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The Fall of Constantinople and the Rise of the West

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The Fall of Constantinople and the Rise of the West

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Abstract

The Renaissance era in Western Europe was marked by a flourishing of economic and cultural life that gave rise to numerous discoveries and inventions. This paper studies the role played by Greek migrants in this process. Using a newly constructed dataset on Greek migrants in Europe after the fall of Constantinople in 1453, I show that a Greek presence in the second half of the fifteenth century increased city growth in the sixteenth century. In terms of mechanisms, I find that a Greek presence increased the available knowledge stock in astronomy, mathematics, and medicine – fields in which ancient Greek and Byzantine scholars were especially advanced. Finally, I document an increase in upper-tail human capital and inventions in these cities. In this way, the findings illustrate the important role of Greek migrants in disseminating scientific knowledge in early modern Europe and show their positive impact on city growth during that time.

Keywords: Economic development, economic history, human capital, innovation, migration

JEL: N13, N33, O15, O33, O47

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1 Introduction

The economic and cultural flourishing of the Renaissance, which reached its zenith in the sixteenth century, was integral to Europe's transition from the middle ages to modernity. The zeitgeist of the Renaissance encouraged curiosity and ingenuity, which led to many inventions and discoveries that promoted human capital accumulation and economic growth in early modern Europe (Acemoglu, Johnson, and Robinson, 2005; Dittmar, 2011, 2019; Boerner and Severgnini, 2019). A significant event in the early stages of the Renaissance period was the fall of Constantinople to the Ottomans in 1453, which initiated the migration of many Byzantine Greeks to Western Europe. Historians have been debating for centuries the extent to which this event affected the development of early modern Europe. Some scholars argue that these Greek migrants and the vast amount of ancient Greek literature they brought with them – literature that was predominantly unknown in Western Europe during the middle ages – substantially contributed to European development in a range of fields (Geanakoplos, 1966, 1989; Harris, 1995).

This paper establishes empirically the important role Greek migrants played in European development in the early modern period. I gather data on the dissemination of Greeks in European cities in the second half of the fifteenth century and show that the 44 destination places for Greek migration in my sample grew considerably faster in the sixteenth century than other cities. These results are corroborated by a difference-in-differences setting as well as an instrumental variable approach that exploits the fact that cities closer to Constantinople were more likely to become a destination for Greek migrants. In terms of mechanisms, I find that a Greek presence increases printing output in astronomy, mathematics, and medicine, suggesting a process of knowledge diffusion from the Greeks to the local population in these fields. Potentially driven by this knowledge diffusion, these cities subsequently experienced a rise in their levels of upper-tail human capital as well as an increase in inventions.

Scientific, medical, and philosophical texts written by ancient Greek authors were of great interest to many scholars in Western Europe in the early modern period. Drawing on data on printing output in Europe in the early modern period from the Universal Short Title Catalogue (USTC), Figure 1 shows that around 11,000 printed publications in the sixteenth century were texts written by ancient Greek or Byzantine authors. In some years during the first half of the sixteenth century, nearly 10% of total printing output in Europe was literature written by such scholars. While some of these texts were available in Europe before the fifteenth century, anecdotal evidence suggests that many of them only became available after the fall of Constantinople to the Ottomans in 1453 and the subsequent migration of larger numbers of Byzantine Greeks to Western Europe (e.g. Kovtun, 1977; Jackson, 2012; Giacomelli, 2021). The USTC data supports this interpretation: The predominant share of texts written by ancient Greek and Byzantine authors that were printed in Europe in the sixteenth century were published in places to which Greeks had previously migrated.

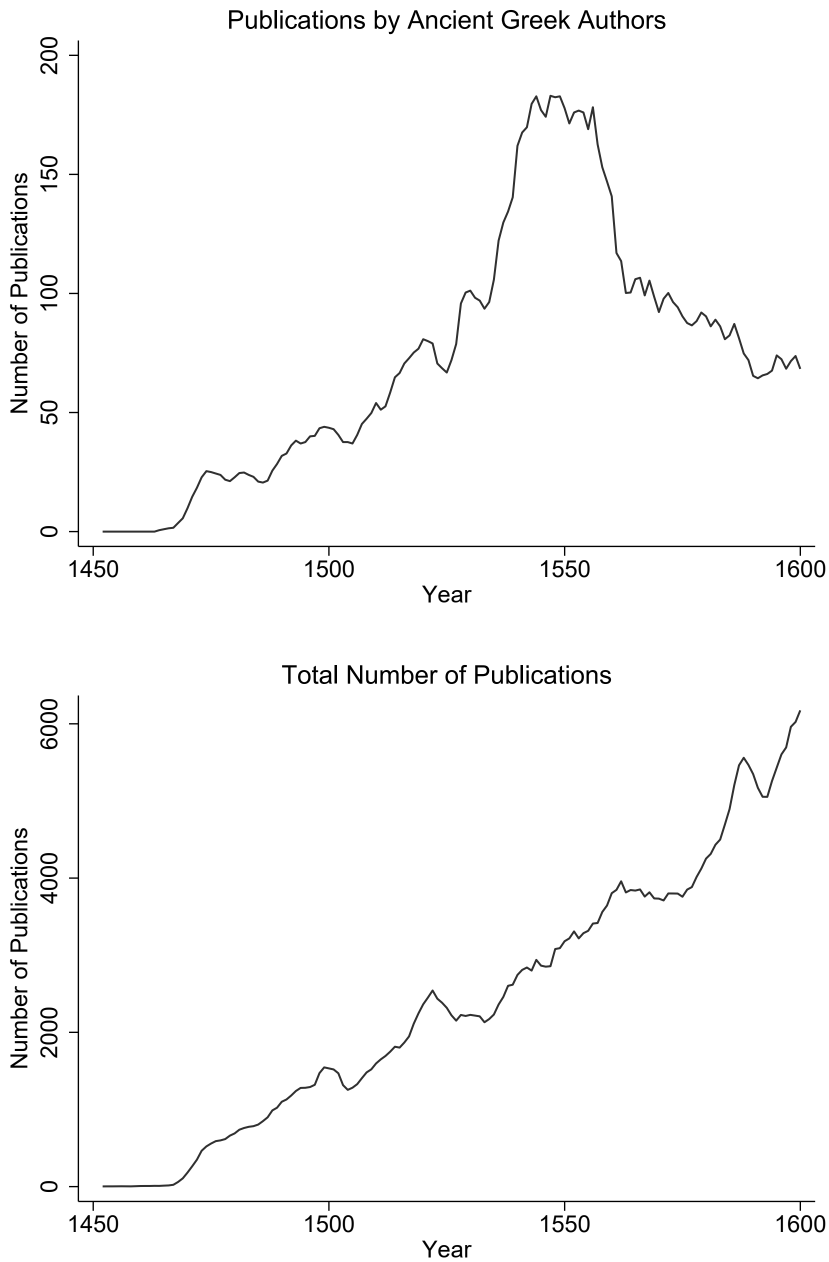

Figure 1 Ancient Greek and Total Printing Output in Europe 1451-1600

Notes: Printing Output in European Cities (5-year moving average). Data comes from USTC (2020).

At the same time, Western Europe saw a steep increase in inventions and discoveries in many fields in the early modern period (e.g. Hall, 1983; Dittmar, 2019). Did ancient Greek knowledge contribute to this increase in inventions and discoveries, and thereby to development in general? In recent work, Netz (2022, p. XI) writes: "What gave rise to modern science was a new appreciation of the science of antiquity and the attempt, finally, to emulate and outdo it. To a large extent, modern science came not from a scientific revolution but a scientific renaissance." Indeed, anecdotal evidence suggests that many scientific and medical developments in Western Europe in the early modern period were based on ancient Greek ideas (e.g. Clagett, 1970; Hall, 1983; Harris, 1995; Kalachanis et al., 2013; Netz, 2022).

The first part of the empirical analysis in this paper shows that destination places for Greek migration in the second half of the fifteenth century grew considerably faster in the sixteenth century, compared to other cities. The next part of the analysis draws on a difference-in-differences approach and examines the timing and the persistence of the growth advantage for destination places of Greek migration. The results show that these cities grew considerably faster in the sixteenth century, compared to other places and the omitted period, which is the fifteenth century. Contrary, there is no differential effect on growth in the fourteenth century or the seventeenth and eighteenth centuries.

To address the concern that the effects are driven by unobservable city characteristics that are related to patterns of Greek migration as well as to city growth, the analysis draws on an instrumental variable strategy. In particular, I exploit the fact that cities closer to Constantinople were more likely to become a destination for Greek migrants, a relationship that holds with and without including country fixed effects. The results of this exercise are similar compared to the OLS setting and indicate that destination places for Greek migration grew around 0.87 log points faster in the sixteenth century than other cities, which translates into a 1.38 percentage points larger yearly growth rate between 1500 and 1600. This is a remarkable effect size, underlining the importance of Greeks and their knowledge for European development during this time period. By contrast, distance to Constantinople is not related to city growth in earlier or later time periods or to other human-capital related city characteristics that predate the fall of Constantinople.

To identify the mechanisms that cause this relationship between Greek migration and growth, I draw on data from the Universal Short Title Catalogue (USTC), a dataset that includes all known published books and pamphlets in Europe from the invention of the printing press in 1451 until the year 1600. The analysis shows that a Greek presence increases printing output in astronomy, mathematics, and medicine – fields in which ancient Greek and Byzantine scholars had made particular achievements.

On the contrary, there is no significant relationship between a Greek presence and other printing categories, such as religious works. These results indicate that Greek migrants played an important role in the dissemination of scientific knowledge in early modern Europe.

To investigate the impact of the increased knowledge stock in these places, I conduct two further exercises. First, I relate a Greek presence to the births of famous people in the sixteenth century, a common proxy for upper-tail human capital in pre-industrial times. Second, I collect data on major inventions from Darmstaedter (1908) and relate a Greek presence to inventions during the sixteenth century. The results of these exercises reveal an increase in upper-tail human capital as well as inventions in places with Greek migrants during the sixteenth century, suggesting that the transferred knowledge was scientifically useful and applicable.

Drawing on the detailed inventions data I conduct a further exercise, where I construct 50-year periods and run a difference-in-differences analysis with the omitted time period including the fall of Constantinople in 1453. The results show that destination places for Greek migration during the second half of the fifteenth century were not on differential trends regarding innovations, relative to other cities, before 1453. Yet, after Constantinople had fallen, these cities saw an increase in inventions, which peaked in the second half of the sixteenth century. This result also holds when instrumenting the interaction terms between a Greek presence and time dummies with interaction terms between the log distance to Constantinople and time dummies.

This paper is related to several strands of the literature. First, it contributes to the literature examining the rise of the West in the centuries predating the Industrial Revolution (e.g. De Long and Shleifer, 1993; Acemoglu, Johnson, and Robinson, 2005; Mokyr, 2005b; Baten and van Zanden, 2008; Dittmar, 2011; Voigtländer and Voth, 2013; Cantoni and Yuchtman, 2014; De la Croix, Doepke, and Mokyr, 2018; Cantoni, Dittmar, and Yuchtman, 2018; Dittmar, 2019; Boerner and Severgnini, 2019; Binzel, Link, and Ramachandran, 2023a,b). In recent decades scholars have identified a range of factors that substantially contributed to Europe's growth during that time period. De Long and Shleifer (1993) show that in the early modern period cities with merchant-controlled councils achieved higher growth rates compared to cities ruled by autocrats. Also focusing on institutions, De la Croix et al. (2018) argue that these played an important role in the creation and dissemination of productive knowledge. Acemoglu et al. (2005) find that places that were involved in the emerging Atlantic trade gained a considerable growth advantage over other cities. Baten and van Zanden (2008) report that human capital, measured as books per capita, had a significant effect on economic performance in European countries, while Dittmar (2011) presents evidence for a higher growth performance by cities that were early adopters of the printing press. In recent work, Dittmar (2019) shows how the interaction of the printing press, universities, and political competition initiated the growth of science and invention in early modern Europe. Boerner and Severgnini (2019) provide additional evidence for the importance of technological inventions in the early modern period. Their results indicate that the spread of mechanical clocks had great relevance for early modern city growth. Binzel et al. (2023a) and Binzel et al. (2023b) highlight the importance of the rise of the European vernacular languages. In this paper, I argue that another crucial determinant of the rise of the West was the fall of Constantinople to the Ottomans in 1453, which led to the migration of Byzantine Greeks to Western Europe and, consequently, to knowledge transmission from East to West.

Within this broader body of literature, recent work has focused on the role of upper-tail human capital in pre-industrial development (Squicciarini and Voigtländer, 2015; Dittmar and Meisenzahl, 2020; Serafinelli and Tabellini, 2022; Becker, Pino, and Vidal-Robert, 2021; De la Croix, Docquier, Fabre, and Stelter, 2022).[1] Squicciarini and Voigtländer (2015) emphasize the important role of upper-tail human capital in the Industrial Revolution. More recent work sheds first light on the formation of upper-tail human capital in the early modern period by highlighting the role of institutions (Dittmar and Meisenzahl, 2020; Serafinelli and Tabellini, 2022) and of market forces (De la Croix et al., 2022). This paper also contributes to understanding the role played by upper-tail human capital in the early modern period, by linking knowledge diffusion from Greek migrants to the local population to higher levels of upper-tail human capital at the city level, and by showing that this knowledge diffusion consequently led to more inventions.

