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DISCUSSION PAPER | 2020 / 29

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Winners and Losers from the Protestant Reformation: An Analysis of the Network of European Universities*

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October 22, 2020

Abstract

Using a new database of European academics, we provide a global view of the effect of the Protestant Reformation on the network of universities and on their individual importance within the network. A connection (edge) between two universities (nodes) is defined by the presence of the same scholar in both universities. We first show that the emergence of Protestantism is strongly associated with rising fragmentation. Dyadic regressions confirm that geography is important as well, but does not substitute for the effect of religion. Considering eigenvector centrality as a measure of the importance of nodes in the network, we find that becoming Protestant or being a newly founded Protestant university is associated with higher centrality. Finally, the number of publications from universities is strongly correlated with centrality, lending credence to the view that the loss of connectedness of the Southern European universities after the (Counter-)Reformation was key in triggering their scientific demise.

Keywords: Upper-Tail Human Capital, Universities, Network, Centrality, Publications, Fragmentation.
JEL Classification Numbers: N33, O15, I25.

*We acknowledges the financial support of the project ARC 15/19-063 of the Belgian French-speaking Community. We thank Sascha Becker, Alice Fabre, Marc Goñi, and Gonzague Vannoorenberghe for discussions on the paper.

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1 Introduction

Medieval universities, together with other bottom-up institutions such as monasteries, guilds, and communes, are considered to be central to the development of Europe (Greif 2006). Still, after having played a pivotal role in the Scientific Revolution of the 16th-17th centuries, many of these grand institutions seem to have plunged into an intellectual coma thereafter. This is particularly true for Southern European universities. One possible culprit for this decline is the loss of mobility of persons and ideas following the Protestant Reformation and the ensuing Catholic Counter Reformation. The literature has already stressed several important effects of the Protestant Reformation on the development of Europe (Cantoni, Dittmar, and Yuchtman 2018, Cantoni 2015, Becker and Woessmann 2009, Becker, Pfaff, and Rubin 2016). In addition to the mechanisms stressed in that literature, Ridder-Symoens (1996) argues that the Reformation led to clustering of universities, which shaped the mobility pattern of students in early modern times.[1] Beyond students' mobility, clustering might also affect the mobility pattern of teachers and scholars, which might be even more subject to restrictions than that of students.

In this paper, we provide a global view of the effect of the Reformation on the network of universities and on their individual position within the network. The objects (*nodes*) in the network are universities active before 1800 in Europe. A connection (*edge* or *link*) between two universities is defined as the presence of the same scholar in both universities. To take a famous example, the English philosopher Roger Bacon (1219–1292) lectured in Oxford (c. 1233), then accepted an invitation to teach in Paris (c. 1237). This established (or rather reinforced, as Bacon was not alone in that case) a connection between those two universities, facilitating the flow of ideas, manuscripts, students between the two places. Connections between universities are built from the database of university scholars developed by de la Croix et al. (2020). The sources used to build this database are primary (published cartularia and matricula), secondary (books on history of universities and on biographies of professors in a specific university) and tertiary (biographical dictionaries by topic or regions, and encyclopedias). Our main motivation for the study of the network of universities lies in the idea that the structure of a network plays a crucial role in the diffusion of information (Jackson, Rogers, and Zenou 2017). The way universities used to be connected with each other through the

[1] "There were henceforth three kinds of university: the Protestant universities, many of them proselytizing, active in training clergymen (Wittenberg, Heidelberg, Geneva and Strasburg for example); secondly, the Catholic universities of the Counter-Reformation, also proselytizing, and dedicated to educating competent clergy (in this the Jesuits played a leading part). The studia of Paris, Louvain, Ingolstadt, Vienna, Graz, Würzburg, Cologne, Pon-à-Mousson, Dole and others, as well as the Iberian universities, are of this kind. The third group comprises several universities that consciously adopted a tolerant attitude, and did not willingly refused students who were not of their religion: for instance, Padua and Siena, Orléans and Montpellier, all of them Catholic universities, or Leiden and the other Dutch universities, model Calvinist universities though they were."

mobility of scholars might have affected the propagation speed of knowledge, ideas, and the intensity of academic production. Our paper aims at exploring to what extent the documented decline in scientific production of Catholic universities during the 17th and 18th centuries can be explained by the fragmentation of the network induced by the Reformation, as well as by their poorer positions in terms of centrality.

To study the effect of the Reformation on the network of European universities, we compare the network before 1527 (creation of the first full fledged[2] Protestant university in Marburg, Germany) with the one after 1598 (edict of Nantes, granting rights to French Protestants, including the right to have their own universities). The period 1527-1598 witnesses a reallocation of scholars to fit the new religious conditions: French and Belgian Protestants moving North, but also British Catholics moving to France (Rheims and Douai, see Bideaux and Fragonard 2003). We study how connected the networks of European universities were, and whether we observe clustering. The before–after comparison allows us to address the question of whether Reformation did correlate with a lower density and/or to more division in the network. In doing so, we need to separate the effect of the Reformation from the effect of the rise in the number of universities. We also want to distinguish the effect of Protestantism from a pure geographical effect. The network lens also endows us with powerful tools to study whether, during the early modern period, the Catholic universities were less connected than the Protestant universities. One should be careful to isolate the effect of religion from the effect of the coverage of the database, as the measures of connectedness depend on the number of observations available. The measures of connectedness will also be used to analyze if there was a decline among Catholic universities in the early modern period, and whether adopting the Reformation helped some of them to avoid this decline.

The two main results can be summarized as follows. First, we find that the Protestant Reformation deeply affected the shape of the network of universities, leading to more fragmentation. Using dyadic regressions, we show that religion is a strong determinant of network structure, even when controlling for geography. In fact, we observe a sharp clear-cut divide between Protestant and Catholic universities in the network after the Reformation, with only 3% of all links connecting them. Fragmentation increases not only between Protestant and Catholic universities, but also within those broad groups. Mobility between Lutheran and Calvinist universities is low, and between Anglican and Presbyterian universities as well. Interestingly, when we simulate a counterfactual network canceling the effect of religion, we find that the proportion of connections between Protestant and Catholic universities would have been multiplied by a factor of nearly 8 if religion did not matter. We also observe much more scholar mobility within rather than between the different strains of Protestantism (Lutheran, Calvinist, Presbyterian,

[2]The Collegium Carolinum in Zurich was created in 1525, but limited initially to teaching theology.

Anglican). In contrast, among Catholics mobility is mostly driven by Jesuits, as we observe more exchanges within Jesuits and between Jesuits and non-Jesuits than among non-Jesuit universities. Second, considering eigenvector centrality as a measure of importance of nodes in the network, we observe that Protestant universities are doing very well in terms of this criterion. In particular converted universities such as Oxford and Cambridge were less central before the Reformation, but more central once they became Protestant. All the newly founded Protestant universities also display higher centrality. The loss of centrality of Catholic universities is patent, and the newly created Jesuit universities did not display the same level of centrality as the newly created Protestant universities. These trends seem particularly relevant to explain the scientific demise of the universities in the South of Europe (including France), as the number of publications of universities is strongly correlated with centrality.

This paper speaks to the literature on the effect of Protestantism on the development of Europe. It offers a new angle based on unique data about the mobility of university professors. Compared to Cantoni, Dittmar, and Yuchtman (2018), Cantoni (2015), Becker and Woessmann (2009), and Becker, Pfaff, and Rubin (2016), we see the Reformation and the Counter-Reformation as affecting the relationships between people and universities, without necessarily affecting preferences or technology (which were the focus of the rest of the literature).

Our paper belongs to a tradition in economic history to use the conceptual framework offered by network theory to describe how relations between nodes shape some economic or social outcome.[3] The seminal paper using networks in economic history is probably Padgett and Ansell (1993). They construct a network of marriages in early Renaissance Florence and analyze its characteristics (centrality, etc.) to understand how the Medici gained political control. Another important paper is by Puga and Trefler (2014), who construct a similar network for Venice in the Middle Ages to study monopolization of the galley trade. Compared to these approaches, we introduce a methodological novelty. We use a dyadic regression to predict links, and, inspired by the quantitative macroeconomics literature, we run counter-factual simulations to show how the network would look if religion did not play a role. A counter-factual network is useful to illustrate the importance of religious affiliation compared to the importance of geographical proximity.[4]

[3]Beyond using network maps to describe relations, there is a rising number of papers using exogenous changes in network structure to build causal identification strategies, see for instance Telek (2018), Becker et al. (2018), Benzell and Cooke (2020).

[4]To our knowledge, only two papers in the economic and social networks literature use counterfactuals. Mayer and Puller (2008) explore how alternative university policies could reduce social segmentation among students, while Canen, Jackson, and Trebbi (2020) investigate how political polarization in the U.S. Congress affects legislative activity. Both papers build their counterfactual analysis on a model of network formation. We cannot use this approach as in our framework, nodes (universities) do not decide to create or sever connections. Dyadic regressions have been widely used to study the determinants of network formation (De Weerdt 2004, Fafchamps and Gubert 2007, De Weerdt, Genicot, and Mesnard

Our analysis is moreover related to the literature on mobility of researchers and scientific production, since the network position of a university reflects by construction the mobility of scholars. Ejermo, Fassio, and Källström (2020) show with contemporary Swedish data that mobility between universities increases significantly the scientific publications of researchers. The arrival of new scholars in a university department can also have positive spillover effects thanks to the diffusion of ideas (Moser, Voena, and Waldinger 2014). In this sense, Ductor et al. (2014) study how knowledge about the coauthor network of an individual researcher helps to develop a more accurate prediction of his or her future productivity. Goyal, van der Leij, and Moraga-González (2006) and Ductor, Goyal, and Prummer (2018) respectively study the broad structure of the coauthorship network among economists and gender differences within this network.

The paper is organized as follows. We first describe the data we built on professors and universities (Section 2). We then explain how we organize them into a network (Section 3), and we describe the main features of the network before and after the Reformation. Section 4 is devoted to separating the role of geography vs the role of religious affiliation. The last section looks at effects on academic production (Section 5).

2 Professors and Universities

In this section we describe the data on scholars used to construct the network of universities and we report qualitative and quantitative evidence on the decline of Southern universities in the 17 and 18th centuries.

The data on professors we use are described in de la Croix et al. (2020). We detail here the main sources for some important samples, to highlight to the reader the strengths and weaknesses of the individual data on which the network of universities will be built. With 3244 professors, the University of Bologna (founded 1088) provides the largest sample, thanks to its seven centuries of existence and to the excellent coverage found in the secondary literature. Almost all the data were encoded from the book of Mazzetti (1847) which provides short biographies for these professors, including whether they had appointments in other universities. The university of Heidelberg (founded 1386) is the Germanic university with the highest number of recorded scholars, 1185 professors, thanks to the list of professors published in Drüll (1991) and Drüll (2002). For the University of Louvain (founded 1425), an important university in the Renaissance and the university of one the authors of this paper, collecting data was more complicated, as there was no Mazetti or Drull to write a catalogue of professors for this once famous university. Data were collected from a variety of sources: Lamberts and Roegiers (1990a), Ram (1861) (for

2019) but not yet to generate counterfactual networks.

the list of rectors), Nève (1856) (for the history of the Collegium trilingue), Schwinges and Hesse (2019) (for deans before 1550), and Brants (1906) (for the law faculty). Each person was searched for in biographical dictionaries such as Eloy (1755) (doctors), Sommervogel (1890) (Jesuits), and the national biography to find more information about his career. The combinations of these various sources unearth 645 professors, hence a good coverage of this university. A similar strategy of combining several secondary sources was applied for the University of Paris. English universities, Oxford and Cambridge, are covered by the books on their alumni (Venn (1922) for Cambridge, and Foster (1891) and Emden (1959) for Oxford). To the list of "official universities" provided by Frijhoff (1996), we took the liberty to add some important higher education institutions, such as Gresham College in London, and the Herborn Academy in the Holy Roman Empire.

Even if the coverage of the smaller universities is sometimes unequal, the coverage of the persons who matter for our study remains high: *mobile* scholars are indeed more likely to be identified as they would appear in multiple sources. *Productive* scholars are also more likely to be in the database, as they would be mentioned in books about each university, even if those books are very incomplete (such as books celebrating the xth anniversary of the university).

While searching for professors, we found many qualitative elements about the decline of universities in the 17th century. The view of the literature is that Catholic universities became unattractive during the 17th-18th centuries, partly because of religious views (the Counter Reformation, the Inquisition). Here are some compelling examples. (1) About the medical school at the University of Valencia during the 17th century: "the neoscholastic ideology of the Counter-Reformation converted the Faculty, for the most part of the century, into a nucleus of intransigent Galenism, opposed to the innovations of the Scientific Revolution." (Piñero 2006) (2) The same view applies to Lleida where the advances of the sixteenth century were later reversed: "The rigid vigilance exercised by the Supreme Council of the Inquisition paralyzed the University and caused the decadence of the university body. In such cases, thought is threatened and all innovation seems dangerous. The teacher dictates the text, students copy it, and that is all. Medieval routines subsist and Aristotle, Galen, and Avicenna reemerge enslaved under the tyranny of obsequious teaching, ... This state of affairs lasted for two centuries. It could be said that throughout this long period, Spanish universities, which had been so prestigious until then, disconnected from the European cultural rhythm." (Esteve i Perendreu 2007) (3) On Salamanca, the most prestigious Spanish university, we read "In the early decades of the eighteenth century, Salamanca was simply treading water. Such a condition cannot be wholly ascribed to the often cited isolation of the Spanish university or to the impact of the Inquisition. These two factors had an undoubted effect in the seventeenth century, but by 1750 (...) faculty politics posed a serious handicap (...)" (Addy 1966) (4) Going now to Italy, a general viewpoint is that "Yet in the 17th century, Italy lost its earlier pre-eminence in literary and scientific culture, falling behind by at least 20-30 years compared to other European countries. The 17th century universities in Italy ceased to attract illustrious teachers for lack of adequate salaries, while political and religious divisions considerably reduced the flow of foreign students." (Pepe 2006) (5) For the case of Pavia, we read that "In the last decades of '500 and until the mid '700, the decline of the University of Pavia is sharp; almost abandoned, at that point it conducted a miserable existence without any hint of the past splendour, when – crowded with students and masters of distinguished authority – it had consistently contributed to the progress and diffusion of culture." (De Caro 1961) (6) About the University of Cahors (France): "We enter the 18th century without any more highlight for her. There is no more star standing in the pulpit. (...) There is no longer this immense crowd coming from afar to follow her classes. There are not even any more grievances, abuses, and speculative turbulence to be charged to her; there is no more than an earthy routine, a discolored, anonymous, needy, and penniless company. The Age of Enlightenment is precisely for the University of Cahors as for most of her sisters the dark time of mediocrity." (Ferté 1975) (7) There is also the idea that they expended all of their energy in futile fights between religious factions: "Louvain was for a long time considered the center of Jansenism, as a champion of Catholic-heretical dogma. However, as the true faith continued to be disputed among the different orders and clerical teachers, the University was able (...) successfully to defend its status and privileges, even at a time when its attractiveness as a center of learning already belonged to the past." (Hammerstein 1996)

This qualitative evidence is confirmed by a more quantitative approach. We first classify universities according to their religious affiliation as reported in Frijhoff (1996). Four broad groups are defined as follows. The set **C** includes all universities which have never ceased to endorse the Catholic faith over the period considered. The set **P** includes the universities which either converted to Protestantism at some point, or which were created as such from the beginning. The set **M** gathers "mixed" universities which accommodated both Catholic and Protestant faiths, either moving back and forth between Protestantism and Catholicism, or teaching both theologies in parallel. It only includes five universities: Heidelberg, Strasburg, Rinteln, Erfurt, and Orange. Finally, the set of orthodox universities **O** is a singleton, with Moscow University. Within **C** it becomes useful to distinguish universities which were run by the Jesuits after the Counter-Reformation, belonging to $\mathbf{C^J}$, from the universities which remained "secular", belonging to $\mathbf{C^S}$, where secular here means not belonging to a monastic order. Their congregation, the Society of Jesus, operated a large number of schools and universities throughout Europe (Grendler 2018), with the aim of educating virtuous leaders who would act for the common good (and fight the Reformation). The oldest and most prestigious Catholic universities fought the influence of this new congregation and kept the Jesuits out (Louvain, Paris, Bologna, Padua, Krakow). Within **P**, we will distinguish the four brands of Protestantism: $\mathbf{P^P}$ for Presbyterian (only in Scotland), $\mathbf{P^L}$ for Lutheran (Germanic, Nordic), $\mathbf{P^C}$ for Calvinist (Dutch, French, Swiss, German), and $\mathbf{P^A}$ for Anglican (English, Irish), with $\mathbf{P^P} \cup \mathbf{P^L} \cup \mathbf{P^C} \cup \mathbf{P^A} = \mathbf{P}$.

