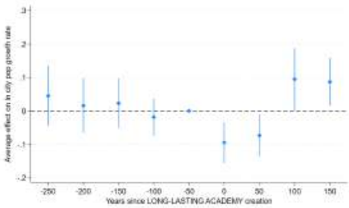


(e)

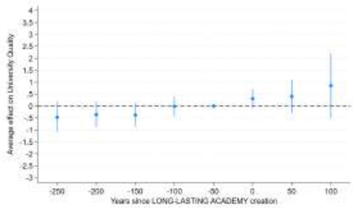


(f)

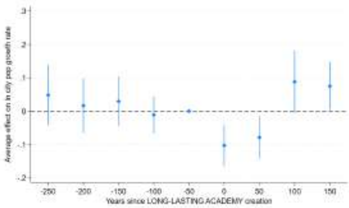
Fig. K42 Effect of creating a literary academy excluding cities (a - b) within 50 km, (c - d) within 100, (e - f) within 150km; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate on the left column, and quality of universities on the right column.



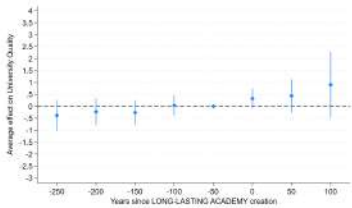
(a)



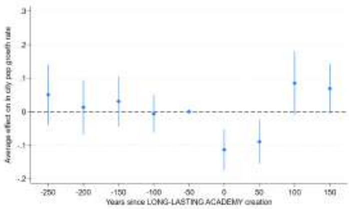
(b)



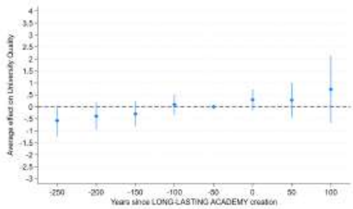
(c)



(d)

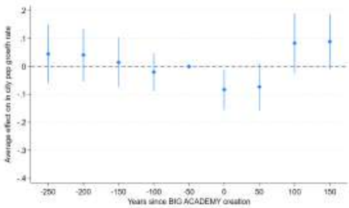


(e)

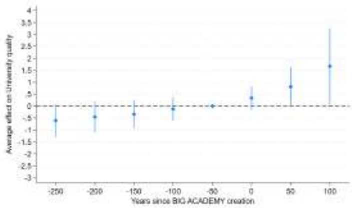


(f)

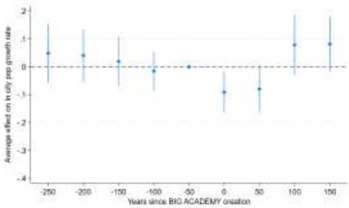
Fig. K43 Effect of creating a long-lasting academy excluding cities (a - b) within 50 km, (c - d) within 100, (e - f) within 150km; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate on the left column, and quality of universities on the right column.



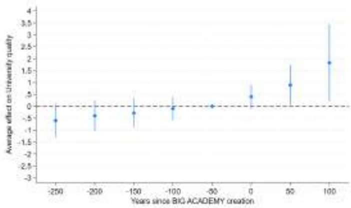
(a)



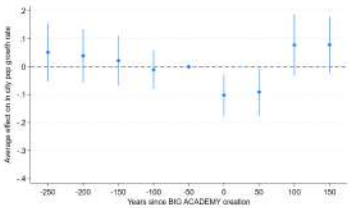
(b)



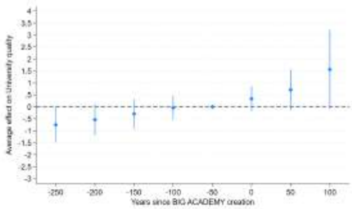
(c)



(d)



(e)



(f)

Fig. K44 Effect of creating a big academy excluding cities (a - b) within 50 km, (c - d) within 100, (e - f) within 150km; estimated with Sun and Abraham (2021). Control group: never-treated. Dependent variable: population growth rate on the left column, and quality of universities on the right column.

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