More generally, this paper adds to the literature on the effects of migration in receiving countries. Previous work has demonstrated that migrants can significantly influence innovation and productivity in a receiving country (see e.g. Hunt and Marjolaine, 2010; Moser, Voena, and Waldinger, 2014; Hornung, 2014; Akcigit, Grigsby, and Nicholas, 2017; Boberg-Fazlic and Sharp, 2019). Moser et al. (2014) show that Jewish migrants from Nazi Germany caused a significant rise in patents in the United States. Hornung (2014) finds that Huguenots migrants in eighteenth century Prussia considerably influenced long-run productivity in the textile industry. Boberg-Fazlic and Sharp (2019) show a similar pattern for Danish migrants in the United States in the 1880s. The Danish migrants contributed substantially to modernizing the dairy industry, in which Denmark was a world leader. Recent work has specifically focused on the relationship between migration and long-run development (Rocha, Ferraz, and Soares, 2017; Droller, 2018; Sequeira, Nunn, and Qian, 2020). Droller (2018) shows

[1] Upper-tail human capital describes the density of human capital in the upper tail of the distribution, see Mokyr (2005a).

that Argentinian counties with higher European migration shares in 1914 exhibited a higher GDP per capita in 1994. Rocha et al. (2017) explain within-differences in economic development in Brazil in the twentieth century with migration settlements in the nineteenth century. Sequeira et al. (2020), focusing on US counties, find a positive relationship between larger immigration shares in the nineteenth century and incomes today. This paper adds to this literature by documenting how even a rather small group of migrants can substantially benefit long-run development in the receiving locations by augmenting the available knowledge stock in various fields. This increased upper-tail human capital and, by extension, the development of inventions.[2]

Moreover, this paper examines the relationship between migration and long-run development from a different perspective than previous works, as it considers pre-industrial Europe in the early modern period. The pre-industrial setting has distinct benefits as an environment to examine how economic performance is influenced by migration and associated changes in human capital, as modern communication technologies such as the telegraph or the telephone hat not yet been invented. In previous work, this setting was exploited by Hornung (2014) to quantify the productivity gains of migration. The absence of modern communication technologies restricted knowledge sharing to face-to-face communication or the circulation in printed material. Consequently, spillover effects between cities or regions were presumably weaker than in modern times, and they should be concentrated in places geographically close to 'treated' cities. Thus, while using data from later time periods might result in an underestimation of the benefits of migration, this is likely to be only a minor issue in the setting of this paper.

The remainder of this paper is structured as follows. Section 2 documents the scope and patterns of the Greek migration, providing detailed information on the mechanisms through which Greek migrants might have influenced European development. Section 3 presents empirical results on the relationship between a Greek presence and city growth in early modern Europe. Section 4 explores the mechanisms that drive the relationship between a Greek presence and city growth. Specifically, this section examines a potential knowledge diffusion from the Greek migrants to the local population in the fields of astronomy, mathematics, and medicine. Furthermore, this section explores effects on upper-tail human capital as well as the development of inventions. Section 5 concludes.

[2]In recent work, Dippel and Heblich (2021) have shown with reference to the German "Forty-Eighters" who migrated to the US after the failed German Revolution of 1848 how a small group of migrants can significantly influence political and social outcomes.

2 Greek Migrants in Europe

2.1 Scope and Patterns of Migration

For most of Western Europe during the middle ages, there is little evidence of a Greek presence. However, parts of Southern Italy and Venice, which had maintained trading relations to the Byzantine Empire for centuries, represent two exceptions. Harris (1995) identifies the large religious and cultural differences between the Latin West and Orthodox East that had developed in the centuries following the collapse of the Western Roman Empire as the main reason for the broad absence of Greeks in most parts of Western Europe.

However, at the onset of the fifteenth century this situation began to change. After having already conquered parts of the Byzantine Empire in the fourteenth century (see e.g. Harris, 2011), the Ottomans began to apply increased military pressure on the Byzantine Empire, which caused the Byzantines to send diplomatic missions to the West to seek support, thus resurrecting relations between the Orthodox East and the Latin West (Harris, 2022). At some point it became increasingly clear that Constantinople itself would soon fall, which slowly initiated migration to Western Europe. One of the first known Greek scholars migrating to Europe was Theodorus Gaza, who arrived in Italy in the 1440s, after his hometown of Thessaloniki had been conquered by the Ottomans (Hunger, 1989; Harris, 1995). However, the historical sources suggest that migration to Europe only became widespread after Constantinople had fallen in 1453 (see e.g. Harris, 1995). In the decades following the loss of their capital, there was a constant stream of Greeks to Western Europe, as the Ottomans continued to conquer places populated by them. Mistra fell in 1460, Trebizond in 1461, and the Principality of Theodoro, the last large region ruled by Byzantine Greeks, in 1475 (Vasiliev, 1936; Geanakoplos, 1976; Karpov, 1989; Venning, 2006). Many Byzantine Greeks from areas now under Ottoman rule migrated to the Greek peninsula rather than to mainland Europe, while some of those displaced also migrated to the West at a later point in time (Harris, 1995; Burke, 2017).

At the outset of the sixteenth century, Greeks were scattered all over Europe and could be found in many cities. While large numbers of them settled in Italy, others traveled as far as the British Isles or Ukraine. Probably by far the largest community of Greeks formed in Venice, where at the end of the fifteenth century around 4,000 to 5,000 Greeks lived (Fedalto, 1967; Geanakoplos, 1976). Using various sources I can identify 45 European cities where Greeks were present at some point in the second half of the fifteenth century among the sample of cities for which I have population data in

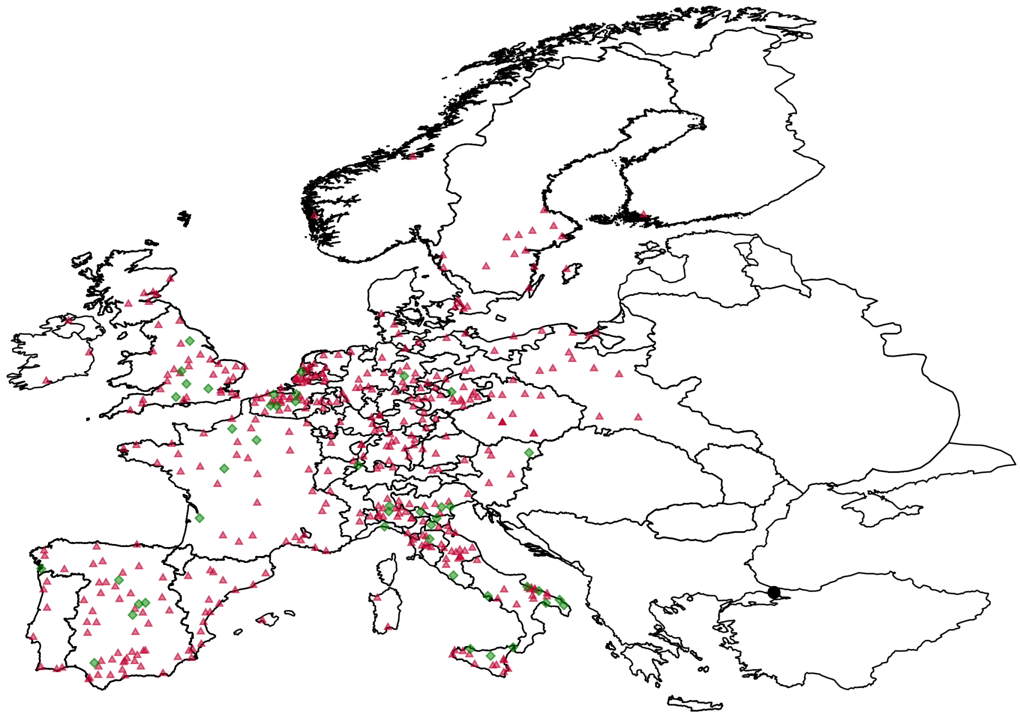

Figure 2 European Cities with a Greek Presence in the Second Half of the Fifteenth Century

Notes: Green squares denote destination places for Greek migration. Red triangles denote cities without a (known) Greek presence. The figure includes all European cities for which there are population figures in 1500 and 1600 in the Bairoch et al. (1988) dataset. The black circle denotes Constantinople.

1500 and 1600.[3,4] Figure 2 shows a geographical overview of these cities among the universe of all European cities with population information in 1500 and 1600. While in Italy there are a particularly large number of cities with a Greek presence, Greek migrants can be found in most European regions.

2.2 Potential Mechanisms of Knowledge Diffusion

This period of Greek migration was one of the first migratory waves in Europe that was predominantly characterized by learned individuals and craftsmen, rather than entire communities (e.g. emigration of nations in the sixth century) or warriors and poor farmers (e.g. the Vikings in Great Britain in the tenth century). Greek migrants in Europe often worked as merchants, artisans, physicians, sailors, or translators, while others were mathematicians or astronomers (Geanakoplos, 1976; Harris, 1995; Fattori, 2019).

Yet their most relevant contribution was not as craftsmen and merchants. Rather, the Greek migrants initiated a process by which ancient Greek literature become much more readily available. While the ancient Greeks had produced large numbers of scientific, medical, and philosophical texts, the availability of such texts declined sharply in Western Europe in late antiquity (see e.g. Blum, 1991;

[3]Table A6 gives a full list of these cities.
[4]The data on population information of cities comes from Bairoch et al. (1988).

Nixey, 2017; Berkowitz, 2021).

Two developments were were primarily responsible for this loss of ancient Greek literature. First, in late antiquity the Western Roman Empire declined and Christianity spread throughout Europe. As their political and societal power increased, the Christians began destroying books and manuscripts they considered pagan, and Greek literature was typically deemed as such (Rohmann, 2016; Nixey, 2017).[5]

Second, ancient manuscripts were usually written on papyrus. By the fifth century parchment began to be used instead. Parchment has several advantages compared to papyrus. Among other benefits, it lasts much longer. By contrast, manuscripts written on papyrus had to be periodically copied, as they would disintegrate over time. As the monks who typically copied the old manuscripts during this epoch were usually not interested in 'unchristian' Greek literature, many works were probably lost to rot in monastery libraries (Blum, 1991; Poehlmann, 1994; Nixey, 2017).

Geanakoplos (1976, p. 55) writes: "After all, Greek language and literature had virtually disappeared from the German-dominated West of the so-called Dark Ages." Nevertheless, copies of some ancient Greek manuscripts had already reached Western Europe in the centuries before the fall of Constantinople. These copies, among others, included texts by Galen, Hippocrates, and Aristotle (Harris, 1995; Perry et al., 2009). However, these texts were often of poor quality, as they had frequently been translated several times prior to arrival, often by non-native speakers. (Boas, 1962; Olmos, 2012). In addition to translations from Greek to Arabic and from Arabic to Latin many works were first translated from Greek to Syriac and then from Syriac to Arabic (Mavroudi, 2015).

Also, many texts from ancient Greek authors were not available and known at all in Europe during this time period. Many manuscripts only appeared in Western Europe in the decades after the fall of Constantinople. Hall (1983, p. 26) writes: "There were, of course, two great textual transfusions into Latinate Europe: one in the twelfth and thirteenth centuries (this brought medieval science into being), the second, considerably more sophisticated in its scholarship, in the fifteenth and sixteenth centuries. We can reasonably argue that a great deal of science was learnt from this second classical revival, which gave Europe almost all Galen, the 'pure' Ptolemy, Archimedes and other Greek mathematicians, the pre-Socratis and above all Plato."

While some Greeks migrating to the West directly after the fall of Constantinople certainly brought Greek literature with them, this does not mean there was a sudden and noticeable increase in the stock of Greek manuscripts in Europe. Indeed, the increased availability of Greek literature

[5] Greek texts were widely classified as 'heretical' for several hundred years longer. For example, when the Crusaders sacked Constantinople in 1204, they burnt large amounts of Greek texts (Murray, 2009).

in the West was a gradual process that took place over several decades and which did not peak until perhaps the 1490s. Jackson (2012) for example shows that Greek medical works were hardly available in Europe until around 1490. This low availability of Greek medical texts only changed when Greeks went back to the East, specifically to gather further texts.

The potential supply of Greek texts was large in the second half of the fifteenth century. The Ottomans were mostly not interested in Greek manuscripts, predominantly viewing them instead as a potential source of income. In the second half of the fifteenth century, they sold "wagon loads of Greek books" that were subsequently transported to Europe (Padover, 1939, p. 329). Moreover, impoverished Greek families willingly sold their libraries (Padover, 1939). For example, the Greek migrant Janus Lascaris made several trips to the East around 1490, commissioned by Lorenzo de Medici, to buy (or copy) Greek medical texts and bring them to Florence. These trips introduced many texts that were new to Europe, such as unknown writings by Hippocrates and Galen, as well as texts by scholars that had not been available in Europe at all before, such as Actuarius, Stephanus, Philaretus, Paul of Aegina, Alexander Trallianus, Rhazes, and Oribasius (Jackson, 2012). On his second trip to the East, from 1492 to 1494, Lascaris gathered at least 80 manuscripts previously unknown in Europe (Kovtun, 1977).

By far the largest collection of Greek manuscripts in the second half of the fifteenth century in Europe was contained in the library of Cardinal Bessarion, a Greek refugee born in Constantinople. After the fall of Constantinople, he felt obliged to rescue as much knowledge as possible.[6] He had other Greeks in his employ who bought numerous manuscripts in the East, from Athens and Crete to Trebizond (Geanakoplos, 1976; Kovtun, 1977). In 1468, his library included 482 Greek texts (Omont, 1894). Giacomelli (2021) argues that this library, including in particular its collection of manuscripts by Galen, played an important role in the ascent of Venice and Padua as centers of medical learning. Bessarion's library also included a Greek text of Ptolemy's *Almagest*, the major astronomical text of antiquity (Shank, 2020). The *Almagest* had previously reached Western Europe in the middle ages and was translated three times into Latin. However, it was practically inaccessible until the fifteenth century (Hall, 1983). This only changed in the 1450s, when George of Trebizond made a new translation based on the Greek manuscript in Bessarion's library (Shank, 2020).