Focusing on the two main types of universities, **C** and **P**, we compute the total number of publications of members of universities by century. Results are shown in Table 1. Detailed data are reported in Appendix (Table B.12). These numbers are computed by summing all the publications recorded in Worldcat by members of universities, including new editions of old books. Worlcat provides a comprehensive contemporary measure of scientific output. One could argue that a measure of output should be based on the works published while the author was still alive. What was published after the death of the person might reflect how the author gained popularity *post-mortem*, which might not be relevant for determining his/her productivity. This, however, is not possible to implement, because many first editions of books are not available anymore. For example, there is no doubt that Pierre Abélard (1079-1142) was a philosopher of great renown during his life. All his written output available in the libraries today, from philosophical works to love letters, was published after 1600.

Table 1: Publications of Universities over Time

	Members by Century						Total Publications by Century (× 1000)					
	13	14	15	16	17	18	13	14	15	16	17	18
Old universities (founded bef. 1500)												
C	894	1499	4080	3866	3252	2987	66.1	64.9	111.0	305.2	175.8	152.0
P	9	11	167	633	789	944	3.1	5.6	6.6	149.5	236.6	335.6
New universities (founded aft. 1500)												
C				377	1584	1846				41.2	72.8	88.3
P				323	893	2394				254.6	420.0	616.2
Ratios **C**/**P**												
old	99.3	136.3	24.4	6.1	4.1	3.2	21.62	11.65	16.81	2.04	0.74	0.45
new				1.2	1.8	0.8				0.16	0.17	0.14

P bef. 1500 covers universities which converted later to Protestantism.
Publications sum publications of members as reported in `www.worldcat.org`

The total publications of Catholic and Protestant universities founded before 1500 is reported in the first two rows of Table 1. It is obtained by summing the publications of their members. When a person taught at several universities over her life, we divide her publications by the number of affiliations and allocate this amount to each university. There is growth in the last three centuries among old Protestant universities: 149k publications in the 16^{th} century to 237k and 336k publications in the 17^{th} and 18^{th} centuries.

There is a clear decline among Catholic universities, from 305k publications in the 16^{th} century to 152k in the 18^{th} century, despite a large number of members of the order of 3000 per century. The overtaking by Protestant scholars is even more striking when we consider new universities. The total output of Protestant scholars is six times that one of Catholic scholars, despite some absolute growth in the Catholic world driven mostly by the elite institutions created by the kings of France (Collège Royal and Jardin des Plantes).

3 The Network of Universities

We now define how we build the network of universities and describe the main macro characteristics before and after the Reformation. We also discuss to what extent the emergence of Protestantism might explain the fragmentation observed after the Reformation.

Let $N = \{1, 2, \ldots, n\}$ be the set of universities in the network g. For two universities $i, j \in N$, we define $g_{ij} \in \{0, 1\}$ as the *link* or *edge* between them, with $g_{ij} = 1$ signifying that at least one individual scholar has taught in both universities and $g_{ij} = 0$ otherwise. We consider that the links are *undirected*: if a scholar has moved from university i to university j, this generates a link *between* i and j, and not a link *from* i to j only. Formally, $g_{ij} = g_{ji}$ for all universities i and j. The *strength of the link* s_{ij} is given by the number of scholars who have taught in both universities i and j. The network of universities, g, is thus the collection of universities (nodes) and the links between them.

The *degree of a university* i, d_i, is the number of distinct universities with which the university i is connected. Formally $d_i = \#|j : g_{ij} = 1|$. The *average degree* of a the network g, denoted $d(g)$, is the mean of the degrees of all connected universities in the network. The *clustering coefficient* of a network, $c(g)$, is a measure of the overlap between the links of different universities. Formally, it measures the proportion of fully connected university-triplets out of the potential triplets in which at least two links are present.

The idea behind our definition of the network is the following. When a given professor had appointments in two (or more) places over his life, it established a relationship enhancing the flow of ideas, manuscripts, and students between the two places, which might last well beyond the death of the professor. Several mechanisms are at play.

First, during the pre-industrial era, knowledge was partly codified in books, but more importantly, was embodied in people. When a scholar moves, she brings knowledge from one place to another. This is why competition to attract talents was fierce among universities, leading to permanent flows between them (Denley 2013). There are many examples of knowledge diffusion through physical moves. Let us mention the rediscovery of Roman law, which was superior to customary law at regulating complex transactions, spread from Italy to France in the Middle Ages either through the hiring by French universities of Italian professors, or by having some French professors be appointed to Italian universities (Arabeyre, Halpérin, and Krynen 2007). Second, codified knowledge in books can also travel physically with scholars. Even though books became more affordable after the invention of the movable type printing press, they were not as accessible as today. Biographical dictionaries contain many examples of professors donating their book collection to the university by testament. Probably the best example of the role of books carried by scholars in the diffusion of knowledge is when the Greek scholars fled the fall of the Byzantine Empire, bringing forgotten books by Greek philosophers to the many Italian universities in which they were hired (Harris 1995). Third, links are established by the presence of doctoral students. When a scholar moves to another university but maintains a connection with current or former students in her original university, a link is established. Students and professors cannot be systematically tracked with the available data, but some examples can be documented using the *Mathematics Genealogy Project*,[5] linking students to masters in the (broad) field of mathematics. Fourth, when a newly created university hires professors from an existing one, a long lasting relationship is established. For example, the University of Dublin, founded in 1592, was originally populated by scholars coming from Cambridge (Venn 1922). This established a long lasting, well documented, link between the two universities. This is also true for Louvain (founded 1425) which started with several professors hired from Cologne, itself founded in 1388 (Lamberts and Roegiers 1990a).

In some cases, links are established when a professor has to flee war or persecution. This happened in particular after the Reformation, when scholars reallocated according to their faith (or in some cases changed faith to keep their current location). Still, an intellectual link was created by this move. For example, the Calvinist reformation developed in Geneva in the 16th century owes much to lawyers active in Bourges during the preceding centuries.

In Figures 1 and 2, we map out the network of universities before and after the Reformation. A connection between two universities illustrates the transfer of one or several scholars between them, without taking into account the direction of transfer.[6] More specifically, Figure 1 captures all the displacements of scholars that occurred between 1000 and 1527, while Figure 2 shows the ones that took place between 1598 and 1800. We deliberately remove from our analysis the period during which Protestantism established and consolidated in Europe, ranging from the creation of the first Protestant

[5] `https://genealogy.math.ndsu.nodak.edu`

[6] Figures D.6 and D.7 show these same networks for which the width of the edges is proportional to the number of scholars connecting two universities.

University in Marburg in 1527, until the edict of Nantes in 1598.[7] We do so in order to avoid capturing noisy displacements of scholars during this troubled period.

We code universities according to their religious affiliation. Before the Reformation, all universities were Catholic, but in the network we nonetheless distinguish between purple universities that remain Catholic after the Reformation and orange universities that convert to Protestantism. The only two green universities, Erfurt and Heidelberg, become mixed universities. After the Reformation, each different brand of Protestantism gets in own color: Anglican are pink, Calvinist yellow, Lutheran orange and Presbyterian maroon. The Jesuit universities that actively took part in the Counter-Reformation are blue, while "secular" Catholic universities are purple. Mixed universities are green while the only Orthodox university in our dataset, Moscow, is grey.

Let us point out that the positioning of universities in these two figures is determined by the standard Fruchterman-Reingold force-directed algorithm (Fruchterman and Reingold 1991) that groups universities more closely together when they are linked to each other. So the positioning of universities is not based on geography, religion, or other university attributes. Overall, we already observe a clear-cut divide between Protestant and Catholic universities after the Reformation, based on the mobility of scholars only.

We now examine the main macro characteristics of the two networks. Statistics discussed below are captured in Table 2.

Table 2: Descriptive Statistics of the Networks

	Before Reformation	After Reformation
Connected universities N	74	169
Connected pairs	322	740
Scholars in connected pairs	1560	2453
Density	0.12	0.05
Average degree $d(g)$	8.7	8.76
Clustering $c(g)$	0.42	0.39
Average distance $l(g)$	2.3	3.13
Diameter	5	7
Average number of communities	4	10

(i) First, we observe a large increase in the number of connected universities between the

[7] From 1529 to 1536, the English Parliament breaks with Rome and establishes the Church of England. In 1555, the Peace of Augsburg allows rulers within the Holy Roman Empire to choose either Lutheranism or Roman Catholicism as the official confession of their state. In 1560, the Scottish Parliament establishes the Kirk. In 1598, the Edict of Nantes grants substantial rights to Huguenots in France. In the Appendix, Table A.11 summarizes major Reformation events and Figure A.5 shows the religious situation in Europe around 1560.

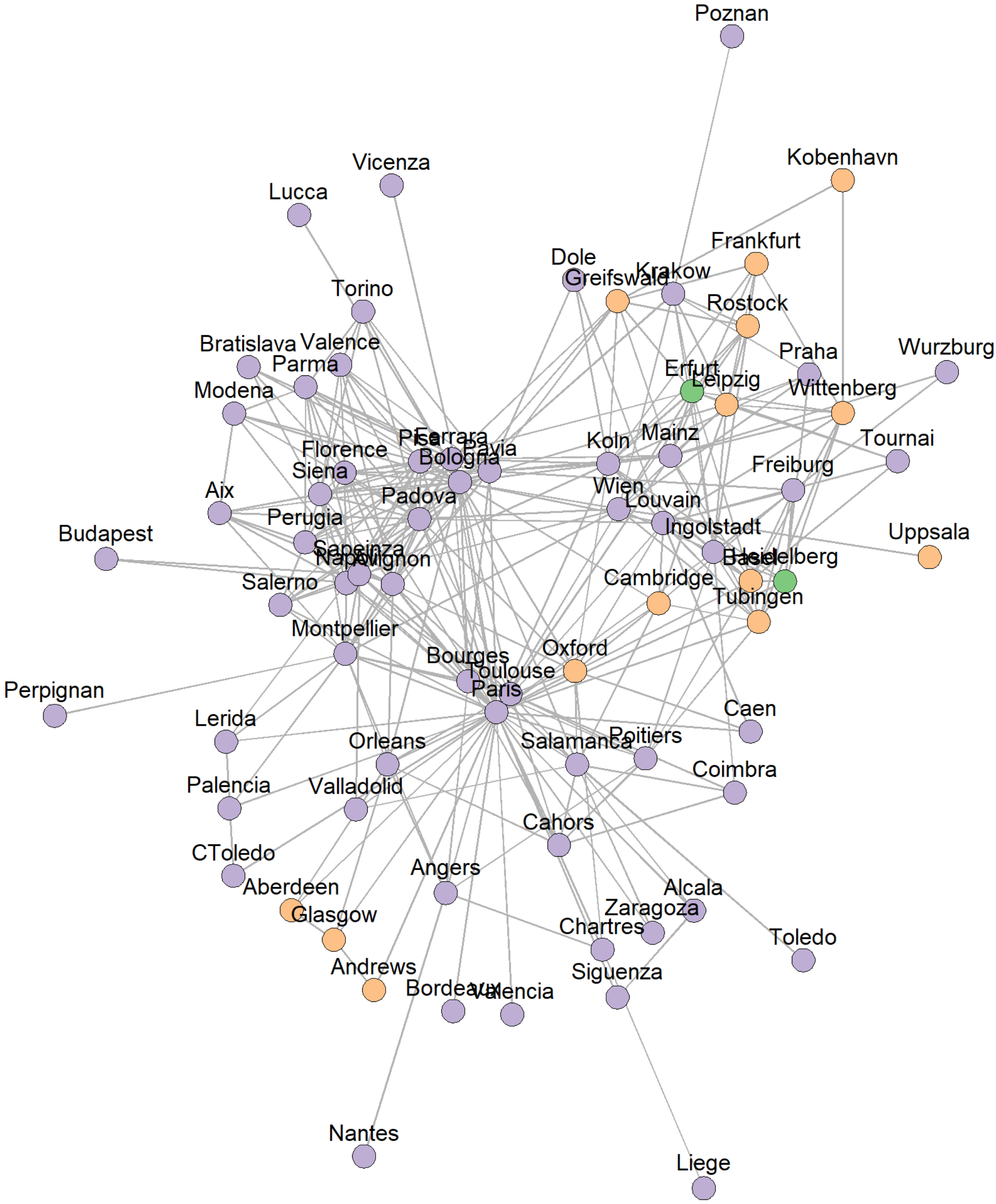

Figure 1: Network of European Universities before 1527

Universities that would remain Catholic after the Reformation are purple, while universities that would convert to Protestantism are orange. Mixed universities are green.

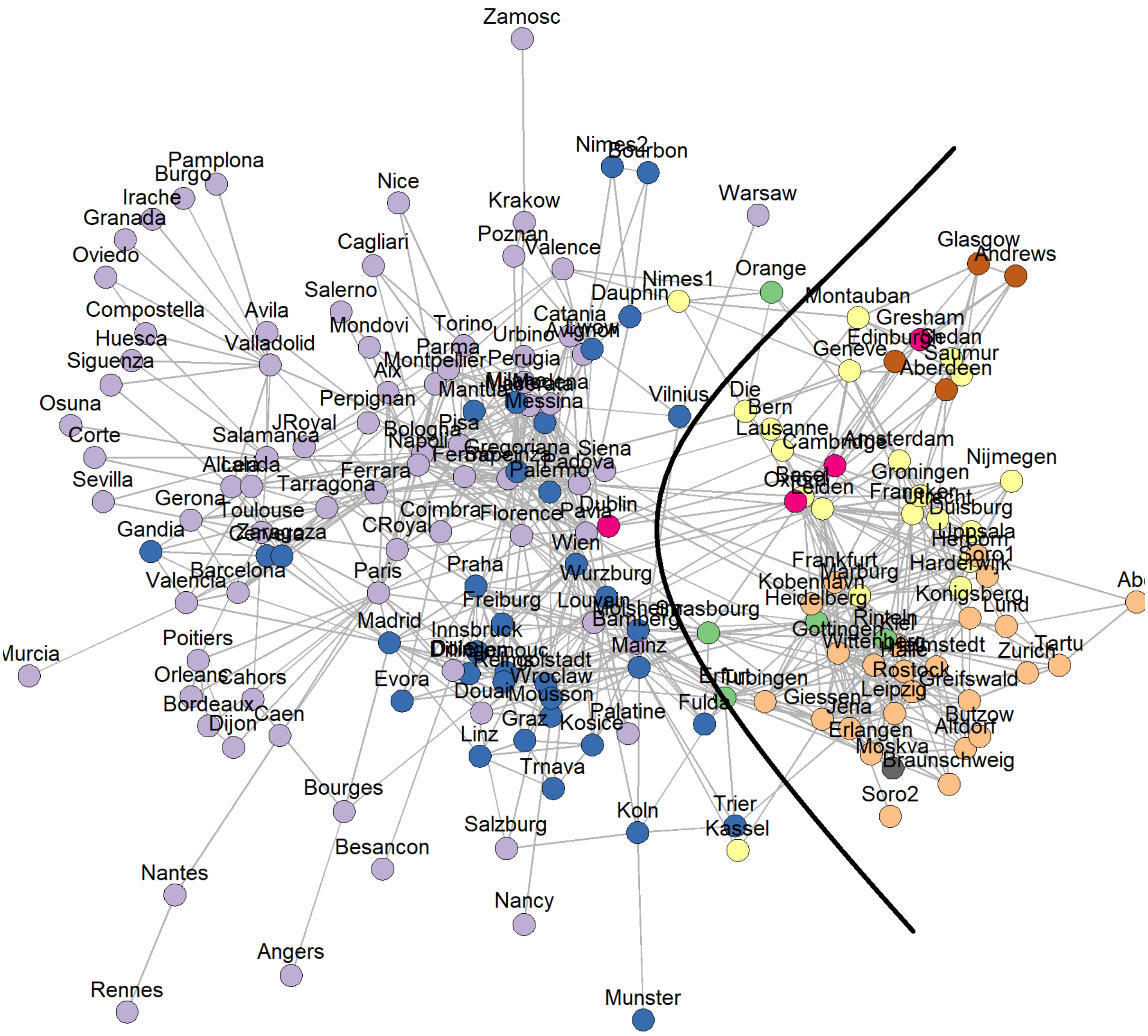

Figure 2: Network of European Universities after 1598

"Secular" Catholic universities are purple, while Jesuit universities are blue-filled. Lutheran, Presbyterian, Calvinist and Anglican universities are respectively orange, brown, yellow and pink. Mixed universities are green. The only Orthodox university, Moscow, is grey.

two periods, going from 74 to 169 connected universities. We removed from our analysis *isolated* universities, i.e. universities for which to our knowledge no scholar teaching there has ever moved from/to another university. They represent 6.33% of the full sample in the first period and 4.52% in the second period. Out of the 74 connected universities before the Reformation, 64 remain connected in the second period. Other universities either disappeared or turned isolated. Moreover, the two networks are *integrated*: under the two periods, all connected universities form an unique component, i.e. there exists a path between any pair of universities. Formally, we say that there is a path between universities i and j either if $g_{ij} = 1$ or if there is a set of distinct intermediate universities $j_1, j_2, \ldots, j_n$ such that $g_{ij_1} = g_{j_1 j_2} = \cdots = g_{j_n j} = 1$.

(ii) Second, the number of connected pairs of universities more than doubles between the two periods, from 322 to 740. This is all the more noticeable as the first period is longer than the second period. In contrast, when we consider the total number of scholars connecting each pair of universities, i.e. the sum of the strengths of the links, the increase is just 57.24%, from 1560 to 2453. As a result, the average number of scholars connecting two universities decreases from 4.84 before the Reformation to 3.31 after. So a professor in a given university was more likely to move to another university that already had a connection with his current university before the Reformation than after. This phenomenon might in part be due to the fact that there were many more universities and thus opportunities for scholars after the Reformation.[8] Despite the increase in observed links between the two periods, the network of universities is more sparse after the Reformation. The density of the network, which is the ratio of observed links in a network to the maximum number of possible links, is more than halved. The lower density observed in the network after the Reformation is mostly driven by the associated increase in the number of connected universities.[9]

(iii) Third, the average degree $d(g)$ of the network g slightly increases while the clustering coefficient decreases between the two periods. We observe that, on average, a university is connected to 8.70 other universities before the Reformation, and to 8.76 after. The clustering coefficient varies from 0.42 to 0.39 between the two periods. So, on average, one university has more connections while two connected universities are less likely to share a common connection with a third university after Reformation than they would be previously. These observations might be explained by the very low proportion of links between Catholic and Protestant universities after the Reformation, see Table 3.

[8]Notice that we count 10 540 professors before the Reformation and 17 556 professors after. Among them, only 732 have worked in at least two universities before the Reformation and 1 506 after. For the scholars who moved during their career, the average number of institutions where they taught is 2.46 before the Reformation and 2.27 after. The maximum number of visited institutions during a scholar's career is 8 before and 7 after the Reformation.

[9]For an undirected network with n nodes, the maximum number of links is $n(n-1)/2$ so the density for an undirected network is: $2L/[n(n-1)]$, where L is the number of observed links in the network.

Thus it is not likely that one Catholic university and one Protestant university sharing a connection together have a mutual "friend".

(iv) Fourth, the average distance is small for the two networks. The *distance* $l(i,j)$ between two universities i and j is the length of the shortest path between them. The *average distance* of all pairs of universities in the network g is denoted $l(g)$. Before the Reformation, it requires on average 2.30 steps to reach any pair of universities in the network. After the Reformation, the average distance is equal to 3.13. The average distance of a network is said to be small if it is close do the logarithm of the size of the network (Goyal, van der Leij, and Moraga-González 2006). Our two networks exhibit very small average distances as they lie below these thresholds. The *diameter*, which is the largest distance between any two universities in the network, is also small for the two networks. It requires at most 5 steps to reach any pair of universities before the Reformation, and 7 steps after the Reformation.

(v) Fifth, the average number of communities detected in the networks increases between the two periods. We use several *community detection algorithms* from the *igraph* package (Csardi et al. 2006) which are designed to identify internally cohesive subgroups that are also to a certain extent separated from other groups or nodes. We detect an average of 4 subgroups in the network before the Reformation. In contrast, we detect on average 10 subgroups in the network after the Reformation. This indicates that the network of universities is more fragmented after the Reformation than it was before.

We now examine more closely how religious affiliation interacts with network structure. Information about connections between Catholic and Protestant universities before and after the Reformation, discussed below, are shown in Table 3.

Table 3: Connections between Catholic and Protestant Universities

	Before Reformation	After Reformation
Proportion of **C** Univ, ω_c	78.37	65.09
Proportion of **P** Univ, ω_p	18.92	31.36
Proportion of interfaith edges	17.39	2.97
Proportion of **C** friends among **C** univ, H_c	89.51	96.60
Proportion of **P** friends among **P** univ, H_p	39.30	79.34
Inbreeding homophily index for **C** Univ	0.52	0.90
Inbreeding homophily index for **P** Univ	0.25	0.70
Modularity with subreligions	/	0.40
Modularity with religions	0.07	0.41

We first note that before the Reformation, 17.39% of connections are between **C** universities and would-be **P** universities (*interfaith edges*), while this share shrinks to 2.97%

after the Reformation. The frequency of connections among pairs of universities when both are within the same religious group is more than 29 times higher than when they are in different religious groups after the Reformation. In contrast, this frequency is only 4.39 times higher before the Reformation.

Additionally, whereas 65.09% of universities are **C** after the reformation, 96.60% of the connections of **C** universities are with other **C** universities. Similarly 79.34% of the connections of **P** universities are with other **P** universities, despite the fact that they represent only 31.36% of connected universities. Therefore, Catholic and Protestant universities tend to have more connections with universities of the same religion over and above the relative size of their religious group. We use the measure developed by Coleman (1958) in order to compare the degree of homophily among Catholic and Protestant universities before and after the Reformation. This measure is called the *inbreeding homophily index* and is equal to

$$IH_i = (H_i - \omega_i)/(100 - \omega_i)$$

with $i = \{c, p\}$ denoting respectively **C** and **P** universities, ω_i denoting the proportion of i universities in the network, and H_i denoting the proportion of i "friends" among i universities. This index measures the amount of bias with respect to baseline homophily as it relates to the maximum possible bias, i.e. the term $(100 - \omega_i)$. We have *inbreeding homophily* for type i if and only if $IH_i > 0$, and *inbreeding heterophily* if and only if $IH_i < 0$. The index of inbreeding homophily is 0 if there is pure baseline homophily and 1 if a group completely inbreeds. The inbreeding homophily index is positive and increases over time for **C** and **P** universities: it increases from 0.52 to 0.90 for **C** universities, and from 0.25 to 0.70 for **P** universities.

Finally, we use the modularity measure to evaluate to what extent the partition of universities along their religious affiliation explains the structure of the network. We consider a community structure Π based on religions. We distinguish four communities in Π : Catholic, Protestant, Mixed and Orthodox. Modularity measures the difference between the observed number of links within communities in a given network g and the expected number of links in a random network exhibiting the same degree distribution as in network g.[10] The expression of the modularity score is

$$M(\Pi, g) = \frac{1}{2L} \sum_{i=1}^{n} \sum_{j=1}^{n} (g_{ij} - d_i d_j/2L)\, \delta_{ij}$$

where n and L are respectively the number of nodes and links in g, d_i is the degree

[10] The random model used in most definitions of modularity is the *configuration model*, which generates random networks from a given degree distribution. It can be shown that the probability of the existence of an edge between node i with degree d_i and node j with degree d_j is $d_i d_j/2L$.

of university i, and $\delta_{ij} = 1$ if i and j are in the same community, and 0 otherwise. The term $1/2L$ normalizes the measure to enable comparison of the modularity scores of networks with different numbers of links. A community structure with zero modularity has exactly as many links within communities as we would expect if the graph was generated randomly. Positive modularity scores represent good community structures as there are more links in communities than we would expect in a randomly generated graph. Similarly, negative modularity scores represent bad community structures. The partition of universities along religious affiliations exhibits positive modularity scores for the two periods. While the modularity score before Reformation is close to 0, it reaches 0.41 after the Reformation, indicating that religion is a good predictor of the network structure.[11] To make sure that the partition along religious affiliations is a significant community structure, we replicate 100 randomized networks that have the same degree distribution as the original data and evaluate their modularity scores. We find that no randomized networks have a modularity score higher than 0.41. In fact, the maximal modularity score of these 100 networks is 0.03. Thus it can be said that division along religious affiliations significantly impacts the structure of the network of universities after the Reformation. However, we should not omit the fact that religious affiliation is highly correlated with geography, as most Protestant universities are located in Northern Europe and most Catholic universities are to be found in Southern European countries. To ensure that our previous analysis does not simply capture the impact of closer geographic distance rather than membership of the same religious group, we disentangle these two effects in the next section.

4 Geography vs. Culture

In this section we show that geography is also important, which is not surprising, but does not substitute for the effect of religion. To study the geographical and religious determinants of a connection between two universities, we use dyadic regressions.

Dyadic regressions in network analysis are regressions in which each observation expresses a relationship between each possible pair of nodes. In our setting, we successively investigate the following dependent variables for all pairs of universities i and j: (i) the presence or the absence of a link g_{ij}; (ii) the strength or intensity of the link s_{ij}; and (iii) the inverse of the length of the shortest path $1/l(i,j)$. Our aim is to estimate to what extent belonging to the same religious group determines the presence and the intensity of a connection between two universities, as well as the length of the shortest path connect-

[11] We also investigate the community structure based on subreligions, where communities are $\mathbf{P^L}$, $\mathbf{P^C}$, $\mathbf{P^P}$, $\mathbf{P^A}$, $\mathbf{C^S}$, $\mathbf{C^J}$, $\mathbf{M}$ and $\mathbf{O}$. The modularity score of this community structure is equal to 0.40 after the Reformation.

ing them in the network, controlling for geography. Since there may exist heterogeneous effects across subreligions, we decompose the effect of sharing the same religious affiliation by distinguishing the effect of both being Lutheran from the effect of both being Calvinist, and so on. We proceed similarly for religions (Protestants and Catholics). Our main independent variables of interest are thus the geographic distance between any pair of universities and dummy functions indicating whether the two universities of the dyad are both Lutheran, Calvinist, etc. Our estimated model is

$$\begin{aligned} y_{ij} =& \beta_0 + \beta_1 d_{ij} + \beta_2 \, \mathbf{I}(i, j \in \mathbf{P}^L) + ... + \beta_8 \, \mathbf{I}(i, j \in \mathbf{M}) \\ &+ \beta_9 \upsilon_{ij} + \beta_{10} \underline{\nu}_{ij} + \gamma \, \mathbf{K}_{ij} + \alpha_i + \alpha_j + \epsilon_{ij} \end{aligned} \tag{1}$$

The dependent variable y_{ij} is a dyadic network measure as described above.

Distance is defined as $d_{ij} = \ln(\text{cost}^{\text{min}} + \text{cost}_{ij})$, where cost_{ij} is the minimum cost it takes to travel from i to j computed using Özak's (2010, 2018) human mobility index. Parameter cost^{min} is the minimum cost incurred when travelling within the same city (say from Jardins des Plantes to Sorbonne). We assume it is equivalent to the cost of walking within the old city of Rome between the Vatican City and the Colosseum (3.5 km).