The USTC data also suggests that the majority of works from ancient Greek authors first spread

[6] In a letter to the Venetian Dodge, Bessarion wrote in 1469 (Labowsky, 1979, p. 147): "Although I always committed to copy out and collect manuscripts wholeheartedly, with even more commitment after the fall of Greece and the miserable conquest of Constantinople, I spent all my energy, all my activity, all my capacity and ability in my quest for Greek manuscripts. I was absolutely terrified that in a very short time so many important books—that is to say, the efforts and the sleepless nights of so many excellent men, so many adornments of the world would have been at risk and lost."

in Europe after the migration of larger numbers of Greeks to Western Europe during the second half of the fifteenth century. Up to 1500, 896 titles by ancient Greek authors had been printed in European cities, while more than 60% of these titles originated from only three authors (Aristotle, Justinian I, and Aesop).[7] In total, titles from around 50 ancient Greek and Byzantine authors were printed up to 1500 (all of these titles were translations into the European vernacular languages or into Latin). The first titles in the Greek language were printed in 1501 in Brescia and Venice. From this point on, the share of total printed output authored by ancient Greek or Byzantine authors went up significantly (from around 2.5% in 1501 to nearly 10% in the 1540s), suggesting that new Greek translations played an important role in this increase in printed works from ancient Greek and Byzantine authors. In total, between 1500 and 1600 more than 10,000 titles by ancient Greek and Byzantine authors were printed in Europe, and these titles can be assigned to 198 individual authors.[8]

Drawing on data on all known printed book editions in Europe in the sixteenth century from the Universal Short Title Catalogue (USTC), Figure 3 descriptively explores the share of titles written in the Greek language (left panel) and by ancient Greek or Byzantine authors[9] (right panel) in the sixteenth century for European cities to which Greeks had migrated in the second half of the fifteenth century and for cities without a (known) Greek presence. The left panel of Figure 3 shows that, especially in the first half of the sixteenth century, the share of titles printed in the Greek language in cities to which Greeks had migrated was significantly higher compared to cities without a (known) Greek presence. While this pattern does not necessarily imply a knowledge diffusion to the local population, it clearly suggests an abundance of Greek literature in cities with a Greek presence. Many of these texts appeared in new print runs shortly thereafter, in the form of Latin or vernacular translations, as can be observed in the USTC data.

The right panel of Figure 3 focuses on literature written by ancient Greek or Byzantine authors printed in European cities in the sixteenth century, but excludes printed works in the Greek language, and only includes works in the European vernacular languages as well as in Latin. Thus, this variable should to some extent capture the diffusion of knowledge from the Greek migrants to the local population. Indeed, the share of such books is considerably larger in cities with a Greek presence, especially in the first half of the sixteenth century. In general, texts written by Greeks accounted for a large share of printing output in Europe, again especially in the first half of the sixteenth century. In 1542, at least 234 of 2749 printed titles in Europe – 8.5% of all titles – were works written by ancient Greek

[7] Note that this figure includes reprints, so the number of individual titles is much smaller.

[8] Appendix Tables A2 and A3 give a list of these authors and the numbers of works printed from these authors.

[9] I was able to identify 198 ancient Greek or Byzantine authors in the USTC database, whose works were printed in Europe in the sixteenth century.

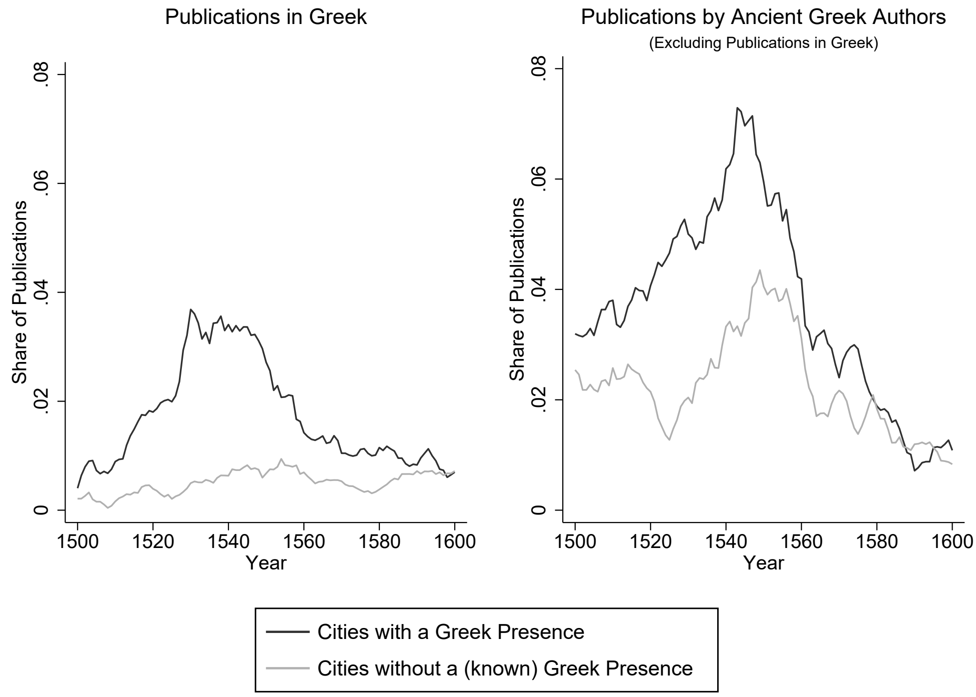

Figure 3 Share of Greek Printing Output in European Cities

Notes: Share of Greek printing output in European cities (5-year moving average). The left panel shows the share of publications in Greek. The right panel shows the share of publications in the vernacular languages and in Latin that are written by ancient Greek and Byzantine authors. Data comes from USTC (2020).

or Byzantine authors (note that this is a lower-bound estimate, as for 27% of the works the author is unknown).[10] Overall, the trend captured by Figure 3 provides initial indication that knowledge was diffusing from Greek migrants to the local population in Western Europe, and that ancient Greek and Byzantine knowledge was playing an increasingly important role in early modern Europe.

This statistical finding is bolstered by anecdotal evidence suggesting that Greek migrants and the literature they brought with them significantly contributed to European development in a range of fields (e.g. Harris, 1995). I focus on three fields in which knowledge transmission was likely and that at the same time could have been relevant for economic development in the early modern period. These fields are astronomy, mathematics, and medicine. Figure 4 shows that, especially in the first half of the sixteenth century, a significant share of printed works in each of these fields was literature written by ancient Greek and Byzantine scholars. In some peak years, 20% to 25% published titles in these categories were texts written by these scholars. In the following, I discuss the potential diffusion of knowledge in each of these fields in more detail.

Astronomy and Mathematics. Many texts in astronomy and mathematics written by ancient Greek scholars were unknown in Western Europe during the middle ages. Anecdotal evidence suggests

[10] Appendix Tables A4 and A5 show printing output from ancient Greek any Byzantine authors by place.

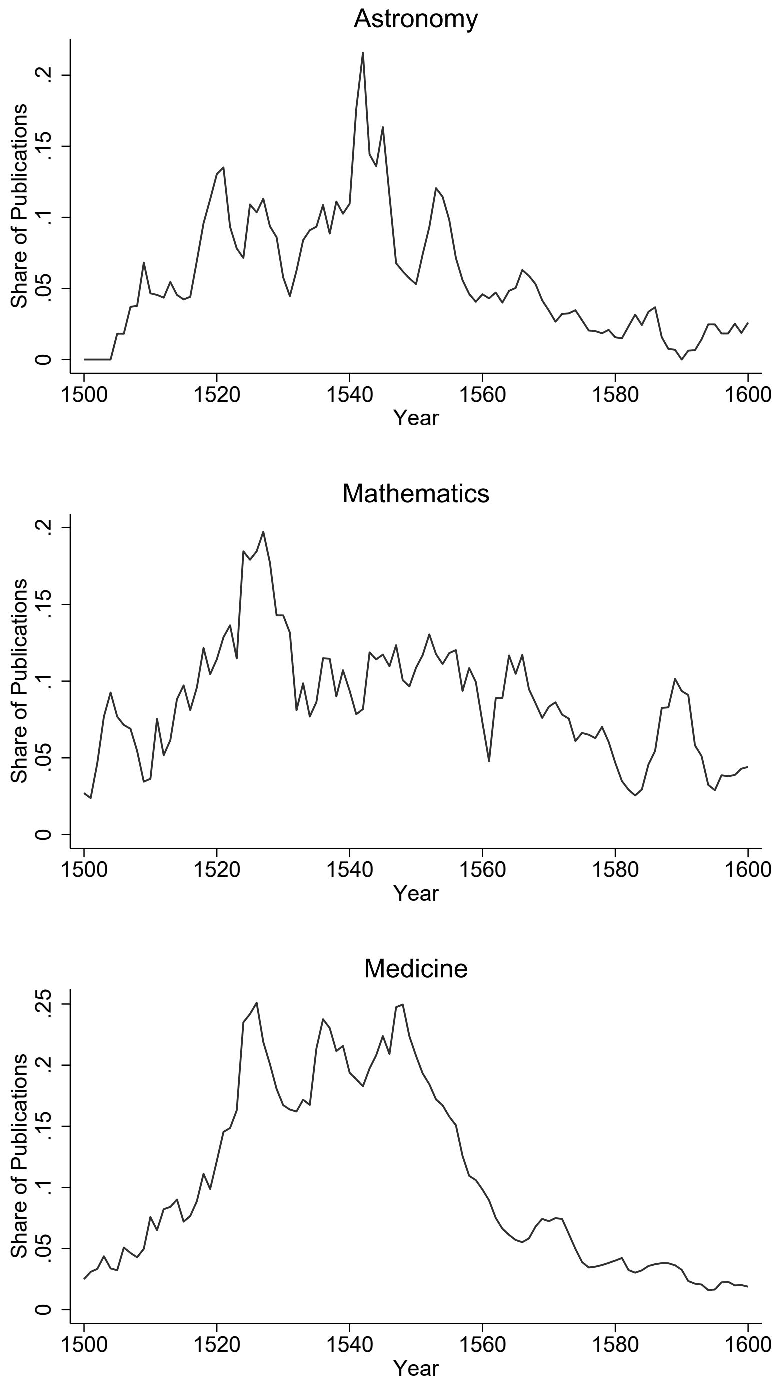

Figure 4 Share of Ancient Greek Printing Output in Astronomy, Mathematics, and Medicine in Europe 1500-1600

Notes: Share of Printing Output in astronomy, mathematics, and medicine that was written by ancient Greek and Byzantine authors in European cities (5-year moving average). Data comes from USTC (2020).

that the greater availability of such texts following the fall of Constantinople led to scientific progress in astronomy and mathematics in many instances.

Euclid's famous mathematical work *Elements*, one of the most printed books in history, was partly known in Europe from the twelfth century on due to an Arabic translation (e.g. Wüstenfeld, 1877). However, the version circulating in Western Europe was not only fragmented, but also included a range of incorrect definitions due to translation errors (Olmos, 2012). Its first complete (and correct) version was published in Venice in 1505, translated from a newly available Greek text from Greek to Latin by Bartolomeo Zamberti (De Risi, 2016). The artist and mathematician Albrecht Dürer was in Venice around the time of the book's first publication. As Dürer was especially interested in the correct presentation of proportions and perspectives, he purchased a copy of the book. In the following decades, he published several treatises on mathematics, applying and advancing Euclid's ideas (Alexander-Skipnes, 2017; Yoon, 2017).

Another example of ancient Greek science that contributed to the development of early modern Europe is the work of Archimedes (ca. 287–212 BC). Some works by Archimedes became available in Western Europe with a Latin translation by the Flemish monk William of Moerbeke in 1269 (Clagett, 1970; Cavagnero, 2018). Yet, similar to early texts of Euclid, this translation included a range of serious errors (Clagett, 1970) and was rarely available prior to the sixteenth century (Cavagnero, 2018). In 1544 Johannes Herwagen published a range of Archimedes' texts in their original Greek form for the first time, accompanied by a Latin translation from James of Cremona (Clagett, 1970). After 1544, the use of Archimedes' work became widespread. As Clagett (1970, p. 229) writes: "Archimedes' influence on mechanics and mathematics can be seen in the works of such authors as Commandino, Guido Ubaldi del Monte, Benedetti, Simon Stevin, Luca Valerio, Kepler, Galileo, Cavalieri, Torricelli, and numerous others." Netz (2022) attributes a great deal of influence to Archimedes' work *On Floating Bodies* in particular. A faulty version of it had been available in Europe since Moerbeke's translation, but only in 1565 Federico Commandino completed a new and corrected translation (Clagett, 1970). Netz (2022) even goes so far as to argue that Commandino's translation of Archimedes' work contributed to initiating a process that led to the invention of the steam engine in 1776.

Johannes Philophonus (ca. 490–575 AD) was a scholar living in the Byzantine Empire in late antiquity. He is known for works in various fields, yet only one of his texts was available in Latin in medieval Europe (Grabmann, 1929). His texts only became widely available there during the first half of the sixteenth century, as can be observed in the USTC data (USTC, 2020). His work considerably influenced several early modern scholars, such as the mathematician Johannes Kepler, the polymath Galileo Galilei, and the philosopher Gianfrancesco Pico della Mirandola (Kalachanis et al., 2013; Wildberg, 2021).

The mathematician and astronomer Nicolaus Copernicus also was potentially influenced by Greek knowledge. Copernicus proposed a mathematical model of the heliocentric system in his influential work *De revolutionibus orbium coelestium* (On the Revolutions of the Celestial Spheres), published in 1543. While Copernicus was the first to construct a sophisticated model of the system, his work was probably inspired by the ideas of Aristarchus, developed around 1,800 years earlier (Thomason, 1992; Kossovksy, 2020).

In general, the speed of astronomical and mathematical developments in Europe increased significantly from the early sixteenth century onward. The desire of artists to represent the natural world realistically as well as the growth of commerce created the need for better calculation methods and navigation techniques, substantially augmenting interest in astronomy and mathematics (Kline, 1953; Dittmar, 2019). The greater availability of ancient Greek texts is likely to have contributed to this process. Netz (2022, p. 511) writes: "There was a scientific renaissance, in the strict sense, throughout the sixteenth century, as the ancient works became available again. This gave rise, throughout the seventeenth century, to what is known as the scientific revolution, which, in the eighteenth century, made the industrial revolution possible." Overall, the anecdotal evidence in this section suggests that ancient Greek knowledge was useful in many instances and contributed to European development in astronomy as well as in mathematics.

Medicine. In contrast to Western Europe, the Byzantine Empire was very advanced in medicine in the middle ages. Already in the ninth century there were some 130 modern hospitals with well-trained physicians throughout the empire (Horden, 2005). These hospitals had separate facilities for women and men, extra rooms for surgeries, libraries and even bathhouses. The staff was mostly specialized in certain tasks, e.g. physicians who only focused on special surgeries (Geanakoplos, 1976; Harris, 1995). While in Western Europe hospitals tended to serve as a place of refuge for all kinds of suffering people and were less of a place for treatment, Byzantine hospitals completely focused on *curing* the sick. Moreover, even the poor and homeless were able to obtain medical treatments that were very sophisticated for the time. Thanks to the availability of medical services to wide parts of the population, physicians in the Byzantine Empire performed surgeries and other treatments much more frequently than their counterparts in Western Europe. Consequently, they had a much richer pool of experience in many areas of medicine (Harris, 1995).