Dummy functions $\mathbf{I}(i, j \in \mathbf{P}^L)$, $\mathbf{I}(i, j \in \mathbf{M})$,... indicate whether or not universities i and j are both Lutheran, Mixed, etc. We include such a dummy function for each subreligion, i.e. $\mathbf{P^L}$, $\mathbf{P^C}$, $\mathbf{P^P}$, $\mathbf{P^A}$, $\mathbf{C^S}$, $\mathbf{C^J}$ and $\mathbf{M}$. We also estimate the same model as in Equation (1), with dummy functions for each main religion instead, i.e. $\mathbf{C}$, $\mathbf{P}$ and $\mathbf{M}$. For each specification, we include cross effects to control for the differentiated impact of belonging to different subreligious (resp. religious) groups. We introduce dummy functions, captured by the vector $\mathbf{K}_{ij}$, for each configuration except the one which will be the reference category.[12]

We also add two other dependent variables: the number of overlapping years during which both universities i and j are active, which is denoted υ_{ij}, and the minimum coverage denoted $\underline{\nu}_{ij} = \min(\nu_i, \nu_j)$ where the coverage ν_i of university i is the number of observed professors who taught there divided by its activity period length. This is to control for the fact that two universities that are simultaneously active during a long time period are more likely to have a connection than two universities that only share a couple of active years. We add minimum coverage controls because we are more likely to observe a connection between two universities for which we have lots of information in our sample, as this is the case for Germany and Italy, than between universities for which we have poorer coverage. To address the issue of autocorrelation, we follow the methodology

[12] For instance, $\mathbf{I}(i \in \mathbf{P}^L \text{ and } \in \mathbf{P}^A \text{ or } i \in \mathbf{P}^A \text{ and } j \in \mathbf{P}^L) \in \mathbf{K}_{ij}$ is equal to 1 if there is one Lutheran university and one Anglican university in the dyad, and 0 otherwise.

used in De Weerdt (2004) and De Weerdt, Genicot, and Mesnard (2019): we use a two-way fixed effect model, which includes a fixed effect for universities i and j, α_i and α_j. Autocorrelation is the possible correlation between the error term associated with the dyad formed by university i and university j, ϵ_{ij}, and all the error terms associated with other dyads in which i or j appear, $\epsilon_{.i}$, $\epsilon_{i.}$, $\epsilon_{.j}$ and $\epsilon_{j.}$. Concretely, we include one dummy for each university that indicates whether the specific university is part of the dyad or not. This means that there are two dummy variables equal to one for each observation. By including these university fixed effects we control for observable attribute variables, for instance the fact that big universities may have more connections than universities with small capacity. These university fixed effects also enable us to control for unobserved attribute variables: for instance, universities that encourage mobility are more likely to have more links than universities that do not. Including these dummies thus purges the effects of all attribute variables and therefore eliminates autocorrelation.

To run our dyadic regressions, we make a dataset of all possible unique combinations of two universities. We include in this dataset all universities where at least one scholar taught during the period under study.[13] After the Reformation, we count 177 such universities, so the number of possible dyads is 15 576.[14] We delete dyads for which the two universities were not active during a same period of time. This is to avoid two potential biases in our estimates. The first one is simply the fact that two universities that were not simultaneously active are less likely to share a connection. For instance, if university i was active until 1650, it is very unlikely that it shares a connection with university j that opened one hundred years later. Second, even for universities whose active periods are separated by less than 100 years, deleting such dyads mitigates the issue of the mobility of scholars triggered by the closing of their university. Assume that university i closes, forcing its scholars to find another teaching position at another university that is currently active. If university j opens only a few years after the closing of university i, we cannot know whether scholars would have chosen university j or not if it were active when their previous university i closed. Deleting such dyads removes these possible biases. Thus our final sample reduces to 15 390 dyads. Similarly, our sample before the Reformation reduces to 2 793 dyads. Results for subreligions are shown in Table 4 below, while results for main religions are displayed in Table C.18 in the Appendix.

Our main result is that religion significantly explains the structure of the network of European universities after the Reformation, even when geography is controlled for. The

[13] In other words, we include the universities that are connected and the ones that are isolated in the networks defined above.

[14] In a network with n nodes, the number of possible dyads is $n(n-1)/2$. Before Reformation, we count 79 universities, so the number of possible dyads is 3 081. Remember that we do not take into account the direction of the links.

Table 4: Dyadic Regressions - Subreligions

	Dependent variable:					
	link	intensity	invsteps	link	intensity	invsteps
	(1)	(2)	(3)	(4)	(5)	(6)
distance	-0.188^{***}	-1.344^{***}	-0.130^{***}	-0.107^{***}	-0.566^{***}	-0.089^{***}
	(0.009)	(0.112)	(0.005)	(0.003)	(0.024)	(0.002)
$\mathbf{I}(i, j \in \mathbf{P}^L)$				0.114^{***}	0.145	-0.085^{***}
				(0.025)	(0.197)	(0.016)
$\mathbf{I}(i, j \in \mathbf{P}^C)$				0.142^{***}	0.206	0.588^{***}
				(0.053)	(0.423)	(0.034)
$\mathbf{I}(i, j \in \mathbf{P}^P)$				0.744^{***}	2.476^{***}	0.908^{***}
				(0.092)	(0.729)	(0.059)
$\mathbf{I}(i, j \in \mathbf{P}^A)$				0.593^{***}	9.071^{***}	0.721^{***}
				(0.092)	(0.728)	(0.059)
$\mathbf{I}(i, j \in \mathbf{C}^S)$				0.114^{***}	0.425^{**}	0.383^{***}
				(0.023)	(0.180)	(0.015)
$\mathbf{I}(i, j \in \mathbf{C}^J)$				0.222^{***}	1.165^{***}	0.628^{***}
				(0.041)	(0.325)	(0.026)
$\mathbf{I}(i, j \in \mathbf{M})$				0.101	-0.446	0.421^{***}
				(0.077)	(0.614)	(0.050)
Cross effects				YES	YES	YES
Obs.	2,793	2,793	2,793	15,390	15,390	15,390
Adj. R^2	0.334	0.271	0.695	0.226	0.102	0.628

All specifications include university fixed effects, number of overlapping years and minimum coverage. Estimator is OLS. Reference category is the set of pairs of universities where one is Lutheran and the other secular. *p<0.1; **p<0.05; ***p<0.01

impact of geographic distance is unsurprisingly significant and consistent across periods. Increasing traveling costs between two universities reduces their odds of being connected and of sharing an intense connection. Moreover, the higher the cost of travel between two universities, the farther they lie from each other in the network. We now study in more detail the effect of religion on network structure. First, we note that for all subgroups except for Mixed universities, sharing the same religious affiliation is associated with a statistically higher probability of being connected in the network (Column 4 of Table 4). This is especially true for Presbyterian, Anglican and Jesuit universities. Column 4 shows that, for two universities, both being Jesuit raises their probability of having a connection by 0.222 on average, all else being equal. This figure is even stronger for Presbyterians and Anglicans, but we should interpret their results with caution, as we only count 4 Anglican and 4 Presbyterian universities in our dataset. Second, Column 5 shows that for two universities, both being Jesuit, Secular, Presbyterian or Anglican significantly increases the number of scholars connecting the two universities. However this does not seem to be the case for Lutherans, Calvinist and Mixed universities. Third, two universities belonging to the same religious subgroup do lie closer to each other in the network, as shown in Column 6, except for Lutheran. When focusing on main religious groups instead of subgroups in Table C.18, we do find that for two universities, both being Catholic significantly increases the chances of having a connection. This illustrates the fact that Catholic universities not only have connections within subgroups, but also across Seculars and Jesuits. Mobility among Catholics is mostly driven by Jesuists though, as we observe more exchanges within Jesuits and between Jesuits and Seculars than among Secular universities. This is in contrast with what we find for Protestant universities: for them, mobility of scholars occurs essentially within rather than between subgroups. Finally, Column 3 of Table C.18 shows that two universities from the same religious group lie closer to each other in the network, but do not have more intense connections (Column 2).

To better grasp the importance of religion we simulate the network predicted by the dyadic regression, with and without religious variables. Using the estimates from the first specification of our dyadic regressions, we simulate links to generate the fitted and the counterfactual networks. To construct the simulated network, we attribute to each dyad its fitted value of the probability of a connection between the two universities of the dyad. Then we define a threshold value for these fitted probabilities above which we assume that a link is created. We choose this threshold such that we obtain the same number of connected universities as in the observed network.[15] We use the same methodology to construct the counterfactual network, except that we cancel the effect of

[15] Alternatively, we simulated fitted and counterfactual networks by choosing thresholds such that we get the same number of links as in the observed network. Our results hold with these alternative simulations.

religion. Figures 3 and 4 show these two networks, and Table 5 displays the descriptive statics.

Table 5: Descriptive Statistics of Observed, Simulated, and Counterfactual Network after Reformation

	Observed	Simulated	Counterfactual (no religions)
Universities	177	177	177
Connected	169	169	169
Components	1	4	4
Links	740	981	1597
Density	0.05	0.07	0.11
Average degree	8.76	11.61	18.90
Diameter	7.00	9.00	7.00
Average distance	3.13	3.41	2.51
Clustering	0.39	0.66	0.60
Average number of communities	10	10.67	8.00
Modularity (subreligion)	0.40	0.49	0.10
Modularity (religion)	0.41	0.37	0.08
Interfaith edges	2.97	4.89	25.49

Number of connected universities matched by construction

The first specification of our dyadic regression only explains 22.6% of observed links, but when comparing the main descriptive statistics of the simulated network with the ones of the observed network, we find that our simulation performs well for average distance, average number of communities, modularity scores and proportion of interfaith edges. However, it generates a larger number of links, which explains higher density, average degree and clustering.[16] We then compare our observed network with its counterfactual. We find that if religion was not a determinant of network structure, the proportion of connections between Protestant and Catholic universities would have risen from 2.97% to almost 25.5%. So if religion had not been a criterion for mobility, we would have observed many more exchanges between scholars in the Protestant and Catholic worlds. The overall structure of the network would have been affected, as illustrated by the drop in modularity scores between the observed network and its counterfactual. While the partitions of universities either across subreligions or across religions explain significantly the structure of the observed network with modularity scores of, respectively, 0.40 and 0.41, these

[16] Our alternative simulations which generate fitted and counterfactual networks with the same number of links as in the observed network respectively exhibit larger numbers of isolated universities and components.

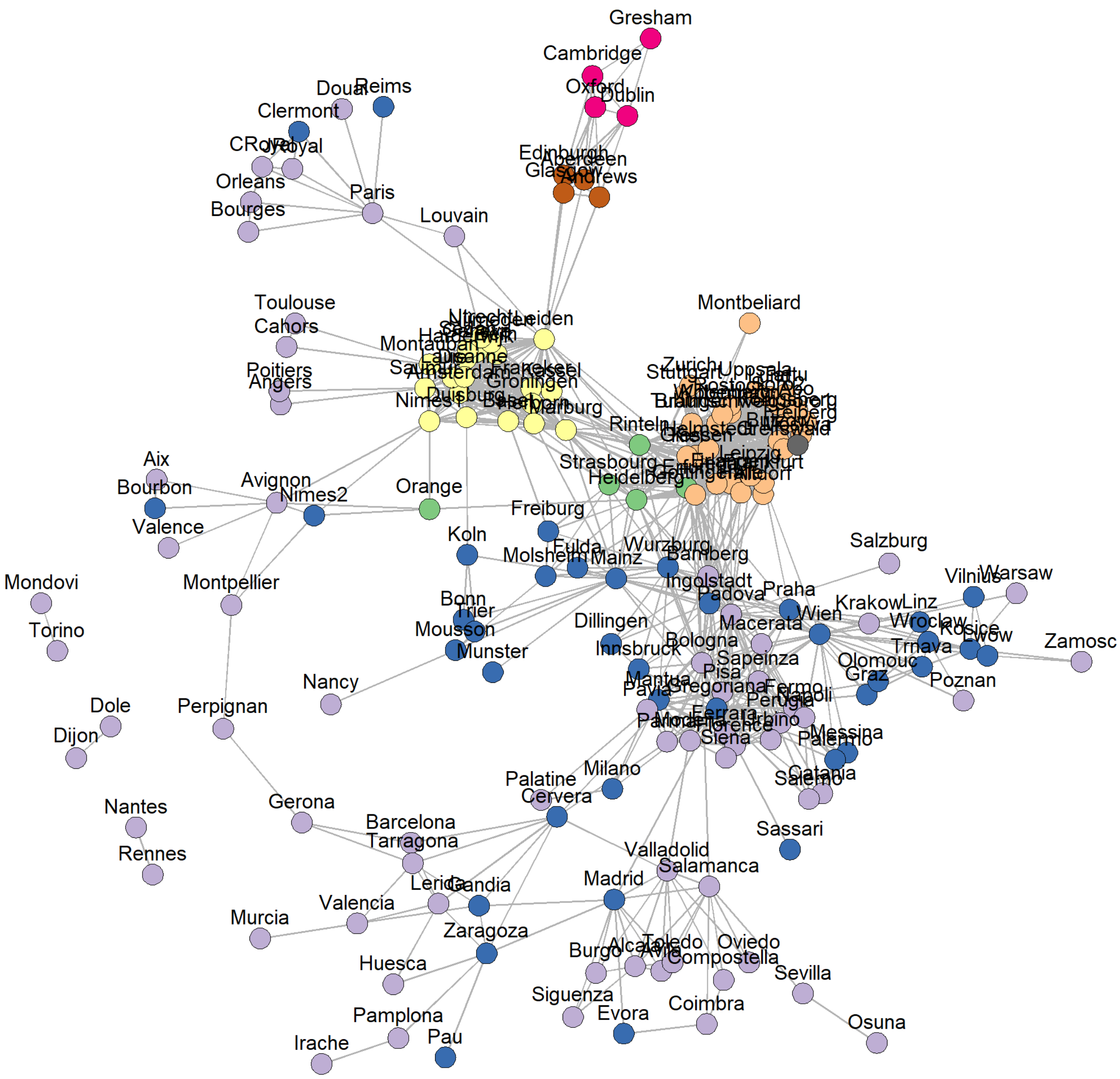

Figure 3: Simulated Network

Catholic “secular” universities are purple, while Jesuit universities are blue. Lutheran, Presbyterian, Calvinist and Anglican universities are respectively orange, brown, yellow and pink. Mixed universities are green. The only Orthodox university, Moscow, is grey.

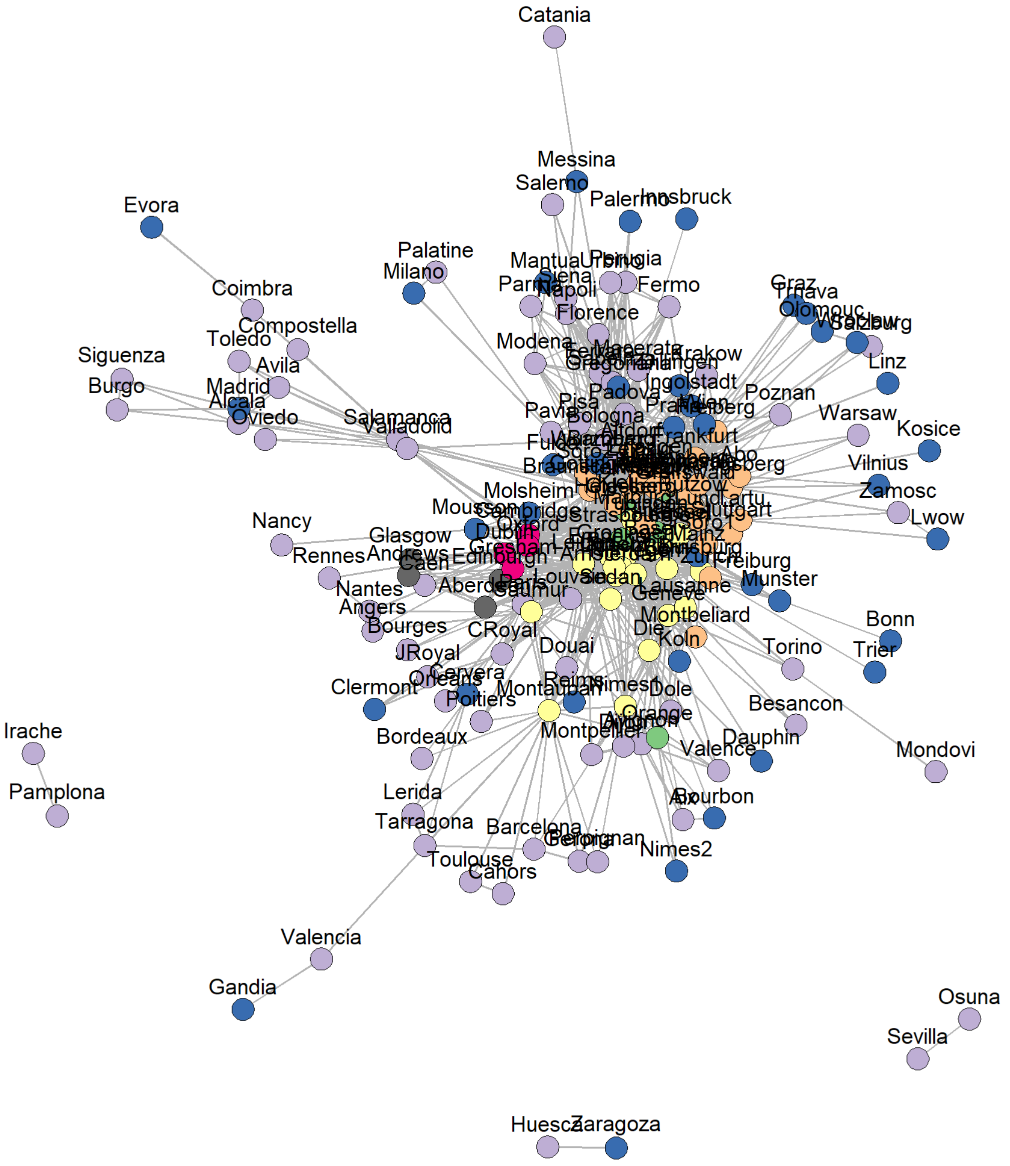

Figure 4: Counterfactual Network

Catholic “secular” universities are purple, while Jesuit universities are blue. Lutheran, Presbyterian, Calvinist and Anglican universities are respectively orange, brown, yellow and pink. Mixed universities are green. The only Orthodox university, Moscow, is grey.

community structures are poor predictors of the counterfactual network structure, as their modularity scores do not exceed 0.10. Accordingly, the network would have been less fragmented, as illustrated by the drop in the average number of communities between the observed and the counterfactual networks. Additionally, it is likely that if religion had not mattered the network of European universities would have been smaller, as illustrated by the decrease in average distance. It is not easy to discern to what extent this drop is due to the removal of the religion effect, or to the increase in links in the counterfactual network. However, increasing links while keeping the number of connected universities constant does not necessarily imply a drop in average distance, as we may notice when comparing these statistics for the observed and the simulated networks.

5 Reformation, centrality and academic production

Having analyzed the macro structure of the network of European universities, we now examine differences between Catholic and Protestant universities' positions within the network. Then, we explore which network statistics are best correlated with academic production of universities. Finally, we discuss to what extent the more central positions of Protestant universities in the network may have enhanced their scientific production.

To compare the position of Catholic and Protestant universities within the network we focus on six main network measures describing different aspects of centrality in a network. We already defined the first one, the *degree* of a university i, d_i, which measures the number of its neighbors. The five other network measures are as follows:

Strength: The strength s_i of an university i is the average strength of all its ties (i.e. the number of scholars connecting i with other universities),

$$s_i = \frac{1}{d_i} \sum_{j:g_{ij}=1} s_{ij}$$

This measure captures the average intensity of all connections of university i.

Clustering coefficient: The clustering coefficient c_i is the proportion of university i's neighbors that are themselves neighbors,

$$c_i = \frac{\sum_{j \neq i; k \neq j; k \neq i} g_{ij} g_{ik} g_{jk}}{\sum_{j \neq i; k \neq j; k \neq i} g_{ij} g_{ik}} \in (0, 1)$$

This coefficient measures the density of university i's neighborhood.

Closeness centrality: The closeness centrality score $\mathcal{C}_i$ measures the minimum number of steps required to access every other university in the network from university i. Formally, this is the inverse of the average distance $l(i,j)$ between a university i and any other university within the network,

$$\mathcal{C}_i = (n-1)/\sum_{j \neq i} l(i,j)$$

Closeness centrality captures how quickly university i is reachable from all other universities in the network.

Betweenness centrality: The betweenness centrality score $\mathcal{B}_i$ is the proportion of shortest paths between any two universities j and k going through university i. We normalize this score by averaging across all pairs of nodes. Formally,

$$\mathcal{B}_i = \sum_{j \neq k : i \notin \{j,k\}} \frac{P_i(jk)/P(jk)}{(n-1)(n-2)/2}$$

where $P_i(jk)$ is the number of shortest paths between j and k that pass through university i and $P(jk)$ is the total number of shortest paths between j and k in the network. This score measures the importance of university i in connecting other universities in the network.

Eigenvector centrality: The eigenvector centrality score of a university i, $\mathcal{E}_i$, is proportional to the sum of the eigenvector centrality of its neighbors.[17] Formally,

$$\lambda \mathcal{E}_i = \sum_j g_{ij} \mathcal{E}_j$$

where λ is a proportionality factor. This measure assigns a score to a university i based on the connections of i and the scores of these connections, assuming that a connection to a high-scoring university contributes more to university i's own score. As opposed to degree d_i which measures the number of neighbors, eigenvector centrality measures how "well-connected" university i's neighbors are. This captures the fact that in some settings, it is more important to have well-connected neighbors than just to have many neighbors.

We now explore whether Catholic and Protestant universities behave differently in terms of these six network statistics after Reformation, controlling for coverage ν_i and duration p_i. The dependent variable y_i is a network measure as defined above. The estimated model is:

$$y_i = \beta_0 + \beta_1 I(i \in \mathbf{P}) + \beta_2 I(i \in \mathbf{M}) + \beta_3 I(i \in \mathbf{P}) + \beta_4 \nu_i + \beta_5 p_i + \epsilon_i \quad (2)$$

[17] Considering the network g as a square matrix of size n, with entries 0 and 1 denoting the absence or the presence of a connection between two universities, we have in terms of matrix notation, $\lambda \mathcal{E} = g\mathcal{E}$. Thus $\mathcal{E}$ is an eigenvector of g and λ is its corresponding highest eigenvalue, see Jackson (2008).

The reference category here is when a university belongs to the set of Catholic universities. Coverage, ν_i, which we already defined, controls for the fact that the dataset covers unevenly the population of university scholars. Duration, p_i, is the number of active years of university i. This controls for the fact that universities which were active during a long period of time are more likely to have many connections.

Table 6: Network position and religion after the Reformation

	Dependent variable:					
	degree	strength	closeness	betweenness	eigenvector	clustering
	(1)	(2)	(3)	(4)	(5)	(6)
$I(i \in \mathbf{C})$	reference category					
$I(i \in \mathbf{P})$	2.815***	−0.253	−0.005	−0.005	0.261***	−0.052
	(0.806)	(1.080)	(0.007)	(0.003)	(0.027)	(0.045)
$I(i \in \mathbf{M})$	4.840**	0.989	0.022	0.006	0.342***	−0.098
	(2.194)	(2.940)	(0.019)	(0.009)	(0.072)	(0.118)
$I(i \in \mathbf{O})$	−0.030	−5.007	−0.017	−0.016	0.300*	0.328
	(4.921)	(6.596)	(0.043)	(0.020)	(0.162)	(0.267)
Obs.	169	169	169	169	169	155
Adj. R^2	0.448	0.068	0.263	0.303	0.487	0.065

In all specifications we control for duration and coverage.
Eigenvector centrality scores have been scaled such that the highest value is equal to one. Estimator is OLS. *p<0.1; **p<0.05; ***p<0.01

Table 6 displays the magnitude of the difference in network measures for Protestant and Catholic universities after Reformation, estimated from equation (2). We find that Catholic universities have significantly fewer distinct neighbors than Protestant universities. Column 1 of Table 6 shows that Protestant universities have on average almost 3 more neighbors than Catholic universities. In addition, Protestant universities have an eigenvector centrality score that is 0.261 higher than the one of Catholics. This difference is also statistically significant. So Protestant universities not only have more neighbors than Catholic universities but also better connected ones. This result is illustrated in Figure D.9 in the Appendix, where the size of the nodes in the network is proportional to their eigenvector centrality scores. Interestingly, we find that these significantly higher degree and eigenvector centrality scores for Protestant universities are mostly driven by Lutherans and Calvinists, as can be seen in Table C.19 in the Appendix. We also observe that within the set of Catholic universities, Jesuits have significantly more neighbors and perform better in terms of closeness centrality than secular universities. Jesuits also have a significantly higher eigenvector centrality score than secular universities, but the estimated coefficient is much smaller than for Lutherans and Calvinists.

To explore how the Reformation has impacted the position of universities within the network, we distinguish between old universities that were already active before the Reformation, and new ones that were created only after. Among the 169 connected universities in the network, 71 were created before the Reformation: 54 of them remained Catholic, while 15 converted to Protestantism and 2 are classified as Mixed. After the Reformation, 56 new Catholic universities were created, along with 38 new Protestant universities, 3 new Mixed universities and 1 new Orthodox university. We then estimate the differences in network measures for old and new Catholic and Protestant universities. We use as reference category the set of old Catholic universities. Results are displayed in Table 7.

Table 7: Network position and religion after the Reformation when distinguishing between old vs. new universities

	Dependent variable:					
	degree	strength	closeness	betweenness	eigenvector	clustering
	(1)	(2)	(3)	(4)	(5)	(6)
Old universities						
$I(i \in \mathbf{C})$	reference category					
$I(i \in \mathbf{P})$	1.578	−0.257	−0.013	−0.008	0.271***	0.032
	(1.397)	(1.884)	(0.012)	(0.006)	(0.046)	(0.075)
$I(i \in \mathbf{M})$	7.792**	1.558	0.026	0.016	0.480***	−0.111
	(3.442)	(4.642)	(0.030)	(0.014)	(0.113)	(0.185)
New universities						
$I(i \in \mathbf{C})$	−0.656	1.131	−0.010	−0.006	0.036	0.092*
	(0.973)	(1.313)	(0.009)	(0.004)	(0.032)	(0.055)
$I(i \in \mathbf{P})$	2.858***	0.592	−0.009	−0.009*	0.283***	−0.026
	(1.073)	(1.447)	(0.009)	(0.004)	(0.035)	(0.058)
$I(i \in \mathbf{M})$	2.325	1.377	0.011	−0.004	0.275***	−0.025
	(2.835)	(3.823)	(0.025)	(0.012)	(0.093)	(0.152)
$I(i \in \mathbf{O})$	−0.256	−4.042	−0.024	−0.021	0.328**	0.376
	(4.984)	(6.721)	(0.044)	(0.020)	(0.164)	(0.269)
Obs.	169	169	169	169	169	155
Adj. R^2	0.447	0.056	0.258	0.305	0.488	0.069

In all specifications we control for duration and coverage.
Eigenvector centrality scores have been scaled such that the highest value is equal to one. Estimator is OLS. *p<0.1; **p<0.05; ***p<0.01

We observe that old universities that converted to Protestantism do not have significantly more neighbors than old universities that kept their Catholic faith. In contrast, new Protestant universities have on average 2.858 more neighbors than old universities. What is striking however, is that both converted and new Protestant universities have much higher scores of eigenvector centrality than old Catholic universities. These differences are statistically significant at 1%. This is all the more noticeable as there is no statistically significant difference in terms of eigenvector centrality scores between old universities that would turn Protestant and old universities that would remain Catholic in the network before the Reformation, as Table C.20 shows in the Appendix.[18] This suggests that old universities that converted to Protestantism saw their position drastically improve within the network in terms of eigenvector centrality score following the Reformation. It is also noteworthy that new Catholic universities do not have significantly higher eigenvector centrality scores than their old counterparts, but we can still notice that their neighboring network is denser, as captured by their higher clustering score.[19] Finally, new Protestant universities perform worse than old Catholic universities in terms of betweenness centrality scores, but estimated coefficients are quite low.[20]

We then explore whether the position of a university in the network is correlated with its academic output. We regress academic output of universities on the different network measures described above. Results are displayed in Table 8.

Every column of Table 8 presents a regression of the academic output of universities on our measures of network position, separately and then together, controlling for coverage and duration. We find that degree, clustering, closeness centrality and eigenvector centrality are all significantly correlated with academic output. The last column shows that this remains true for clustering and eigenvector centrality only when all centrality measures are included in the regression. Interestingly, eigenvector centrality and clustering have opposite effects on academic production. While a higher eigenvector centrality score is associated with greater academic output, higher clustering, by contrast, is associated with lower production. Let us remember here that a high eigenvector centrality score means that a university is connected with universities that are well-connected in the network. Clustering captures another dimension: it measures the proportion of an university's neighbors that are connected with each other. So results from Table 8 suggest that academic production is all the greater when the university is connected to well-connected universities that are themselves not connected with each other. In fact, a university in this configuration lies at the junction of different paths that do not intersect. Assuming that the flow of ideas follows these paths, we may understand that such a university is ideally placed to receive the maximum amount of new and non redundant ideas, which

[18]If anything, it seems that old universities that would remain Catholic used to have higher eigenvector centrality scores before the Reformation, as illustrated in Figure D.8 in the Appendix.

[19]This result holds when we control for degree on *clustering*.

[20]Betweenness centrality scores range between 0 and 0.135.