While many treatment methods conducted in the Byzantine Empire dated back to ancient Greek techniques, the Byzantine Greeks made further progress themselves. For example, Nicephorus Skeuophylax described the bloodless method of removing kidney stones in the ninth century (Miller, 1997). Another Byzantine Greek advancement was the treatment of brachial aneurysm by ligation of a specific brachial artery, developed by Aetius of Amida in the sixth century (Prioreschi, 1996). On the pharmacological frontier, Alexander of Tralles made a range of new developments. One of his developments was the Armenian Stone, a treatment for fever that consisted of a combination of copper oxyacetate, azurite and malachite (Scarborough, 1984). A text by Nicholas Myrepsos, living in the thirteenth century, remained the main pharmaceutical code at the medical faculty in Paris until the second half of the seventeenth century (Geanakoplos, 1976). Byzantine physicians also specialized in treating eye disorders. People traveled great distances to receive eye surgeries in Constantinople (Harris, 1995). Overall, medicine was of such significance in the Byzantine Empire that every sophisticated citizen was expected have at least some basic medical knowledge (Harris, 1995).

Yet there is some evidence that medical knowledge in Western Europe was rising in the late middle ages, thus narrowing the gap to the Byzantine Empire. For example, in twelfth century Monte Casino the 'Articella' was assembled, a canon of medical scriptures that included works by Galen and Hippocrates, among others (Harris, 1995; Glick, Livesey, and Wallis, 2005). However, not at least because these texts did not become more widely available prior to the fifteenth century, we can presume the persistence of differences in medical knowledge between the Byzantine Empire and most parts of Western Europe. Accordingly, it is reasonable to assume that Greek migrants influenced medicine in Western Europe, by increasing knowledge and improving treatment methods. In some cases, there is evidence that Byzantine physicians occupied important medical positions in Western Europe during this time period (such as Serapion, who was the physician to the Scottish King in the 1460s; Andreas Spata of Constantinople, who became medical adviser in Ragusa in 1458; and Demetrius de Cerno, who attended to the French King Charles VII). However, manuscripts were presumably the most important vehicle for the transmission of Greek medical knowledge from Byzantium to Western Europe (Harris, 1995).

Ancient Greek scholars such as Galen, Hippocrates, and Dioscorides wrote numerous treatises in many medical fields. While these works set the foundation for medical treatment in the Byzantine Empire, in Western Europe the vast majority of these texts were unknown throughout the middle ages. Thanks to translations of Greek medical texts into Latin that were contracted by the Norman and Angevin rulers of Southern Italy and Sicily throughout the twelfth and thirteenth centuries, this situation had already changed somewhat at the outset of the fifteenth century (Harris, 1995). Yet many works only first appeared or reached comprehensive availability in Western Europe with the arrival of the Greek migrants. For example, from the more than 100 texts written by Galen that were included in five volumes on Galen's work printed in the 1520s in Venice, around half had only been available previously in Greek (Fortuna, 2019). Not only new texts by Galen, but also new texts by Hippocrates, as well as texts by scholars that had not been available in Europe at all before, such as Actuarius, Stephanus, Philaretus, Paul of Aegina, Alexander Trallianus, Rhazes, and Oribasius now appeared in Western Europe (Jackson, 2012). Fortuna (2019, p. 444) writes: "Hitherto unknown theories and ideas of Galen on anatomy, physiology, and philosophy, as well as new pharmacological and surgical therapies including orthopaedic practices and venesection, became available through these texts." The availability of these theories and ideas then led to further progress. For example, the new anatomy of the sixteenth century originated in the recovery of these texts (Hall, 1983).

In general, as can be observed in the USTC data, the first printed works of Greek medical scholars mostly emerged in cities with a recorded Greek presence (e.g. Hippocrates, 1484 in Rome; Galen, 1490 in Venice; Dioscorides, 1499 in Venice). This is also the case for works by famous physicians of the Byzantine Era (e.g. Oribaseios, 1533 in Venice; Theophilus Protospatharius, 1536 in Venice; Aetius Amidenus, 1533 in Basel) (USTC, 2020).

Finally, the large number of medical Graecisms in the European vernacular languages also indicates a considerable Greek influence on medical practice in Europe (Harris, 1995). In this way, we find numerous lines of evidence indicating that Greek migrants played an important role in advancing Western European medical knowledge in the sixteenth century.

3 Greek Presence and City Growth

The mechanisms discussed in section 2.2 suggest that the knowledge transmitted by Greek migrants affected European development in several fields. This knowledge appears to have advanced scientific frontiers in astronomy and mathematics while also contributing to medical progress. Section 3 turns to empirically exploring the potential relationship between Greek migration and development in a sample of European cities.

The city level is best suited for this analysis for two reasons. First, in the early modern period European nation states either did not yet exist or had a lower level of significance for society and the economy. Accordingly, institutions at the city level were crucial for economic development. Previous works examining growth factors within this period also usually focus on the city level (see e.g. Acemoglu et al., 2005; Dittmar, 2011; Cantoni, 2015; Johnson and Koyama, 2017; Dittmar and Seabold, 2018; Dittmar and Meisenzahl, 2020). Second, I can exploit variation in Greek presence between European cities. In the sixteenth century communication technologies such as the telegraph or telephone had not yet been invented. Thus, knowledge sharing either relied on face-to-face communication or the circulation of printed material. Consequently, spillover effects between cities could only occur with some delay and were likely to be weaker compared to more modern times, such that the growth-enhancing effects of Greek migration should be directly observable at the city level.

3.1 Data

The main independent variable in this study is a dummy that measures a Greek presence in European cities in the second half of the fifteenth century. This variable is constructed by searching the literature on the Greeks migrating to Western Europe following the fall of Constantinople. Table A1 shows a list of the identified cities with a Greek presence in the second half of the fifteenth century, including the source. As Harris (1995) is the most comprehensive work on the destination cities for Greek migrants it is used as standard reference when several sources are available. For most places, the recorded numbers of Greek migrants are not precise. Often only the presence of few influential Greeks is recorded in historical documents. Thus, I cannot construct a measure reflecting the relative sizes of Greek communities in European cities. Therefore, I follow Johnson and Koyama (2017), who examine the relationship between a Jewish presence and European city growth in the middle ages and the early modern period and are confronted with similar issues. More precisely, I create a dummy variable at the city-level that takes the value of 1 if any Greek presence from that city in the second half of the fifteenth century has been recorded historically and 0 otherwise. This procedure results in a list of 45 cities with a recorded Greek presence in the second half of the fifteenth century.

For the analysis I combine this newly constructed measure on a Greek presence in European cities in the second half of the fifteenth century with city population data from Bairoch, Batou, and Chévre (1988), which includes data for 2,202 European cities at various points in time. Restricting the analysis to cities with available population data in 1500 and 1600 and excluding cities from countries without known Greek migration (Scandinavia, Poland and Portugal) results in a sample of 400 cities. I then additionally exclude Venice from the analysis. Venice had maintained trading relationships with the Byzantine Empire for centuries and was by far the most important destination for Greek immigrants.[11] My final sample includes a total of 399 cities. Forty-four of these places are classified as destination cities for Greek migration. I then add further variables from various sources to control for important city characteristics, mostly from Rubin (2014) and Binzel et al. (2023a). Data for

[11]The results are quantitatively indistinguishable if Venice is included.

country-fixed effects and for clustering standard errors at the territory level comes from Nüssli (2008). Descriptive statistics of the variables included in the regressions are summarized in Table A7.

3.2 City Growth in the Sixteenth Century

I then start the analysis by estimating the following model

$$y_i = \alpha + \beta \text{GreekPresence}_i + \delta_i + \theta_i + \varepsilon_i, \qquad (1)$$

where y_i is log city growth 1500-1600 in city i and GreekPresence_i denotes a Greek presence in the second half of the fifteenth century in city i. δ_i is a vector of control variables. θ_i stands for country (as of 1500) fixed effects.

Table 1 presents the results of this exercise. Column (1) shows the relationship between a Greek presence and city growth only conditional on log population in 1500 and geographic controls. These controls include longitude, latitude, an interaction term between longitude and latitude and the log distance to Venice. The log distance to Venice is added to control for a potential influence of Venice, which was an important destination for Greek migration as well as one of Europe's most important cities at the time. The coefficient of the dummy variable measuring a Greek presence is statistically significant at the 1% level and implies the recipient cities of Greek migration enjoyed a considerable growth advantage of around 0.36 log points compared to cities without Greek migration.[12] In column (2) country fixed effects are added. Column (3) additionally includes other city characteristics that might be correlated to city growth and Greek migration. These characteristics include printing output in the vernaculars as well as in Latin, a dummy variable for the presence of a bishop in 1517, and a dummy variable for the presence of a university in 1450. Adding these controls to the model reduces the coefficient of the variable measuring a Greek presence by roughly 17 percent, while it remains positive and significantly related to city growth. In column (4) further geographic controls are added to the model. These controls include the log distance to a coast as well as the log distance to a trade route to account for the possibility that Greeks disproportionately migrated to thriving trading cities. Moreover, column (4) controls for the log distance to Wittenberg to account for the spread of Protestantism. Adding these geographic controls hardly changes the underlying relationship. Overall, the results suggest that cities to which Greeks migrated grew some 0.35 to 0.42 log points or 41.2%

[12] When the geographic controls are not included, the coefficient of the dummy on a Greek presence is equal to 0.360 and significant at the 1% level.

Table 1 Greek Presence and City Growth: OLS Results

	Log City Growth 1500-1600			
	(1)	(2)	(3)	(4)
Greek Presence	0.357***	0.418***	0.347***	0.345***
	(0.130)	(0.127)	(0.086)	(0.089)
Log Population in 1500	-0.224***	-0.246***	-0.372***	-0.376***
	(0.046)	(0.049)	(0.058)	(0.056)
Latitude	-0.003	-0.016	-0.031**	-0.024*
	(0.003)	(0.010)	(0.015)	(0.013)
Longitude	0.004	-0.003	-0.029	-0.045
	(0.035)	(0.058)	(0.072)	(0.081)
Lat X Lon	0.000	0.000	0.001	0.001
	(0.001)	(0.001)	(0.002)	(0.002)
Log Distance to Venice	0.052	0.007	0.094**	0.064
	(0.043)	(0.044)	(0.046)	(0.064)
University in 1450			-0.077	-0.076
			(0.096)	(0.092)
Bishop in 1450			0.031	0.022
			(0.041)	(0.042)
Log Nr of Vernacular Books			0.096***	0.100***
			(0.031)	(0.030)
Log Nr of Latin Books			-0.021	-0.022
			(0.031)	(0.030)
Log Distance to Coast				-0.029
				(0.031)
Log Distance to Trade Route				0.002
				(0.014)
Log Distance to Wittenberg				0.118
				(0.076)
Observations	399	399	399	399
R^2	0.159	0.218	0.299	0.313
Country FE	No	Yes	Yes	Yes

Notes: OLS regression results with standard errors clustered at the territory level in parentheses. The dependent variable is log population growth at the city level over the period 1500 to 1600. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

to 51.9% faster during the sixteenth century, compared to cities with no known Greek presence.

3.3 City Growth, 1300–1800

Next, I examine the relationship between a Greek presence and city growth drawing on a flexible difference-in-differences model. This allows me to better determine the timing as well as the persistence of potential growth advantages resulting from a Greek presence. Therefore, I restrict the analysis to cities with population information in all centuries between 1300-1800, which leaves me with a sample of 170 cities. I then run the following model

$$Y_{i,t} = \alpha + \sum_{t=1300}^{1700} \beta_t \text{GreekPresence}_i * \phi_t + \phi_t + x_i' * \phi_t + \delta_i + \epsilon_{i,t}, \tag{2}$$

where $Y_{i,t}$ is log growth in city i and time period t. GreekPresence$_i$ denotes a Greek presence in city i. ϕ_t are dummy variables for each century from 1300-1400 to 1700-1800 – with the omitted century being 1400-1500. x_i' is a vector of control variables. δ_i are a set of city fixed effects.

Table 2 Greek Presence and City Growth: Difference-in-Differences Results

	Log City Growth 1300-1800			
	(1)	(2)	(3)	(4)
Greek Presence X 1300	0.155	0.073	0.114	0.134
	(0.145)	(0.175)	(0.142)	(0.140)
Greek Presence X 1500	0.466^{***}	0.378^{***}	0.458^{***}	0.432^{***}
	(0.123)	(0.092)	(0.152)	(0.150)
Greek Presence X 1600	0.326^{*}	0.158	0.061	0.200^{*}
	(0.169)	(0.176)	(0.132)	(0.108)
Greek Presence X 1700	0.225^{*}	0.126	0.037	0.131
	(0.127)	(0.146)	(0.111)	(0.109)
Observations	850	850	850	1548
R^2	0.364	0.429	0.531	0.581
City FE	Yes	Yes	Yes	Yes
Population X Time	Yes	Yes	Yes	Yes
Historic Controls	No	Yes	Yes	Yes
Geographic Controls	No	No	Yes	Yes
Country X Time FE	No	No	Yes	Yes
Balanced Panel	Yes	Yes	Yes	No

Notes: OLS regression results with standard errors clustered at the territory level in parentheses. The dependent variable is log population growth at the city level for the centuries between 1300 and 1800. In all columns an interaction term between log population and time is included. Historic controls include an interaction term between early access to the printing press (as of 1500) and time, the presence of an university in 1450 and time, an interaction term between a dummy for a city turning protestant until 1600 and time, an interaction term between the damage a city took in the Thirty Years War and time, and an interaction term between the presence of an port and time. Geographic controls include an interaction term between longitude and time, an interaction term between latitude and time, an interaction term between longitude*latitude and time, and an interaction between log distance to Venice and time. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 2 presents the results. Column (1) only controls for an interaction term between log population and century dummies. Columns (2) and (3) allow for historical and geographical characteristics to have time-varying effects. Column (2) adds interactions between the century dummies and various historical controls, namely a measure of early access to the printing press, a dummy for the presence of a university in 1450, a dummy for a city turning Protestant until 1600, a variable denoting the damage a city took in the Thirty Years War, and a dummy for the presence of a port. Column (3) adds interactions between the century dummies and various geographical controls (longitude, latitude, the log distance to Venice), an interaction between the century dummies and country fixed effects, as well as a triple interaction between the century dummies and longitude and latitude. Column (4) additionally includes cities for which there is population information missing in one of the centuries.