Table 8: Academic output and network position after the Reformation

	Dependent variable:						
	log(1 + publications)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
degree	0.191***						0.003
	(0.030)						(0.063)
strength		0.020					0.016
		(0.026)					(0.019)
clustering			−1.798***				−1.944***
			(0.557)				(0.531)
closeness				14.411***			−5.244
				(3.832)			(5.253)
betweenness					10.987		2.741
					(8.436)		(8.617)
eigenvector						5.349***	4.969***
						(0.706)	(1.056)
Obs.	169	169	155	169	169	169	155
Adj. R^2	0.391	0.243	0.300	0.301	0.248	0.437	0.515

All specifications include coverage and duration.
"publications" sums the publications of the university members as reported in `www.worldcat.org` *p<0.1; **p<0.05; ***p<0.01

would enhance its academic production. Of course, our regressions only allow us to establish correlation between position in the network and academic production, not to infer causality. Moreover it is also very plausible that causality goes the other way: more prestigious and productive universities likely attract more scholars, which improves their central position in the network. But still, the diffusion of ideas mechanism described above is also possibly at play.

We have seen in Table 6 that being a Protestant university is strongly correlated with higher eigenvector centrality scores. Table 8 shows that this measure is an accurate predictor of higher academic output. We now study whether being a Protestant university is significantly associated with higher academic output. In doing so, we want to assess to what extent their more central position in terms of eigenvector centrality explains their academic production. For this purpose, we regress our measure of academic output on dummy variables indicating the religious affiliation of universities. We use Catholic universities as the reference category. We then run the same regression including eigenvector centrality and clustering, the two network measures that are statistically significant to explain academic output. Table 9 displays the results.

Table 9: Academic production, religion and position in the network after the Reformation

	Dependent variable:		
	log(1 + publications)		
	(1)	(2)	(3)
C	reference category		
P	2.847***	2.289***	1.989***
	(0.284)	(0.352)	(0.277)
M	1.979**	1.247	0.822
	(0.773)	(0.810)	(0.623)
O	2.477	1.834	2.536*
	(1.733)	(1.721)	(1.334)
eigenvector		2.141**	2.099***
		(0.822)	(0.634)
clustering			−1.445***
			(0.404)
Obs.	169	169	155
Adj. R^2	0.529	0.545	0.641

All specifications include coverage and duration. "publications" sums the publications of the university members as reported in `www.worldcat.org` Eigenvector centrality scores have been scaled such that the highest value is equal to one. Estimator is OLS. *p<0.1; **p<0.05; ***p<0.01

The first column in Table 9 shows that being a Protestant university is significantly associated with higher academic output in comparison to Catholic universities, which confirms results from Table 1. However we observe that the estimated coefficient associated with being a Protestant university decreases from 2.847 to 1.989 once we control for eigenvector centrality and clustering in the second and third columns. Moreover, eigenvector centrality score remains significantly correlated with greater academic production. So we may state that a significant part of publications produced in Protestant universities is explained by their higher eigenvector centrality scores. Table C.21 in the Appendix shows these same regressions with dummy variables indicating affiliation to subreligions. We use secular Catholic universities as the reference category. Interestingly, we find that in all other subgroups, universities publish significantly more than Secular universities. The estimated coefficient associated with Jesuit universities is the lowest though, but still statistically significant. All estimated coefficients decrease once eigenvector centrality and clustering are included. Here again, the coefficient associated with eigenvector centrality is still positive and statistically significant.

Finally, we zoom in on the 2.97% of links between Catholic and Protestant universities. Twenty professors link the Catholic and Protestant worlds, representing only a very small share of the total number of professors who taught in at least two universities after the Reformation in our sample (20/1506 = 1.3%). A short biography of these bridge builders is provided in Appendix E. There is a majority of renowned scholars, who might be immune from petty religious fights. Who would dare to ask one of the Bernoulli to convert to Catholicism if Padova really wants to hire him ? We also note that these links involving superstars touch a small number of universities. Padova seems an example of openness. The Dutch universities too seem to have been quite open. We do not observe any connection involving a Spanish or a Polish university. Beyond the stars, we also have a few "obscure" scholars establishing links between the two worlds. This seems to occur more often when they teach some very specialized topic (Hebrew, Arabic). Then, there are cases of conversion, for which we do not know what came first: a true conversion requiring a change of university, or a better job offer requiring a conversion.

Table 10 displays the results of a regression of the number of academic works on a dummy variable indicating if a professor connects a Protestant and a Catholic university. On average, our twenty connecting persons have 308 more works published compared to 161 on average among other connecting scholars.

Table 10: Publications of the Connecting Scholars

	Dependent variable: number of works
constant	160.506***
	(10.920)
connecting **P** and **C**	307.586***
	(94.755)
Obs.	1,506
Adj. R^2	0.006

Estimator is OLS. *p<0.1; **p<0.05; ***p<0.01

6 Conclusions

For a long time, the European academic world was an interconnected network with scholars moving positions at will. With the Reformation and the Counter-Reformation, the academic world became divided. Few people held positions in both worlds. We show in this paper that this religious divide had asymmetric consequences. The Catholic South lost centrality in the network of universities, and this was not fully compensated by the creation of new universities by the very dynamic Society of Jesus (Jesuits). Publications in the Catholic world peaked at their pre-reform level. On the Protestant side, the converted universities tended to gain centrality, while newly created universities quickly came to enjoy a central position, in particular in the Lutheran and Calvinist worlds. This ascension to primacy goes together with higher and rising publication levels.

These results were obtained by looking at a new database of tens of thousands of European scholars through the lens of network theory. We also create a new tool by generating simulated and counter factual networks as predicted from a dyadic regression. With this tool it is possible to separate the effect of religion and show that the proportion of connections between Protestant and Catholic universities would have been multiplied by a factor of nearly eight if religion did not intervene.

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A History Cheat Sheet

Table A.11: Timeline of Major Reformation Events

Date	Event
1517	Luther circulates 95 Theses from Wittenberg
1521	Edict of Worms condemns Luther as a heretic
1527	Creation of the first Protestant University in Marburg
1530	Formation of the Schmalkaldic League of Protestant Princes
1529-1536	English Reformation Parliament establishes the Church of England
1534	Formation of the Society of Jesus by Saint Ignatus of Loyola
1545-1563	Council of Trent
1546-1547	First Schmalkaldic War in the Holy Roman Empire(HRE)
1552-1555	Second Schmalkaldic War in the HRE
1555	Peace of Augsburg allows rulers within the HRE to choose either Lutheranism or Roman Catholicism as their official confession
1560	Scottish Reformation Parliament establishes the Kirk
1562-1598	French Wars of Religion
1598	Edict of Nantes grants Protestants substantial rights in France
1648	Peace of Westphalia recognizes Roman Catholicism, Lutheranism and Calvinism as three separate Christian traditions in the HRE
1685	Edict of Fontainebleau revokes Edict of Nantes

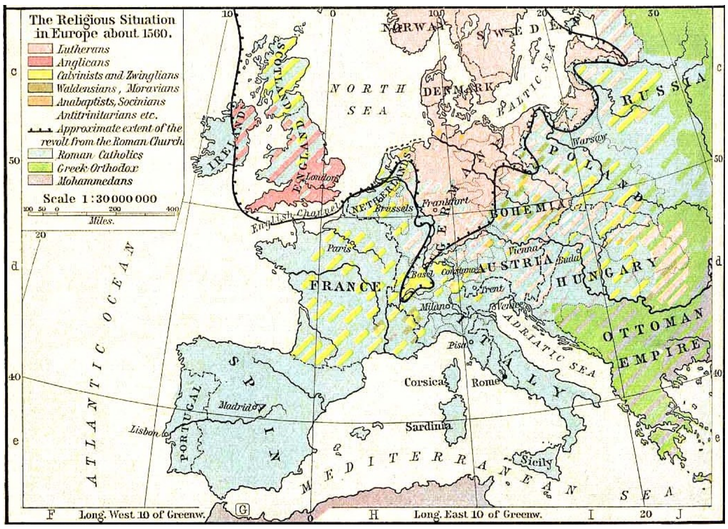

Figure A.5: The Religious Situation in Europe about 1560

Source: The Historical Atlas by William R. Shepherd, 1923. From Wikimedia Commons, see `https://commons.wikimedia.org/wiki/File:Europe_religions_1560.jpg`

B Publications

Table B.12 reports the total number of works by members of universities. It is limited to the universities for which we have found at least 20 members and at least 200 publications. Even if we did not manage to record all their obscure scholars, the known scholars, who are contributing significantly to the publications, are very likely to appear in the sources consulted.

Table B.12: Publications by Members of Universities (1/6)

		Members by Century						Total Publi. by Century (×1000)					
University	Start	13	14	15	16	17	18	13	14	15	16	17	18
Old catholic													
Ubologna	1088	297	435	784	549	564	547	9.5	3.0	8.7	19.6	9.8	6.8
Ctoledo	1126	13						1.2					
Umodena	1175	16	9	14	55	24	162	1.5	0.3	0.2	1.3	0.8	6.3
Uparis	1200	253	178	71	19	138	16	42.3	17.8	4.9	42.4	19.2	19.5
Usalamanca	1218		1	73	217	34	164			2.9	17.4	7.5	7.2
Upadua	1222	61	173	487	179	296	214	0.3	2.3	1.2	4.8	23.3	12.4
Unapoli	1224	68	48	9	173	153	88	1.4	0.4	3.7	3.1	0.9	7.7
Utoulouse	1229	7	126	84	98	74	98	1.7	0.6	0.7	8.8	1.7	2.0
Usalerno	1231	41	11	13	38	21	18	0.2	0.2		1.5	0.2	0.3
Uorleans	1235	18	14	49	2	8	12	0.5	0.4	0.3	3.6	0.2	3.6
Usiena	1246	27	128	95	34	18	9	0.7	0.7	2.3	2.8	0.5	0.7
Uangers	1250	3	14	44	35	36	52		0.2	0.5	2.1	0.2	0.3
Uvalladolid	1280		1	2	12	12	7		0.5	0.6	1.2	0.8	0.6
Umontpellier	1289	55	14	62	93	59	66	1.9	3.7	0.4	2.6	5.1	6.2
Ulerida	1300	1	5	19	11	4	2	0.8	0.3	0.5	0.9	1.7	0.3
Uavignon	1303	13	37	86	85	111	114	0.2	0.9	2.6	4.2	3.1	0.9
Uroma	1303		11	93	111	213	172		0.2	36.4	31.8	12.4	9.6
Ucoimbra	1308				31	27	22				6.8	0.7	0.8
Uperugia	1308	7	138	226	191	25	4		3.7	3.9	2.1	1.0	0.1
SFlorence	1321		2	33	1	17	32		22.8	6.7	7.1	4.2	4.1
Ucahors	1332	1	6	12	43	34	33	0.1	0.2	0.5	3.5	0.5	0.3
Upisa	1343	1	7	24	52	57	2	0.1	2.8	1.2	5.2	8.2	3.7
Uprague	1348		55	89	42	157	259		0.2	1.2	1.0	1.9	5.7

Table B.13: Publications by Members of Universities (2/6)

		Members by Century						Total Publi. by Century (×1000)					
University	Start	13	14	15	16	17	18	13	14	15	16	17	18
Old Catholic (con't)													
Uperpignan	1350		1	6	1	15	55				0.6	0.6	1.9
Upavia	1361	1	14	813	367	215	17	0.9	0.8	9.7	15.9	2.4	9.7
Ucracow	1364		3	241	459	221	37			0.3	1.6	3.1	1.7
Uvienna	1365		4	29	1	13	212		0.7	3.6	3.2	3.5	1.9
Ucologne	1388	3	26	277	218	6	29	1.8	1.4	7.7	6.6	2.7	0.7
Uferrara	1391		3	54	32	12	1		0.3	4.5	9.3	0.5	0.3
Uwurzburg	1402			24	51	9	19			1.0	1.9	6.7	5.0
Utorino	1404	1	2	11	24	8	3	0.3	0.2	1.0	2.5	0.2	1.4
Uaix	1409	5	31	37	53	94	13	0.9	0.2	0.1	0.8	2.5	2.9
Uparma	1412	2	1	7	3	29	13		0.2	0.8	0.2	2.5	0.7
Udole	1422			2	3	3					2.5	0.3	
Ulouvain	1425			139	196	172	145			0.7	5.5	23.7	6.3
Upoitiers	1431			15	4	39	25			0.2	3.2	0.6	0.1
Ucaen	1432			4	5	12	19			0.1	0.3	0.2	0.2
Ubordeaux	1441		1	8	111	27	27				6.3	1.9	0.9
Ubarcelona	1450				9	5	7				0.4	0.3	1.0
Uvalence	1452			2	55	66	88				5.8	3.4	0.3
Ufreiburg	1457			23	56	74	1			1.3	27.2	2.5	4.9
Uingolstadt	1459			12	7	37	49			0.1	18.9	6.9	6.5
Ubourges	1464				27	7	4				6.9	0.6	0.2
Uzaragoza	1474				17	22	24				1.4	1.3	0.5
Umainz	1476			7	36	54	88			0.6	2.3	4.6	5.7
Usiguenza	1489				12	12	7				0.3	0.2	0.3

Table B.14: Publications by Members of Universities (3/6)

		Members by Century						Total Publi. by Century (×1000)					
University	Start	13	14	15	16	17	18	13	14	15	16	17	18
Old Catholic (con't)													
Ualcala	1499				48	18	11				7.7	0.5	0.1
Old would-be Protestant													
Uoxford	1200	3	3	25	86	138	127	2.9	5.2	0.3	13.2	45.8	32.7
Ucambridge	1209	6	7	13	85	124	135	0.1	0.4	0.3	32.7	57.9	61.9
Uleipzig	1409		1	16	35	31	122			0.5	6.0	18.5	67.8
Ustandrews	1411			3	7	15	43			0.9	2.2	2.2	1.8
Urostock	1419			5	45	134	18			0.9	8.8	27.8	18.7
Uglasgow	1451			2	4	11	38			0.6	0.3	11.1	11.3
Ugreifswald	1456			21	49	72	85				2.5	11.2	18.3
Ubasel	1460			47	85	52	72			0.5	26.6	16.3	8.8
Ucopenhagen	1475			4	79	96	136				7.8	12.9	28.4
Utubingen	1476			29	152	13	133			1.9	48.9	21.7	29.5
Uuppsala	1477			1	4	91	11				0.2	8.7	47.5
Uaberdeenold	1495			1	2	12	24			0.6	0.4	2.4	8.8
Old Mixed													
Uerfurt	1379		12	161	59	9	36			0.9	7.0	2.4	26.9
Uheidelberg	1386		43	456	345	98	242		0.2	2.4	29.5	28.8	9.1
New Catholic													
Uvalencia	1500				78	58	31				1.2	2.1	4.3
Cpoznan	1519				8	92	97				0.6	0.7	0.2

Table B.15: Publications by Members of Universities (4/6)

		Members by Century						Total Publi. by Century (×1000)					
University	Start	13	14	15	16	17	18	13	14	15	16	17	18
New Catholic (con't)													
Ucompostella	1526				53	171	213				0.5	0.4	0.3
CollegeFr	1530				51	12	16				15.5	11.9	34.7
Umacerata	1540				15	314	252				0.7	1.0	1.5
Ureims	1548				6	8	15				0.6	0.6	1.3
Udillingen	1553				13	42	29				3.5	9.3	3.1
UromaGregoriana	1556				87	199	145				14.2	18.4	3.4
Udouai	1559				15	33	17				1.9	4.7	8.6
Uolmutz	1570				5	29	55					0.1	0.5
Upontamousson	1572				35	221	23				0.8	3.8	4.2
Upalermo	1578				1	9	67					0.8	1.6
Uvilnius	1578					1	14					2.8	0.6
Ufermo	1585				5	12	11				0.3	0.1	0.9
Ugraz	1585				2	52	6				0.7	3.2	2.4
Uaixbourbon	1603					86	49					1.8	6.0
Umolsheim	1617					41	124					0.3	0.4
Usassari	1617					17	48						0.2
Umantua	1625					49	5					0.2	0.3
Cmadrid	1625				2	15	12				0.5	4.4	0.3
Jplantes	1635					27	62					4.5	4.4
Utrnava	1635				1	2	31				0.3	0.4	0.8
Ubamberg	1648					85	229					0.7	3.3
Uinnsbruck	1668					8	26					0.5	2.6

Table B.16: Publications by Members of Universities (5/6)

		Members by Century						Total Publi. by Century (×1000)					
University	Start	13	14	15	16	17	18	13	14	15	16	17	18
New Catholic (con't)													
Ubreslau	1702					1	19					0.1	0.1
Ucervera	1714						247						0.7
Urennes	1735						3						1.6
New Protestant													
Uwittenberg	1502				74	53	54				145.0	52.3	38.4
Ufrankfurt	1506				38	31	5				6.5	15.1	21.5
Czurich	1525				7	7	9				14.1	2.7	5.8
Umarburg	1527				8	11	183				18.0	18.9	22.5
Ebern	1528				9	12	12				2.6	0.5	1.9
Ulausanne	1537				13	7	6				15.7	0.3	4.0
Ukonigsberg	1544				12	22	28				6.5	6.2	5.5
Ujena	1558				78	14	161				2.4	82.1	148.8
Ugeneve	1559				17	21	18				19.7	7.6	4.7
Uleiden	1575				29	128	86				11.9	63.6	33.6
Uhelmstedt	1575				18	119	151				4.5	37.3	36.8
Ualtdorf	1578				2	22	29				0.6	11.4	10.0
Uedinburgh	1582				2	31	124				0.4	4.3	43.8
Aherborn	1584				2	11	9				1.2	5.4	0.8
Ufraneker	1585				2	61	8				0.4	13.8	17.6

Table B.17: Publications by Members of Universities (6/6)

		Members by Century						Total Publi. by Century (×1000)					
University	Start	13	14	15	16	17	18	13	14	15	16	17	18
New Protestant (con't)													
Udublin	1592				3	2	33				0.2	5.1	7.6
Usaumur	1596					41						4.5	
Umontauban	1598				1	3					0.3	1.6	
Usedan	1599				5	35					0.8	13.5	
Ugiessen	1607					11	186					21.5	3.4
Ugroningen	1612					4	53					7.4	8.9
Aamsterdam	1632					24	48					5.5	15.4
Udorpat	1632					31	23					0.8	0.5
Uutrecht	1636					41	74					12.6	19.8
Uabo	1640				1	32	63				0.2	0.8	7.3
Uharderwijk	1647				1	47	64					5.3	12.5
Ukiel	1652					33	184					5.6	25.0
Uduisburg	1654				1	14	23				3.7	3.8	2.3
Ulund	1666					22	63					4.0	8.3
Uhalle	1694					3	83					6.5	77.2
Ugottingen	1734						339						13.2
Uerlangen	1742						129						2.7
Tubraunschweig	1745						115						13.9
Ubutzow	1760						31						2.8
New mixed													
Ustrasbourg	1538				83	11	141				37.2	28.0	13.2
Urinteln	1620					78	82					5.3	7.3

C Additional regression tables

Table C.18: Dyadic Regressions - Religions

	Dependent variable:		
	link	intensity	invsteps
	(1)	(2)	(3)
distance	-0.118^{***}	-0.604^{***}	-0.098^{***}
	(0.003)	(0.023)	(0.002)
$\mathbf{I}(i, j \in \mathbf{C})$	0.152^{***}	0.231	0.128^{***}
	(0.026)	(0.206)	(0.017)
$\mathbf{I}(i, j \in \mathbf{P})$	0.008	0.199	0.115^{***}
	(0.027)	(0.211)	(0.017)
$\mathbf{I}(i, j \in \mathbf{M})$	0.099	-0.751	0.144^{***}
	(0.071)	(0.559)	(0.046)
Cross effects	YES	YES	YES
Obs.	15,390	15,390	15,390
Adj. R^2	0.194	0.083	0.610

All specifications include university fixed effects, number of overlapping years and minimum coverage. Estimator is OLS. Reference category for religions is the set of all pairs of universities with one Protestant and the other Catholic.
*p<0.1; **p<0.05; ***p<0.01

Table C.19: Network position and subreligion after the Reformation

	Dependent variable:					
	degree	strength	closeness	betweenness	eigenvector	clustering
	(1)	(2)	(3)	(4)	(5)	(6)
$I(i \in \mathbf{C^S})$	reference category					
$I(i \in \mathbf{C^J})$	2.742***	2.151*	0.029***	0.005	0.046*	−0.048
	(0.926)	(1.279)	(0.008)	(0.004)	(0.027)	(0.053)
$I(i \in \mathbf{P^L})$	4.406***	−0.255	−0.002	−0.008*	0.415***	0.056
	(1.079)	(1.489)	(0.009)	(0.005)	(0.032)	(0.062)
$I(i \in \mathbf{P^C})$	4.872***	−0.316	0.023**	0.002	0.231***	−0.183***
	(1.155)	(1.594)	(0.010)	(0.005)	(0.034)	(0.065)
$I(i \in \mathbf{P^P})$	0.391	0.023	−0.032	−0.005	−0.005	−0.081
	(2.348)	(3.240)	(0.020)	(0.010)	(0.069)	(0.130)
$I(i \in \mathbf{P^A})$	−2.578	8.533***	−0.008	−0.003	−0.020	−0.211
	(2.345)	(3.237)	(0.020)	(0.010)	(0.069)	(0.129)
$I(i \in \mathbf{M})$	5.631***	1.785	0.031*	0.008	0.351***	−0.116
	(2.115)	(2.918)	(0.018)	(0.009)	(0.062)	(0.117)
$I(i \in \mathbf{O})$	1.326	−4.790	−0.007	−0.016	0.366***	0.334
	(4.708)	(6.497)	(0.041)	(0.020)	(0.138)	(0.261)
Obs.	169	169	169	169	169	155
Adj. R^2	0.498	0.101	0.335	0.305	0.628	0.111

In all specifications we control for duration and coverage. Estimator is OLS.
*p<0.1; **p<0.05; ***p<0.01

Table C.20: Network position and religion before the Reformation

	Dependent variable:					
	degree	strength	closeness	betweenness	eigenvector	clustering
	(1)	(2)	(3)	(4)	(5)	(6)
$I(i \in \mathbf{C})$	reference category					
$I(i \in \mathbf{P})$	0.634	−0.743	0.005	−0.001	−0.056	−0.091
	(1.568)	(1.445)	(0.016)	(0.014)	(0.051)	(0.076)
$I(i \in \mathbf{M})$	−8.643**	−10.368***	−0.071*	−0.062*	−0.360***	0.039
	(4.020)	(3.706)	(0.041)	(0.035)	(0.131)	(0.184)
Obs.	74	74	74	74	74	64
Adj. R^2	0.553	0.479	0.498	0.260	0.545	0.089

In all specifications we control for duration and coverage. Estimator is OLS.
*p<0.1; **p<0.05; ***p<0.01

Table C.21: Academic output, subreligion and network position after the Reformation

	Dependent variable:		
	log(1 + publications)		
	(1)	(2)	(3)
$I(i \in \mathbf{C^S})$	reference category		
$I(i \in \mathbf{C^J})$	1.112^{***}	1.020^{***}	0.605^{**}
	(0.333)	(0.332)	(0.267)
$I(i \in \mathbf{P^L})$	3.550^{***}	2.722^{***}	2.705^{***}
	(0.387)	(0.552)	(0.447)
$I(i \in \mathbf{P^C})$	2.841^{***}	2.380^{***}	1.847^{***}
	(0.415)	(0.466)	(0.374)
$I(i \in \mathbf{P^A})$	3.203^{***}	3.242^{***}	2.526^{***}
	(0.842)	(0.834)	(0.648)
$I(i \in \mathbf{P^P})$	3.004^{***}	3.015^{***}	2.427^{***}
	(0.843)	(0.834)	(0.644)
$I(i \in \mathbf{M})$	2.342^{***}	1.640^{**}	1.199^{*}
	(0.759)	(0.823)	(0.637)
$I(i \in \mathbf{O})$	2.879^{*}	2.148	3.001^{**}
	(1.690)	(1.709)	(1.336)
eigenvector		1.998^{**}	1.588^{**}
		(0.958)	(0.754)
clustering			-1.575^{***}
			(0.414)
Obs.	169	169	155
Adj. R^2	0.555	0.564	0.654

In all specifications we control for duration and coverage.
Estimator is OLS. *p<0.1; **p<0.05; ***p<0.01

D Additional Figures

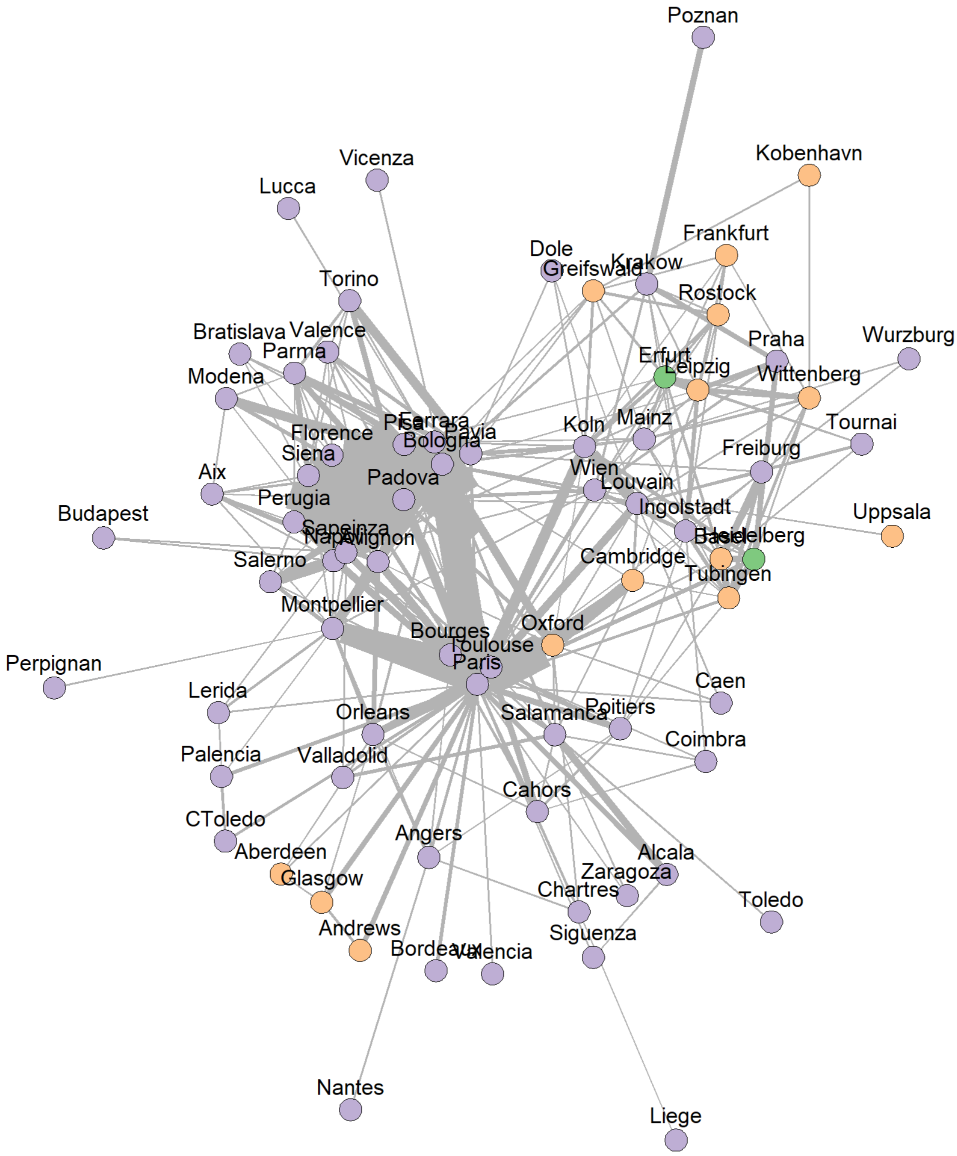

Figure D.6: Network of European Universities before 1527
Note: the width of the links is proportional to their strength.