The coefficient on the interaction term between a Greek presence and 1300 is statistically insignificant and close to zero in all columns, implying that cities to which Greeks migrated during the fifteenth century did not grow faster during the fourteenth century, compared with other cities, relative to the omitted time period. In contrast, the interaction term between a Greek presence and 1500 is positive and significant at the 1% or 5% levels in all columns, suggesting that destination places for Greek migration experienced relatively higher growth in the sixteenth century. Throughout all columns, the growth advantage enjoyed by cities that received Greek migration declines in later centuries. As knowledge is expected to diffuse over the long run, the disappearance of the growth advantage over the long run is expectable. In column (1), the coefficient on the interaction term between Greek presence and time is still significant for the interaction term between a Greek presence and 1700. This pattern might be explained by the rare presence of Greeks in cities that were later damaged most during the Thirty Years War, and thus were likely to have a below-average growth performance during this time period. Overall, the results of this exercise are in line with the previous findings.

3.4 Instrumental Variable Results

The previous results showed a positive and significant relationship between a Greek presence in the second half of the fifteenth century and city growth in the sixteenth century, a relationship that is not affected by controlling for many important city characteristics. Using a difference-in-differences approach yields similar findings, and there is no statistically significant relationship between a Greek presence in the second half of the fifteenth century and city growth in earlier or later time periods. However, we cannot yet completely rule out the possibility that the identified relationship is driven by unobservable city characteristics that are both related to the probability that Greeks migrated to a city as well as that city's growth. For example, Greek migrants potentially might have been especially attracted by innovative places, and higher levels of innovation could have directly translated into higher growth rates. Moreover, the migrants may have recognized which cities had the strongest growth potential, thus preferentially relocating to these cities.

To address concerns that the association between a Greek presence and city growth in the sixteenth century is driven by such factors, I next examine this relationship by drawing on an instrumental variable strategy. In particular, I exploit the pattern that "the farther away from Constantinople and the East the émigrés traveled, the less numerous and more isolated their groups or settlements tended to become" (Geanakoplos, 1976, p. 193). While Greeks could be found all over Europe at the outset of the sixteenth century, the probability of a Greek presence in a city was larger for places that were geographically closer to Constantinople. I therefore use the log distance to Constantinople as an exogenous source of variation in Greek presence in European cities in the second half of the fifteenth century.

The exclusion restriction requires that the distance to Constantinople is not related to any important European city characteristics that are related to economic development and that predate the fall of Constantinople, and should only be related to city growth in the period where it increases the probability of a Greek presence in a European city. Therefore, in Table 3, I relate the log distance to Constantinople to city growth from the fifteenth to the seventeenth century as well as to a range of human capital related city characteristics that predate the fall of Constantinople. Columns (1) and (2) show the relationship between a city's log distance to Constantinople and growth in the sixteenth century. Country fixed effects are introduced into the model in column (2). The coefficient in column (1) suggests that log distance to Constantinople indeed is negative and significantly related to growth in the sixteenth century. Introducing country-fixed effects into the model in column (2) has hardly any impact on this relationship.

In contrast, there is no such relationship between a Greek presence and city growth from 1400-1500 or 1600-1700; see columns (3) and (4).[13] In columns (5) to (7), I examine the relationships between distance to Constantinople and city characteristics that could be related to human capital accumulation. A city's distance to Constantinople is neither correlated to the presence of a university in 1450 (column 5), nor is it correlated to the log number of births of famous individuals between 1350 and 1450, which is a proxy variable for upper-tail human capital, (column 6) or a dummy denoting if in a city a major invention occurred between 1350 and 1450 (column 7). Together, these results suggest that while the log distance to Constantinople is negative and significantly related to city growth in the sixteenth century, no such relationship exists for other time periods or other important city characteristics that predate the Greek migration to Western Europe. Thus, it seems reasonable to conclude that the log distance to Constantinople only affects city growth by increasing the probability of a Greek presence in a European city in the second half of the fifteenth century.

However, it could also be possible that the distance from Constantinople is capturing other growth-impacting events or factors in the second half of the fifteenth century that had an epicenter to the south or east of Europe. To address this concern I conduct an analysis similar to column (2) in Table 3, where I related the log distance to Constantinople to city growth 1500-1600, while I now include varying coordinates. Constantinople is located at 41.02 degrees latitude and 28.98 degrees

[13]The results for the reduced common sample that has population information from 1400-1700 (191 cities) are similar.

Table 3 Log Distance to Constantinople, City Growth, and Human Capital Outcomes

	Log Growth 1500-1600	*Log Growth 1500-1600*	*Log Growth 1400-1500*	*Log Growth 1600-1700*	*University in 1450*	*Log Births of Famous People*	*Dummy Inventions*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log Distance to Constantinople	-1.105*** (0.387)	-1.254*** (0.364)	-0.140 (1.110)	0.455 (0.593)	0.205 (0.254)	-0.003 (0.346)	0.136 (0.094)
Observations	399	399	205	365	399	399	399
R^2	0.261	0.287	0.396	0.314	0.295	0.354	0.205
Country FE	No	Yes	Yes	Yes	Yes	Yes	Yes
Basic Geo Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Main Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Further Geo Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: OLS regression results with standard errors clustered at the territory level in parentheses. Basic geo controls include longitude, latitude, longitude*latitude and log distance to Venice. Main controls include the presence of a bishop in 1517, the presence of a university in 1450, the log of 1 + the number of printed works in the vernacular and the log of 1 + the number of printed works in Latin. Further geographic controls include the log distance to Wittenberg, the log distance to the coast and the log distance to a trade route. Note that in column (3) and column (4) log population in 1500 is substituted with log population in 1400 (column 3) and log population in 1600 (column 4). The set of controls varies in column (5), as the presence of a university acts as dependent variable and thus was excluded from the controls. In column (6), the dependent variable is the log of 1 + the number of births of famous people 1350-1450. In column (7), the dependent variable is a dummy for the presence of at least one invention in 1350-1450. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

longitude. Panel A of Appendix Figure A3 shows the t-values of regressions when the longitude is kept constant at 29 but the latitude varies between degrees 21 and 61. The results show that the relationship between city growth in the sixteenth century and the log distance to these coordinates is strongest roughly at the location of Constantinople. Panel B of Appendix Figure A3 shows the t-values of regressions when the latitude is kept constant but the longitude varies between the degrees of 9 and 49. The results show that some places with a lower longitude than Constantinople have larger negative t-values. Interestingly, these are exactly the places along the westward axis Greek migrants would have traveled to reach Western Europe. Panel C of Appendix Figure A3 shows the t-values of 441 regressions where latitudes between degrees of 21 and 61 are combined with longitudes between degrees of 9 and 49. The results again show that the t-value for Constantinople (denoted by the red line) is among the largest negative t-values of the included coordinates. The 13 coordinates with larger negative t-values are again all on the axis between Constantinople and the Adriatic Sea. Overall, these results show that it is unlikely that the coefficients are reflective of other events happening in the second half of the fifteenth century to the south or east of Europe, as the relationship between city growth and the log distance to these coordinates considerably weakens the further away the coordinates lie from Constantinople.

For the instrumental variable design, I estimate the following first-stage regression

$$\text{GreekPresence}_i = \alpha + \beta \text{LogDistConstantinople}_i + \delta_i + x_i' + \varepsilon_i, \tag{3}$$

where GreekPresence_i denotes the presence of Greek migrants in city i in the second half of the fifteenth century. $\text{LogDistConstantinople}_i$ is the log distance to Constantinople for city i. δ_i is a vector of control variables. θ_i stands for country (as of 1500) fixed effects.

Table 4 reports the IV results. The structure of the table follows the structure of Table 1. Consistent with the OLS results, a Greek presence is positively and significantly related to city growth throughout all columns. The size of the coefficient changes only slightly with the inclusion of country-fixed effects (column 2), controlling for important historical variables (column 3), and including geographical city characteristics (column 4). The first stage F-Statistic ranges between 37.5 and 52.8, which by far exceeds the Stock-Yogo rule of thumb threshold of 10 and suggests that the log distance to Constantinople is a strong predictor for Greek migration into European cities.

Compared with the OLS results, the magnitude of the coefficients is larger. In column (4), the coefficient suggests that destination cities for Greek migration in the second half of the fifteenth century gained a growth advantage of around 0.87 log points compared with other places. Put differently, these cities experienced a yearly growth advantage of around 1.38 percentage points during the sixteenth century, which is a remarkable effect size. The difference in OLS and IV coefficients might partly be explained by measurement error in the Greek dummy. As discussed in Section 2, evidence on the Greek presence in Western European cities is sparse. Thus, it is likely that some cities included in the 'control' group (cities without a Greek presence) should actually be included in the 'treatment' group (cities with a Greek presence). This misclassification would then produce a downward bias in the OLS estimates. Furthermore, the instrument might partly capture spillover effects from being in the vicinity of a destination place for Greek migration.[14] Overall, these results show that Greek migration was indeed an important driver of European development in the early modern period.

Appendix Table A9 examines the robustness of the relationship between a Greek presence and city growth when excluding specific groups of cities or controlling for additional factors. All columns include country fixed effects and a full set of control variables, analogous to column (4) in Table 4. Column (1) in Table A9 excludes cities that were early adopters of the printing press, while column

[14]Indeed, when being in the vicinity of a destination place for Greek migration is controlled for, the coefficients are somewhat smaller; see Appendix Table A8.

Table 4 Greek Presence and City Growth: IV Results

	Log City Growth 1500-1600			
	(1)	(2)	(3)	(4)
Greek Presence	0.736***	0.882***	0.861***	0.866***
	(0.257)	(0.236)	(0.264)	(0.220)
Observations	399	399	399	399
First-Stage F Statistic	37.545	44.552	42.869	52.799
	Panel B: First-stage Results			
	(1)	(2)	(3)	(4)
Log Distance to Constantinople	-1.215***	-1.192***	-1.335***	-1.448***
	(0.195)	(0.173)	(0.197)	(0.192)
Observations	399	399	399	399
R^2	0.213	0.240	0.281	0.297
Country FE	No	Yes	Yes	Yes
Basic Geo Controls	Yes	Yes	Yes	Yes
Main Controls	No	No	Yes	Yes
Further Geo Controls	No	No	No	Yes

Notes: Instrumental variable regression results with standard errors clustered at the territory level in parentheses. The dependent variable in the second stage is log population growth at the city level over the period 1500 to 1600. A Greek presence is instrumented with the log distance to Constantinople. Basic geo controls include longitude, latitude, longitude*latitude and log distance to Venice. Main controls include the presence of a bishop in 1517, the presence of a university in 1450, the log of 1 + the number of printed works in the vernacular and the log of 1 + the number of printed works in Latin. Further geographic controls include the log distance to Wittenberg, the log distance to the coast and the log distance to a trade route. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

(2) excludes cities with an especially large level of upper-tail human capital, as measured by the birth of famous people in the fifteenth century. In these places knowledge from the Greek migrants might have been easier to incorporate. In both columns, the coefficient is similar to that of the full sample. Overall, the results suggest that the mechanisms at play are not limited to cities with an early printing press or especially large levels of upper-tail human capital. In column (3) I exclude cities that were founded by the Romans and thus might have been culturally closer to the Byzantine Empire, while in column (4) cities with a high market potential are excluded. Again the results are similar compared to the baseline results. To address the concern that the results are driven by migration in general, I follow Wahl (2017) and construct a proxy variable for migration based on the famous people dataset from Schich et al. (2014) and include this variable in column (5). Finally, column (6) additionally includes cities that are located in countries without a known Greek presence in the second half of the fifteenth century. Again in both columns the coefficients are similar to the baseline results.

Appendix Table A10 examines potential regional heterogeneity in the relationship between a Greek presence and city growth. Therefore, single European regions are excluded from the analysis one by one. All columns again include country fixed effects and a full set of control variables, as column (4) in Table 4. In column (1), Italian cities are excluded. Italy is geographically closer to the Byzantine

Empire than most other parts of Europe. Moreover, cities like Venice and Genoa maintained trading relationships with the Byzantine Empire for centuries. Thus, especially in the early stages after the fall of Constantinople, Italy was the most popular destination for Greek migrants. Consequently, the effects could potentially be driven to a large extent by Italian cities. However, in column (1) the coefficient on a Greek presence is even larger and remains significantly related to city growth in the sixteenth century at the 1% level. Excluding French cities in column (2) also hardly changes the results. In column (3) I exclude cities that are located in the Holy Roman Empire (HRE). Many major European events at the outset of the early modern period happened in the HRE, such as the invention of the printing press in 1451, the Protestant Reformation in 1517, and the Schmalkaldic War of 1546-47. These events itself had important implications for European development along various dimensions. Thus, the interaction of Greek migration with these events could have resulted in a differential growth effect. Yet, similar to columns (1) and (2), the coefficients on the variable measuring a Greek presence suggest that the effects are similar when excluding cities located in the HRE. The results also remain similar when excluding cities located in Spain (column 4), England (column 5), and the Low Countries (column 6).

Finally, I employ an alternative instrumental variable strategy. Migrants in the middle ages and the early modern period often were attracted by cities that had been previously depopulated by the plague (see e.g. Alfani, 2013; Hornung, 2014). There is no clear evidence of Greeks migrating preferentially to cities that experienced plague shocks. Yet given the need for labor as well as the surplus of housing in these cities, they were especially attractive for migrants, and it seems plausible to assume that Greeks, like other migrants, tended to exploit the opportunities offered by these places. Moreover, Dittmar and Meisenzahl (2020) show that plagues during the early modern period were not growth-enhancing per se, and argue that plagues in short time periods up to 25 years can be treated as exogenous. Thus, as an additional instrumental variable strategy I use plague shocks in European cities between 1438 and 1462 as an instrument for Greek presence in European cities.[15] As the results in Table A11 reveal, the first-stage is weaker compared to the main instrumental variable strategy, but the instrument is close to the Stock and Yogo threshold of 10 throughout all columns and implies a robust positive relationship between plague shocks and Greek migration. The coefficients on the Greek dummy in the second stage are similar, while somewhat larger, compared with the coefficients of the main instrumental variable strategy.[16]

[15] This period is selected to include the fall of Trebizond in 1461.