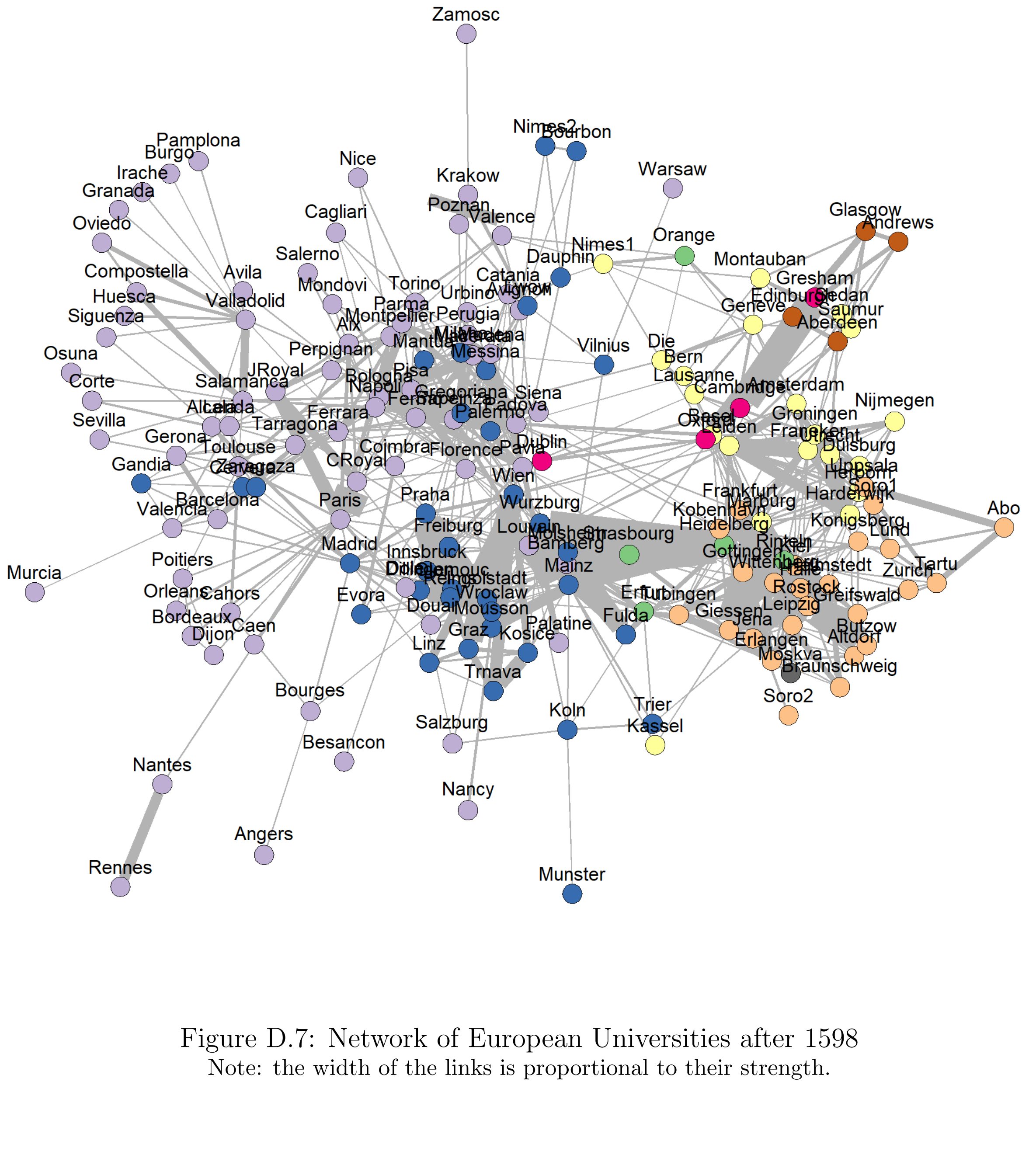

Figure D.7: Network of European Universities after 1598

Note: the width of the links is proportional to their strength.

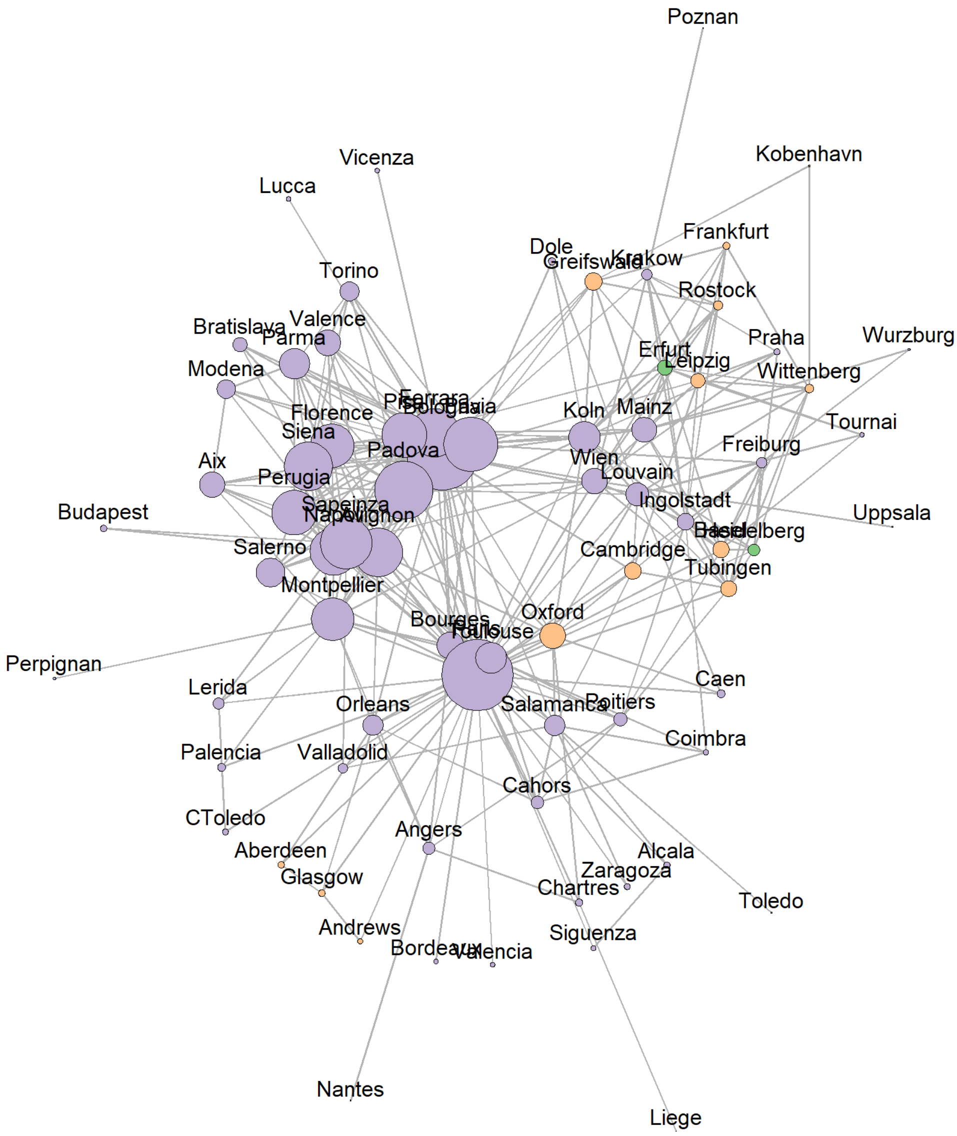

Figure D.8: Network of European Universities before 1527

Note: the size of the nodes are proportional to the eigenvector centrality score.

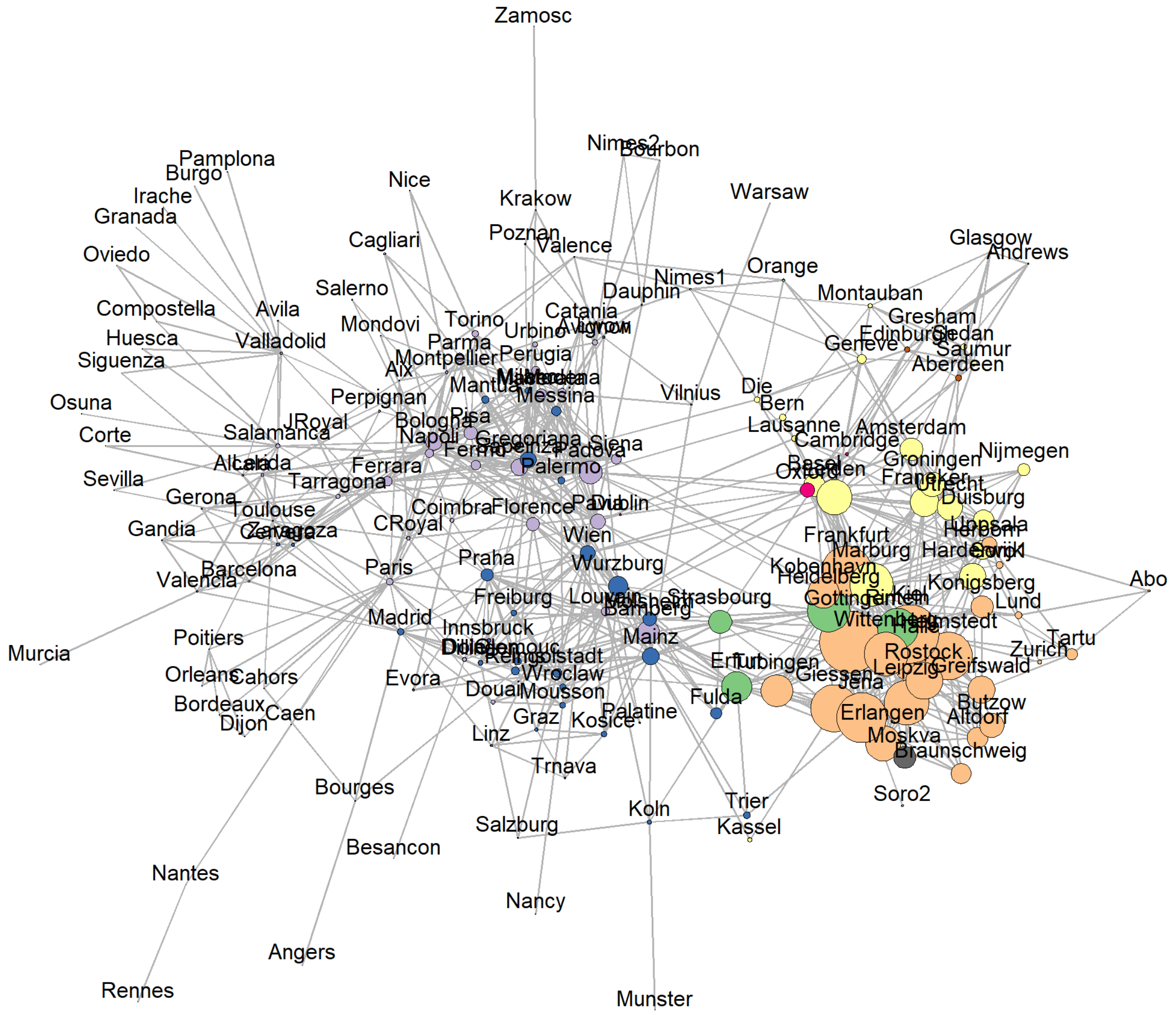

Figure D.9: Network of European Universities after 1598

Note: the size of the nodes are proportional to the eigenvector centrality score.

E Scholars Linking Protestant and Catholic Universities

Stars

Nicolaus I Bernoulli (1687-1759) obtained in 1716 the Galileo-chair at the University of Padua (Del Negro 2015), where he worked on differential equations. In 1722 he returned to Switzerland and obtained a chair in Logics at the University of Basel (Herzog 1780).

Nicolaus II Bernoulli (1695-1726) was magister of philosophy in Basel in 1711 (Herzog 1780). From 1719 he had the Chair in Mathematics at the University of Padua (Del Negro 2015).

Giovanni Battista Ferrari (1584-1655) was a Jesuit known for his work in Botany. He taught Hebrew at the Jesuit university of Rome (Villoslada 1954). We also find him teaching Hebrew at the protestant university in Die when he was young (Bourchenin 1882).

Jakob Hermann (1678-1733) was appointed to a chair in mathematics in Padua in 1707 (Del Negro 2015), but moved to Frankfurt an der Oder in 1713, and thence to St. Petersburg in 1724. Finally, he returned to Basel in 1731 to take a chair in ethics and natural law.

Johann Peter Frank (1745-1821) was appointed professor of physiology and medical policy at the University of Göttingen in 1784 (Ebel 1962), but the next year he went to Italy for his health and joined the faculty of the University of Pavia (Raggi 1879), teaching clinical medicine (1785-1795).

Johan Rhode (1587-1659), was a Danish physician who spent most of his time in Padua (Del Negro 2015), but also had positions in Siena and Copenhagen (Slottved 1978).

Samuel-Auguste Tissot (1728-1797) was a Swiss physician who studied in Montpellier, held a chair in medicine in Pavia (Raggi 1879) before returning to Lausanne (Dulieu 1983) where he was in charge of reorganizing the curriculum in medicine.

Gerard van Swieten (1700-1772) was a Catholic Dutch physician. He gave lessons in Leiden, drawing many students. Michaud (1811) wrote that he was professor there, but soon attracted envy. In 1734 the university forbade him from continuing. By May 1745, the Van Swieten family had sold all their belongings in the Netherlands and traveled to Vienna. In his new position he implemented a transformation of the medical university education and founded the botanical garden.

Jakob Gronovius (1645-1716) was a Dutch classical scholar who taught in Leiden and in Padova (Facciolati 1757).

Micheál Ó Mordha (1639-1723). He first taught in Paris (Junius Institute 2013), both at the university and at the Royal College. Returning to Ireland, Ó Mordha became the college's first Catholic provost of Trinity College, Dublin.

Minor persons

Jean-Nicolas de Parival (1605-1669) was a French Catholic, teaching French at the University of Leiden, and later on, at the University of Louvain (Académie royale 1866).

Josephus Abudacnus was an Egyptian Copt who traveled in Europe, mainly teaching Arabic. We find him in Oxford, Louvain (1615-1617), and Vienna. "Thanks to his determination to teach oriental languages of which his knowledge was sometimes limited, he had a remarkable aptitude for collecting distinguished acquaintance" (Hamilton 1994).

Philippe Codurc (1580-1660) was a French Protestant who we find teaching in Montpellier (predominantly Catholic at that time) and in Nimes (predominantly Protestant) (see Bourchenin (1882)).

Jean-Frédéric Guib (-1681) was a Scottish Protestant. We find him teaching in Valence (Catholic, see Barjavel (1841)), Nimes (mostly Protestant) and Orange (mostly Protestant) ((see Bourchenin (1882)).

Conversion cases

Johannes Anton Winther has published a few works, is mentioned (Bamberg 2019) in Bamberg from 1652 to 1654 (Professor für Physik und Metaphysik) and in Tübingen from 1663 to 1675 (Conrad 1960). It is not totally certain it is the same person, but it is mentioned in the Tübingen source that he returned to the Catholic Church in 1675.

Christopher Besoldus (1577-1638) was born of Protestant parents. In 1610 became professor of law at Tübingen (Conrad 1960). He was publicly converted to Catholicism in 1635. Two years later, he accepted the chair of Roman Law at the University of Ingolstadt (Michaud 1811).

August Fischer (fl. 1617-1625), a quite obscure lawyer, started his career in Jena then converted to Roman Catholicism and obtained a position in Trier (Stolleis 1988).

Arnold Geulincx (1624-1669) was made professor of philosophy in Louvain in 1646 (Lamberts and Roegiers 1990b). He lost his post in 1658, possibly for religious reasons. Geulincx then moved north to the University of Leiden (Leiden 2019) and converted to Calvinism.

Uncertain cases

Johannes Justus Pistorius, has published a few works, and is mentioned in Giessen in 1656 (Haupt and Lehnert 1907) and in Bamberg from 1669 to 1672 (Professor für Mathematik mit Ethik, Bamberg 2019). It is not totally certain it is the same person though.

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ISSN 1379-244X D/2020/3082/29

IRES | Louvain Institute of Data Analysis and Modeling in economics and statistics