[16] These results are not sensitive to shifting the 25 year period a few years forward or backwards. Results are available upon request.

4 Mechanisms

The results in Section 3 revealed a positive and significant relationship between a Greek presence and city growth in European cities in the sixteenth century. This section turns to examining the underlying mechanisms that might explain this relationship. As discussed in Section 2, the knowledge transfer originating by the Greek migrants potentially affected several fields that could also be relevant for economic growth. Based on the historical literature, I hypothesize that Greek knowledge might have contributed to pushing scientific frontiers in astronomy and mathematics as well as to medical development. In Section 4 I first discuss the additional data sources used for the analysis. I then present the results of the relationships between a Greek presence and Greek printing output, scientific printing output, upper-tail human capital, and the numbers of inventions in cities.

4.1 Data

To investigate the effects of a Greek presence on the advancement of knowledge in astronomy, mathematics and medicine I employ the Universal Short Title Catalogue (USTC) database (USTC, 2020). This dataset includes all known published printed works in Europe between the invention of the printing press in 1451 and the year 1600. For each entry it includes information on the title, subject, author, language, and place of printing. My final dataset includes a total of 354,354 works and 37 different book categories (based on data from Binzel et al., 2023a,b).[17] It enables me to identify works of Greek authors, works in the Greek language, as well as works in astronomy, mathematics, and medicine.[18] This allows me to observe the timing and location of the first print runs of influential Greek works. It also allows me to observe potential differences between cities in printed works in the Greek language in general as well as potential differences between cities in single categories such as astronomy, mathematics, and medicine.

Based on the USTC data I create several variables that I use in the empicical analysis of Section 4. First, I create a variable measuring printing output by ancient Greek and Byzantine authors at the city level. I was able to identify 198 ancient Greek and Byzantine authors whose works were printed in European cities during the sixteenth century, resulting in roughly 11,000 titles. This variable includes titles printed in Greek, Latin, and the European vernacular languages. Second, I create

[17]Previous research has used the USTC to measure specific types of printing output. Becker and Pascali (2019) use it to identify anti-jewish literature. Dittmar and Seabold (2018) create measures of business education publications as well as religious publications by denomination. Dittmar (2019) uses the USTC to create a measure of scientific printing output. Becker et al. (2021) use the USTC to identify censored printing output. Binzel et al. (2023a) and Binzel et al. (2023b) use the language information in the USTC to distinguish between vernacular and Latin printing output.

[18]Note that the USTC category I use to measure astronomic printing output is called ‘Astrology and Cosmography’. The official title of the category measuring mathematical titles is called ‘Science and Mathematics’.

variables measuring printing output in astronomy, mathematics, and medicine. These variables do not include printed works in the Greek language in order to better capture knowledge diffusion to the local population. In the main analysis, I aggregate these variables to a measure of 'scientific' printing output. Finally, I construct variables measuring printing output in Hebrew, religious printing output, and poetry printing output for a placebo analysis.

Additionally, I employ data from Schich et al. (2014). This dataset includes the dates and locations of births and deaths of famous individuals around the world over a time span of more than 2,000 years. It contains individuals who were notable for various reasons, including historically well-known rulers, scientists, entrepreneurs, and authors. Previous work has shown that the births of famous individuals can be used as a proxy for upper-tail human capital in the early modern period (see e.g. Squicciarini and Voigtländer, 2015; Serafinelli and Tabellini, 2022; Dittmar and Meisenzahl, 2020). If a Greek presence did positively affect the diffusion of astronomical, mathematical, and medical printing output, this should also directly lead to larger levels of upper-tail human capital. Thus, examining the relationship between a Greek presence and the births of famous individuals within a city is a direct test of the impact of the hypothesized knowledge diffusion.

Moreover, I follow Dittmar (2019) and Dittmar and Meisenzahl (2022) and collect data on inventions from Darmstaedter (1908). This data allows me to explore if the disseminated knowledge could systematically be utilized for further scientific progress and inventions. In the cases where Darmstaedter (1908) does not provide information on the place, I consult other sources to identify the locations where these inventions took place. These sources include Poggendorf (1863), Gillispie (1980), and www.wikipedia.com. I exclude 163 of the 604 events noted in Darmstaedter (1908) between 1301-1600. These events are excluded either because they describe geographic discoveries, or because they are only references to inventions or improvements, e.g. in a book, or because they cannot be assigned to a place. My final sample includes a total of 441 inventions in European cities between 1301 and 1600. 361 of these inventions took place in the cities included in the analysis in Section 3.

4.2 Greek Presence, Knowledge Diffusion, Upper-tail Human Capital, and Inventions

To study the relationships between a Greek presence and printing output in astronomy, mathematics, and medicine as well as upper-tail human capital and inventions I then re-estimate equations 1 and 3. As dependent variables I now use the log(1 + printing output in 1500-1600) in astronomy, mathematics, or medicine in city i and the log(1 + number of births of famous people 1500-1600) in city i. Due to the lower numbers of inventions this data is transformed into a dummy variable measuring the presence of at least one invention in 1500-1600 in city i.[19]

Table 5 shows the IV results (Appendix Table A12 shows the OLS results). Column (1) of Table 5 relates a Greek presence to printed works from ancient Greek and Byzantine authors. The historical evidence discussed in Section 2.2 suggests a greater availability of such texts in destination places for Greek migration. Indeed, the coefficient on a Greek presence is significant at the 1% level and implies that destination places for Greek migration printed around 1.14 log points, or 213% more of such titles than other cities. Column (2) then turns to printing output in the fields of astronomy, mathematics, and medicine, which, according to the anecdotal evidence discussed in Section 2.2, might have been affected by the diffusion of knowledge from the Greek migrants. More precisely, the dependent variable in column (2) is the log of 1 + the total number of works in astronomy, mathematics, and medicine printed in a city during the sixteenth century, while excluding titles printed in Greek. To better capture knowledge diffusion to the local population this variable only includes works in the European vernacular languages as well as in Latin. The coefficient on a Greek presence is positive and significantly related to the dependent variable at the 1% level. The magnitude of the coefficient in column (2) suggests that cities where Greeks were present produced around 1.09 log points or 197% as many scientific books in the sixteenth century than other places.

Column (3) relates the variable measuring a Greek presence in European cities to the log number of births of famous individuals in the sixteenth century, which is a proxy for upper-tail human capital. This is a direct test of the proposed knowledge transmission, as larger scientific book production should also translate into larger levels of upper-tail human capital. The coefficient on the variable measuring a Greek presence in European cities indeed suggests such a relationship and implies that cities where Greeks were present experienced around 0.84 log points more births of famous individuals during the sixteenth century, compared to cities without a Greek presence.

Finally, column (4) explores a potential relationship between a Greek presence and the presence of inventions during the sixteenth century. The coefficient on a Greek presence is positive and significantly related to the dependent variable and suggests that people living in destination places for Greek migration were 0.44 log points or 55.3% more likely to make at least one invention during the sixteenth century, compared to people in other European cities.

Overall the results in Table 5 show that places where Greeks were present produced considerably more scientific knowledge during the sixteenth century than other places. The results also show that

[19]The results are very similar when the log of 1 + the numbers of in inventions 1500-1600 are used as dependent variable.

Table 5 Greek Presence, Printing Output, Upper-tail Human Capital, and Inventions: IV Results

	Panel A: Second Stage			
	Greek Output 1500-1600	*Scientific Output 1500-1600*	*Famous People 1500-1600*	*Inventions 1500-1600*
	(1)	(2)	(3)	(4)
Greek Presence	1.144^{***}	1.089^{***}	0.842^{**}	0.442^{***}
	(0.360)	(0.333)	(0.346)	(0.157)
Observations	399	399	399	399
First stage F-statistic	52.799	52.799	47.042	49.950
	Panel B: First-stage Results			
	(1)	(2)	(3)	(4)
Log Distance to Constantinople	-1.448^{***}	-1.448^{***}	-1.448^{***}	-1.458^{***}
	(0.199)	(0.199)	(0.211)	(0.206)
Observations	399	399	399	399
R-squared	0.297	0.297	0.331	0.299
Country FE	Yes	Yes	Yes	Yes
Basic Geo Controls	Yes	Yes	Yes	Yes
Main Controls	Yes	Yes	Yes	Yes
Further Geo Controls	Yes	Yes	Yes	Yes

Notes: Instrumental variable regression results with standard errors clustered at the territory level in parentheses. A Greek presence is instrumented with the log distance to Constantinople. Additional controls are the same as used in Table 1. In columns (1) and (2) the dependent variables are the log of 1 + the number of books printed in a specific category between 1500 and 1600 in a city. In column (3), the dependent variable is the log of 1 + the number of births of famous people in the sixteenth century. Additionally, the log of 1 + the number of births of famous people from 1350 to 1450 is added as a control in column (3). In column (4), the dependent variable is a dummy denoting the presence of at least one invention in the sixteenth century. Additionally, the presence of at least one invention from 1350 to 1450 is added as a control in column (4). $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

subsequently, potentially driven by this increased knowledge production, these cities saw a rise in upper-tail human capital as well as in the development of inventions.

Table A13 provides a more detailed analysis of scientific printing output, by disentangling astronomical, mathematical, and medical output. Furthermore, Table A13 includes several placebo analyses. In columns (1) to (3) the dependent variables are the log of 1 + the total number of works in astronomy (column 1), the log of 1 + the total number of works in mathematics (column 2), and the log of 1 + the total number of works in medicine (column 3). The coefficient on a Greek presence is positive and significantly related to the dependent variable in each of the columns, showing that the results of Table 5 are not just driven by one of the categories but that each of them was highly influenced by a Greek presence.

Columns (4) to (6) turn to several placebo tests. While it is difficult to find specific types of printing output that were unlikely to have been affected by a Greek presence and that had sufficient output, there are some types of printing output that lack a logical connection to a Greek presence and that were also printed in larger amounts. In column (4) the dependent variable is the log of 1 + the total number of works in Hebrew. Knowledge of Hebrew was dispersed across Europe and not concentrated spatially like the main European vernacular languages. Moreover, a Greek presence probably should not have increased Hebrew printing output. In column (5) the dependent variable is the log of 1 + the total number of works in religion. At the outset of the early modern period, the Orthodox East and the Latin West had long been split in terms of religion. While the Greek migrants were mostly allowed to worship their religion in Western Europe in the fifteenth and sixteenth centuries, it took decades until they could do so in own, regular churches. Moreover, Christianity in Western Europe in general was hardly affected by the Orthodox beliefs of the Greek migrants (Harris, 1995).[20] Thus, if the increase in scientific printing output in destination places for Greek migration was due to newly available useful literature brought by Greek migrants, there should be no significant relationship between a Greek presence and the amount of printing output in religion. Finally, in column (6) the dependent variable is the log of 1 + the total number of works in poetry. Recent developments in the arts were also likely unaffected by the influx of ancient Greek literature. Reassuringly, the coefficients in columns (4) to (6) are much smaller compared to the previous columns and are statistically insignificant. Overall, Table A13 shows that while printing output in the fields of astronomy, mathematics, and medicine was influenced by a Greek presence, other printing output was not necessarily affected.

4.3 Inventions over Time

Due to the fact that the inventions data are available at the annual level, they allow for a detailed analysis of the relationship between Greek migration and inventions over time. Therefore, I divide the data from 1304 to 1603 into six periods, each spanning 50 years, and run a difference-in-differences analysis with the omitted time period being 1404-1453, which is the period including the fall of Constantinople in 1453.[21]

Table 6 shows the results for a dummy measuring the presence of an invention in a city in a time period as the dependent variable and the interaction of the time dummies with a Greek presence in the second half of the fifteenth century. As can be seen in column (1), the coefficients are insignificant and around zero in the periods before the omitted period of 1404-1453. After the fall of Constantinople the pattern changes. Starting with the period 1454-1503, destination places for Greek migration saw

[20] Geanakoplos (1976) argues that texts written by the 'Greek Church Fathers' became interesting to the West, but mostly not before the end of the sixteenth century.

[21] Such an analysis would potentially also be possible with the famous people data from Schich et al. (2014). Yet it is not clear which time span the omitted period should include and when exactly a positive effect should emerge, as the births of famous people predate the activities for which they became famous for several decades. However, the results indicate a relative rise of births of famous people in destination places for Greek migration relative to the omitted time period and other cities when the omitted time period is 1404-1453 and also when it is set to 1354-1403, accounting for the lag.

Table 6 Greek Presence and Inventions: Difference-in-Differences Results

	Inventions: 1304-1603				
	OLS				IV
	(1)	(2)	(3)	(4)	(5)
Greek Presence X 1304-1353	0.026	0.027	0.026	0.023	0.141
	(0.062)	(0.053)	(0.053)	(0.054)	(0.136)
Greek Presence X 1354-1403	-0.054	-0.082	-0.084	-0.088	-0.023
	(0.065)	(0.053)	(0.056)	(0.057)	(0.156)
Greek Presence X 1454-1503	0.142**	0.092*	0.095*	0.092*	0.243*
	(0.067)	(0.052)	(0.051)	(0.052)	(0.140)
Greek Presence X 1504-1553	0.177**	0.093	0.107	0.102	0.258**
	(0.074)	(0.065)	(0.065)	(0.066)	(0.120)
Greek Presence X 1554-1603	0.242***	0.145**	0.149**	0.146**	0.408**
	(0.069)	(0.063)	(0.063)	(0.064)	(0.186)
Observations	2,394	2,394	2,394	2,394	2,394
R^2	0.431	0.469	0.476	0.476	0.467
K-P F-statistic	-	-	-	-	10.638
City FE	Yes	Yes	Yes	Yes	Yes
Population Control	No	Yes	Yes	Yes	Yes
Historic Controls	No	Yes	Yes	Yes	Yes
Geographic Controls	No	No	Yes	Yes	Yes
Country X Time FE	No	No	No	Yes	Yes
IV (Dist to Constantinople)	No	No	No	No	Yes

Notes: OLS regression results with standard errors clustered at the territory level in parentheses in columns (1) to (4). Instrumental variable results with log distance to Constantinople as an instrument in column (5). The dependent variable is a dummy measuring the presence of at least one invention in 50-year periods from 1304-1353 to 1554-1603. Historic controls include an interaction term between early access to the printing press (as of 1500) and time, the presence of an university in 1450 and time, an interaction term between a dummy for a city turning protestant until 1600 and time, and an interaction term between the presence of an port and time. Geographic controls include an interaction term between longitude and time, an interaction term between latitude and time, an interaction term between longitude*latitude and time, and an interaction between log distance to Venice and time. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

a rise in inventions relative to other cities and to the omitted time period. The coefficient increases over time and suggests an increase in inventions in destination places for Greek migration compared to other cities and the omitted time period of around 0.24 log points or 27.4% in the period from 1554 to 1603 (see also Appendix Figure A4). Adding interactions between historic and geographic controls and time as well as an interaction between country fixed effects and time reduces this estimate to around 0.15 log points or 15.7% (column 4). Column (5) in Table 6 shows the results when a Greek presence is instrumented with the log distance to Constantinople. The results are similar, while the coefficients in the periods following the fall of Constantinople are somewhat larger. The IV estimates suggest that the probability for a major invention being made in a destination place for Greek migration in the second half of the sixteenth century is around 0.41 log points or 50.4% larger compared to other cities and the omitted time period. Overall these results show that the Greek migrants and the knowledge they brought with them did indeed strongly contribute to the surge in inventions in Western Europe during the sixteenth century.

5 Conclusions

This paper studied the role Greek migrants played in European development in the early modern period, after Constantinople had fallen to the Ottomans in 1453. I created a new dataset on the presence of Greek migrants in European cities in the second half of the fifteenth century and conducted the first quantitative analysis of the effects that resulted from the fall of Constantinople and subsequent migration of Byzantine Greeks to Western Europe, specifically considering how the transmission of knowledge from East to West impacted European development. The results show that destination places for Greek migration in the second half of the fifteenth century grew considerably faster in the sixteenth century, compared to other cities. The OLS results are corroborated by a difference-in-differences setting as well as an instrumental variable approach that exploits the fact that a Greek presence was more likely in places geographically closer to Constantinople.

Next, I examined the mechanisms underlying this relationship between Greek migration and city growth in Western Europe in the sixteenth century. Drawing on the historical literature, I identified three fields of knowledge in which Greek migrants might have influenced European development and that could have been relevant for economic development. These fields are astronomy, mathematics, and medicine. Drawing on data on all known books and pamphlets printed between the invention of the printing press in the year 1451 and the year 1600 from the Universal Short Title Catalogue (USTC), my analysis shows that destination places for Greek migration printed significantly more books in astronomy, mathematics, and medicine, a finding that appears attributable to the diffusion of knowledge from migrant Greeks. By contrast, no such effect is observable for other book categories, such as religious works. Moreover, destination places for Greek migration experienced an increase in upper-tail human capital and in the development of inventions in the sixteenth century.

Altogether, this paper sheds new light on how Greek migration to Europe led to the reintroduction of knowledge from the ancient world that had been preserved in Byzantium, an event that contributed to the dynamism of the Renaissance. Specifically, the paper provides strong empirical evidence for the hypothesis that the Greeks augmented available scientific knowledge in the cities to which they migrated, and that this had positive effects on economic development. More generally, the results also suggest that even rather small groups of migrants can substantially benefit long-run development in the places that receive them, thanks to the diffusion of new knowledge to local populations.

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Appendix

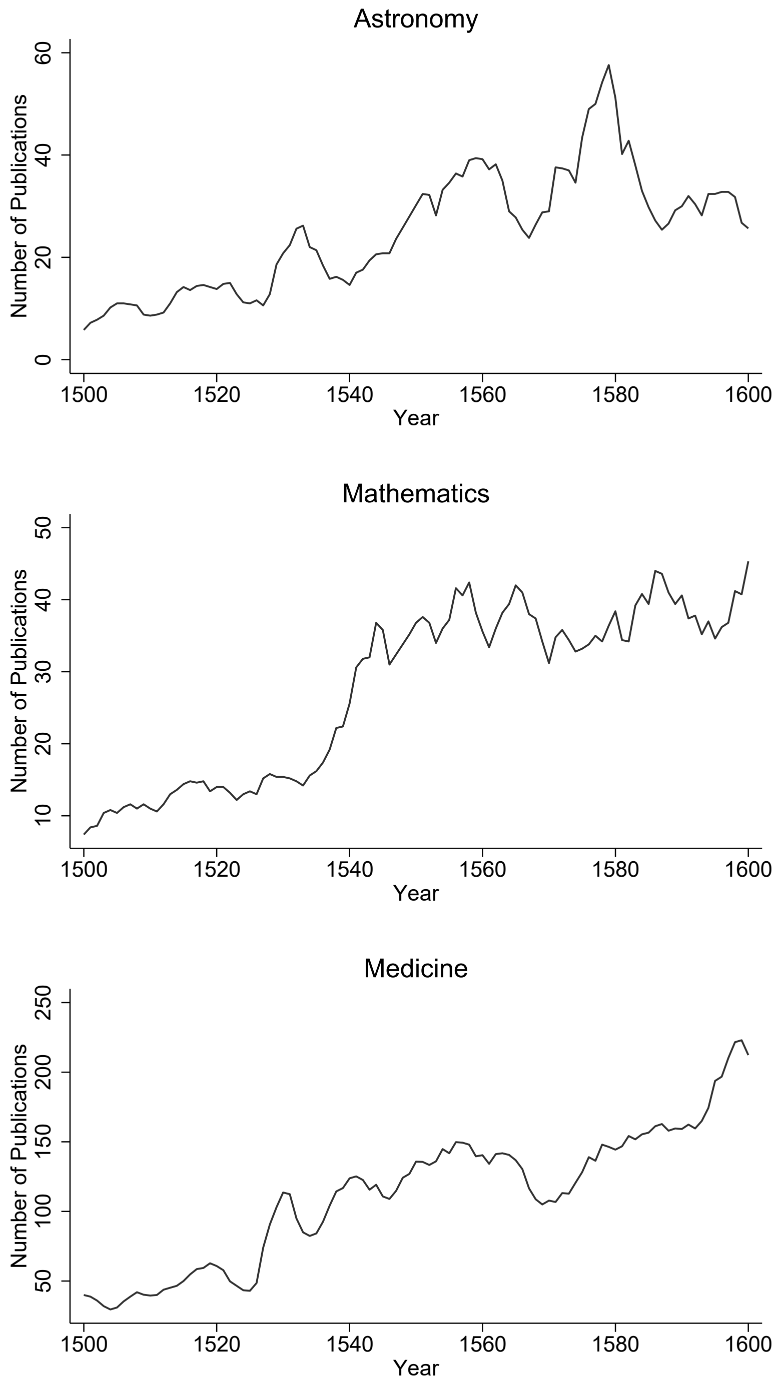

Figure A1 Total Printing Output in Astronomy, Mathematics, and Medicine in Europe 1500-1600

Notes: Total number of printed works in astronomy, mathematics, and medicine in European cities in the sixteenth century (5-year moving average). Data comes from USTC (2020).

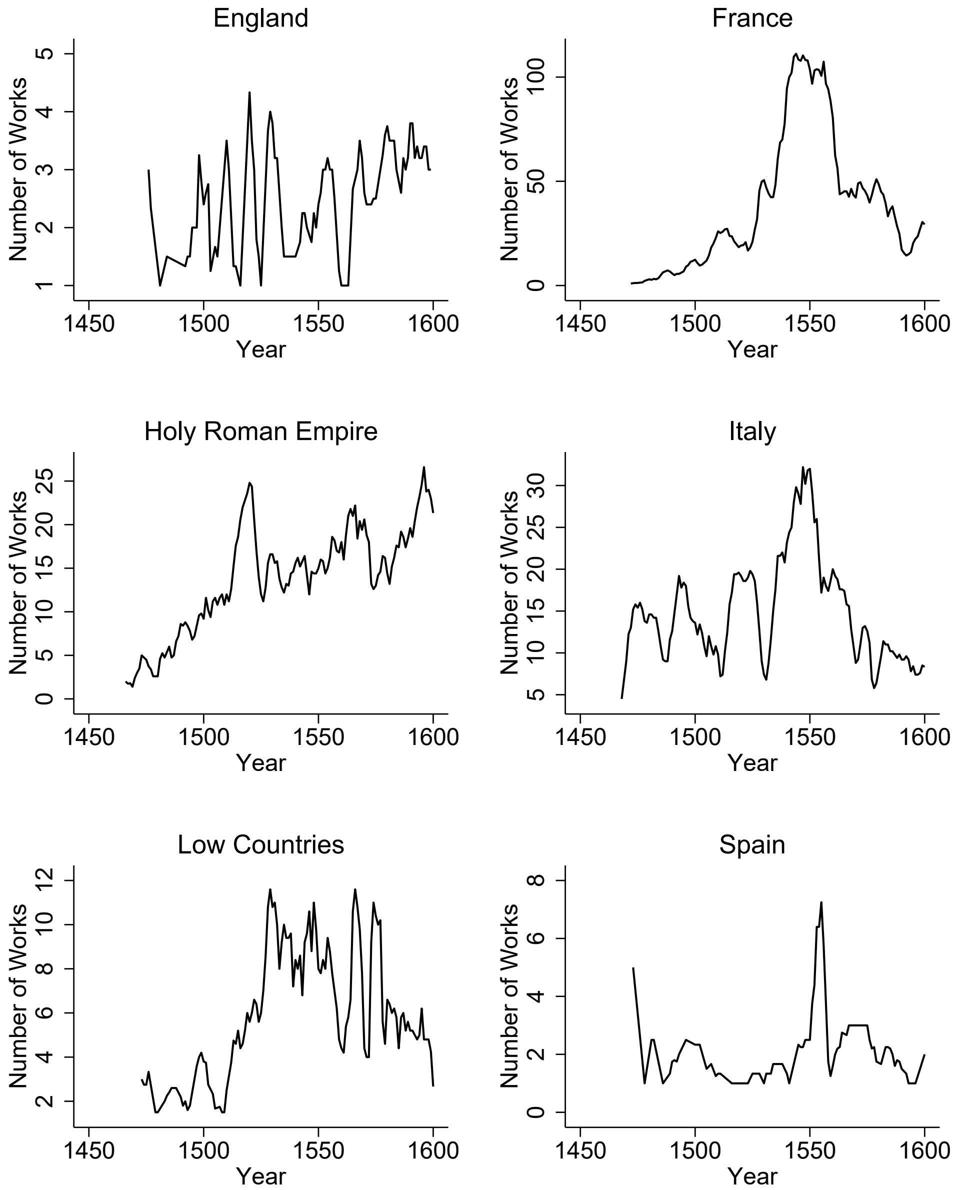

Figure A2 Total Printing Output by Ancient Greek Authors by Major Countries

Notes: Total number of printed works by ancient Greek authors in European cities by country (5-year moving average). Data comes from USTC (2020).

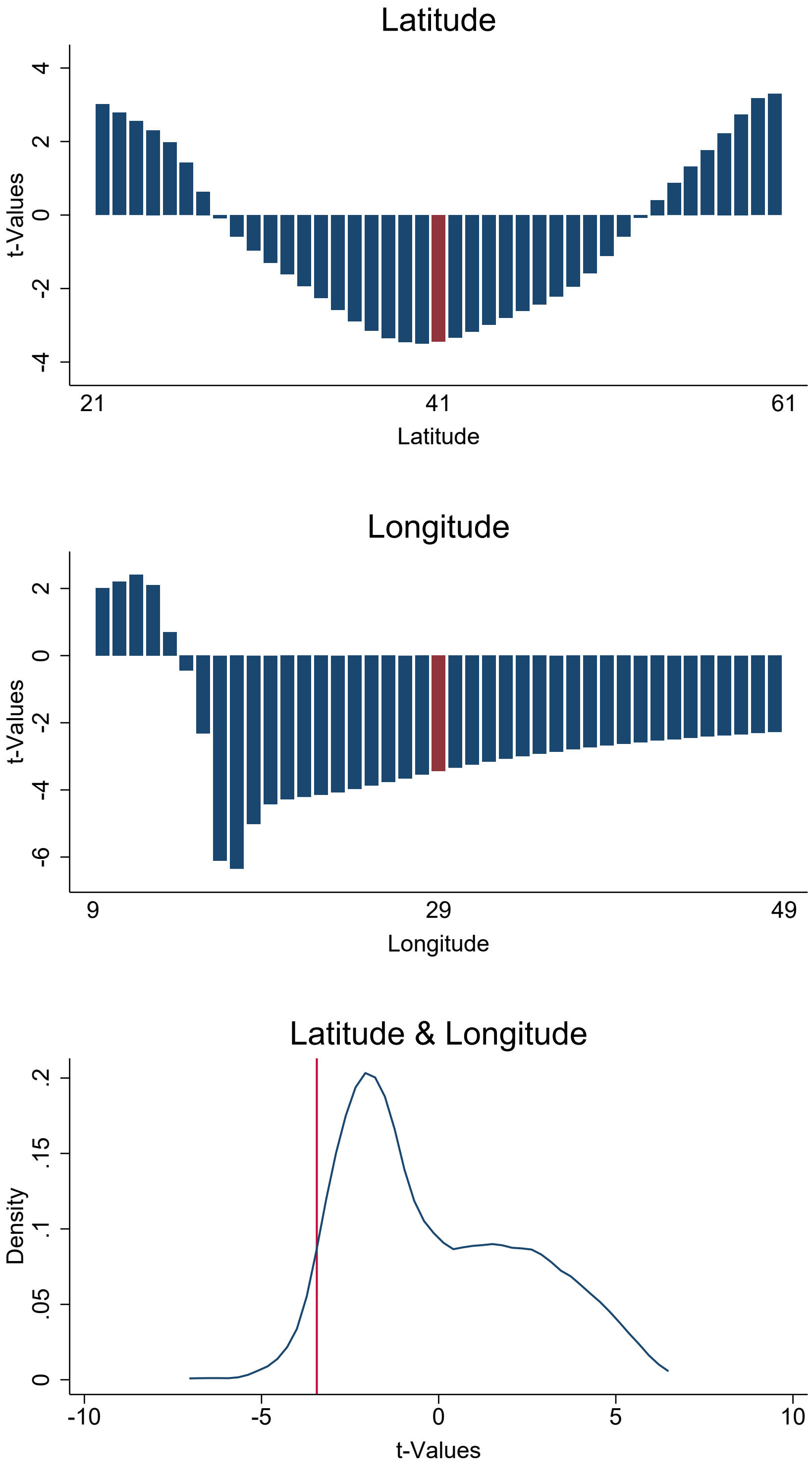

Figure A3 Log City Growth 1500-1600 and Distance to Various Coordinates between 21 and 61 Latitude and 9 and 49 Longitude

Notes: Panel A shows the results when log city growth 1500-1600 is regressed on the log distance to the longitude of Constantinople combined with different latitudes between 21 and 61. The red bar shows the t-value for the log distance to Constantinople. Panel B shows the results when log city growth 1500-1600 is regressed on the log distance to the latitude of Constantinople combined with different longitudes between 9 and 49. The red bar shows the t-value for the log distance to Constantinople. Panel C shows the distribution of t-values for 441 regressions combining different latitudes (from 21 to 61 in steps of two) and longitudes (from 9 to 49 in steps of two). All regressions include a full set of controls and country fixed effects as in Column (2) of Table 3.

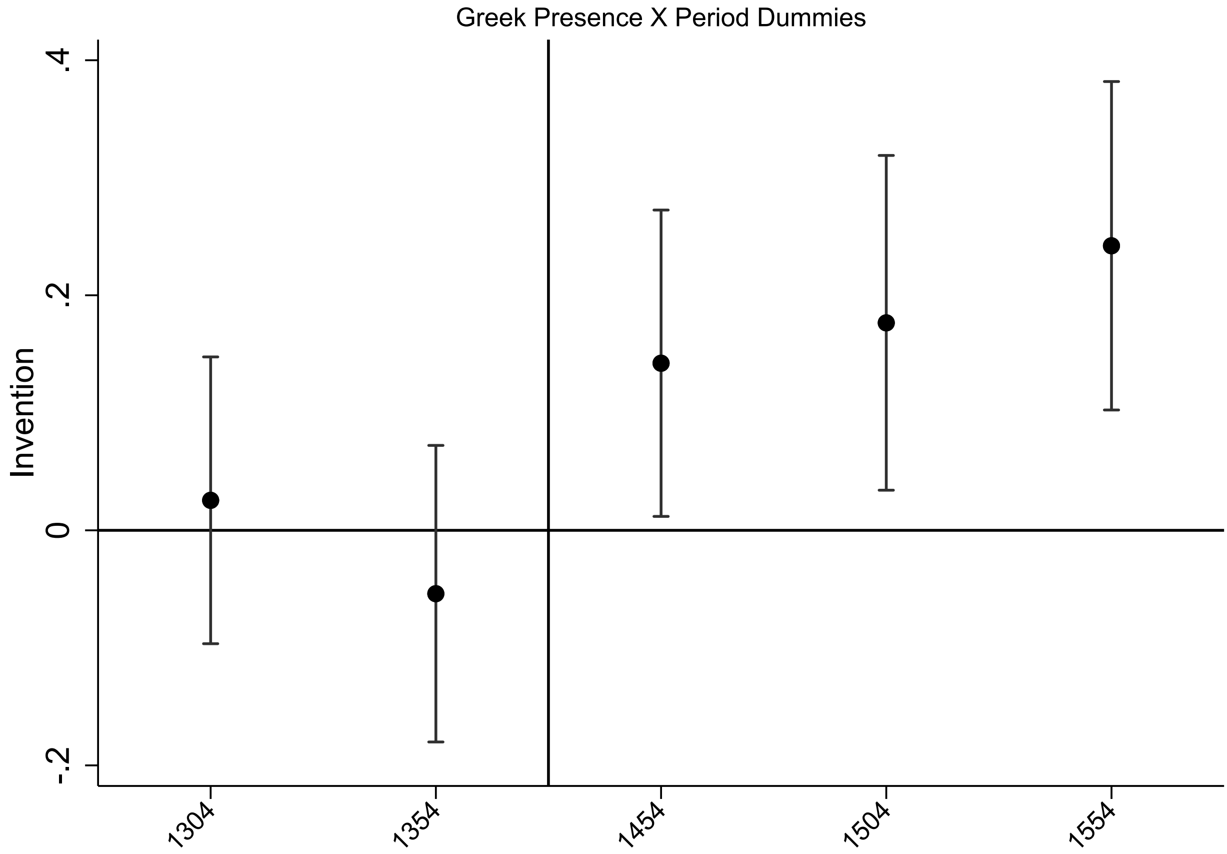

Figure A4 Inventions in European Cities 1304-1603

Notes: This figure corresponds to column (1) of Table 6.

Table A1 Cities with a Greek Presence

Place	Country	Source
Alcala de Henares	Spain	Hall (1969)
Antwerp	Belgium	http://www.ime.gr/projects/migration/15-19/en/v3/
Bologna	Italy	Harris (1995)
Bari	Italy	http://www.ime.gr/projects/migration/15-19/en/v3/
Barletta	Italy	http://www.ime.gr/projects/migration/15-19/en/v3/
Basle	Switzerland	Harris (1995)
Bordeaux	France	Harris (1995)
Brindisi	Italy	http://www.ime.gr/projects/migration/15-19/en/v3/
Bruges	Belgium	Harris (1995)
Brussels	Belgium	Harris (1995)
Coventry	England	Harris (1995)
Ferrara	Italy	Geanakoplos (1962)
Florence	Italy	Harris (1995)
Genoa	Italy	Harris (1995)
Haarlem	Netherlands	Harris (1995)
Hildesheim	Germany	Harris (1995)
Lecce	Italy	Setton (1956)
Leipzig	Germany	Mueller (2005)
Lille	France	Harris (1995)
London	England	Harris (1995)
Louvain	France	Van Rooy (2019)
Madrid	Spain	Geanakoplos (1976)
Mantua	Italy	Cortesi (2017)
Messina	Italy	Harris (1995)
Milan	Italy	Harris (1995)
Naples	Italy	Harris (1995)
Nicosia	Cyprus	Harris (1995)
Oxford	England	Harris (1995)
Padua	Italy	Harris (1995)
Palermo	Italy	Geanakoplos (1962)
Paris	France	Harris (1995)
Pavia	Italy	Harris (1995)
Rome	Italy	Harris (1995)
Rouen	France	Harris (1995)
Salisbury	England	Harris (1995)
Sevilla	Spain	http://www.ime.gr/projects/migration/15-19/en/v3/
Taranto	Italy	Harris (1995)
Toledo	Spain	Harris (1995)
Tournai	Belgium	Harris (1995)
Tours	France	Harris (1995)
Valladolid	Spain	Harris (1995)
Venice	Italy	Harris (1995)
Vienna	Austria	www.schallaburg.at
Vigo	Spain	Harris (1995)
York	England	Harris (1995)

Notes: List of European cities for which at least one source notes a Greek presence in the second half of the fifteenth century. For many of these cities evidence on a Greek presence is available from several sources. In these cases the standard reference is Harris (1995).

Table A2 Ancient Greek Authors: Part I

Author	Nr of Works	Author	Nr of Works
Achilles Tatius	26	Demetrius	6
Adamantius	4	Demetrius Pepagomenus	1
Aelianus Tacticus	5	Demosthenes	197
Aeschines	27	Didymus Chalcenterus	6
Aeschylus	12	Dio Chrysostomus	27
Aesopus	741	Diodorus Siculus	47
Aetius Amidenus	13	Diogenes Cynicus	4
Agathias Scholasticus	2	Diogenes Laertius	82
Albinus Platonicus	1	Diogenes, Laertius	6
Alcinous Platonicus	13	Diomedes	32
Alexander Aphrodisiensis	75	Dion	1
Alexander Trallianus	17	Dionysius Areopagita	37
Ammonius Hermiae	58	Dionysius Halicarnassensis	30
Anacharsis	3	Dionysius Halicarnasseus	7
Anacreon	27	Dionysius Periegetes	44
Andocides	1	Dioscurides Pedanius	70
Andronicus Rhodius	1	Empedocles	3
Antipater	1	Epictetus	50
Aphthonius	106	Epiphanius	3
Apollinarius Laodicensis	4	Epiphanius aus Eleutheropolis	8
Apollodorus	2	Epitectus	2
Apollonius Dyscolus	5	Erotianus	2
Apollonius Pergaeus	3	Euclides	94
Apollonius Rhodius	7	Eunapius Sardianus	5
Appianus alexandrinus	95	Euripides	96
Aratus Solensis	7	Eusebius Caesariensis	116
Archimedes	6	Eustathius Thessalonicensis	1
Archytas	3	Eustratius	4
Aretaeus Cappadocius	3	Euthymius Zigabenus	31
Arethas Caesariensis	4	Galenus, Claudius	594
Aristaenetus Nicaenus	8	Gelasius Cyzicenus	1
Aristeas	12	Georgios Pisides	3
Aristophanes	69	Georgius Trapezuntius	87
Aristoteles	1860	Gregentius	1
Aristoteles (pseudo)	5	Gregorius Cyprius	3
Artemidorus Daldianus	40	Gregorius II Cyprius	1
Astramsychus	2	Gregorius Nazianenus	1
Athenagoras Atheniensis	13	Gregorius Naziansenus	1
Babrius	1	Gregorius Nazianzenus	14
Basilius Caesariensis, St	45	Gregorius Nazianzenus, St	71
Callimachus	13	Gregorius Nemesius	2
Cebes	24	Gregorius Nyssenus, St	27
Cebes Philosophus	15	Heliodorus Emesenus	50
Cebes Thebanus	10	Hephestion	3
Clemens Alexandrinus	26	Hermes Trismegistus	26
Cleomedes	4	Hermogenes Tarsensis	28
Colluthus Lycopolitanus	1	Herodianus	88
Constantinus VII Porphyrogennetos	3	Herodianus Syrus	8
Cyrillus Alexandrinus	17	Hesiodus	128
Cyrillus Hierosolymitanus	10	Hesychius Alexandrinus	5

Notes: List of ancient Greek and Byzantine authors included in the USTC dataset (Part I). The author names are shown as they appear in the USTC dataset, which leads to some authors appearing more than once due to different spelling.

Table A3 Ancient Greek Authors: Part II

Author	Nr of Works	Author	Nr of Works
Hesychius Milesius	3	Philo Judaeus	1
Hierocles Alexandrinus	10	Philostratus	9
Hipparchus Bithynus	1	Phocylides Milesius	9
Hippocrates	296	Phrynichus Arabius	1
Homerus	318	Pindarus	31
Horapollo	23	Plato	231
Ignatius Antiochenus, St	19	Plato (pseudo)	1
Isidorus Pelusiota	3	Plutarchus	680
Isocrates	251	Polyaenus Macedonicus	1
Jamblichus	7	Polybius	39
Jamblichus Chalcidensis	1	Priscianus Caesariensis	32
Johannes Chrysostomus	2	Proclus	38
Johannes Chrysostomus, St	524	Procopius Gazaeus	4
Johannes Geometres	5	Psellus, Michael	26
Johannes Philoponus	62	Ptolemy	89
Justinianus I	956	Pythagoras	33
Ktesias	1	Pythagoras Samius	7
Lucianus Samosatensis	343	Quintus Smyrnaeus	6
Lycophron	14	Ruffus Ephesius	1
Lycurgus Atheniensis	65	Simplicius, ca490-560	40
Lysias	10	Sophocles	69
Macarius Egyptius	2	Sosiades	1
Marcellus Sidetes	1	Stephanus Byzantinus	5
Maximus Tyrius	11	Stobaeus	22
Menander	5	Suidas	14
Michael Ephesius	2	Symeon Metaphrastes	6
Michael Syncellus	3	Synesius Cyrenaeus	13
Musaeus	21	Synesius Cyrenensis	12
Naphsus Philolaeus	1	Themistius	21
Nectarius archiepiscopus Constantinopolitanus	2	Theocritus	54
Nicander	9	Theodoretus Cyrensis	46
Nicander Colophonius	3	Theodoretus Cyrrhensis	32
Nicephorus Callistus Xanthopulus	47	Theodorus Prodromus	9
Nicomachus Gerasinus	1	Theodosius Tripolites	1
Nilus (pseudo)	1	Theognis	3
Nonnus Panopolitanus	22	Theognis Megarensis	34
Ocellus Lucanus	2	Theognis Megareus	2
Onasander	13	Theophanes Nicaenus	2
Oppian	9	Theophilus Antecessor	12
Oppianus Anazarbensis	6	Theophilus Protospatharius	5
Oribasius	13	Theophrastus	42
Orpheus	10	Theophylactus Achridensis	67
Palaephatus	9	Theophylactus Simocattes	3
Pappus Alexandrinus	4	Theophylactus de Achrida	48
Paulus Silentiarius	6	Thucydides	68
Paulus aus Ägina	17	Timaeus Locrus	3
Pausanias	16	Xenocrates	1
Phalaris, ca570-544	50	Xenocrates Chalcedonius	1
Philo Alexandrinus	45	Xenophon	182

Notes: List of ancient Greek and Byzantine authors included in the USTC dataset (Part II). The author names are shown as they appear in the USTC dataset, which leads to some authors appearing more than once due to different spelling.

Table A4 Printing Output from Ancient Greek Authors by Place: Part I

Place	Nr of Works	Place	Nr of Works
's-Hertogenbosch	5	Dresden	1
Aalst	2	Duesseldorf	1
Albi	1	Eboli	1
Alcala de Henares	17	Edinburgh	4
Altdorf	2	Eisleben	2
Amsterdam	4	Erfurt	29
Ancona	1	Esslingen	1
Angouleme	1	Estella	1
Antwerp	351	Faenza	2
Arnhem	1	Fano	1
Arras	2	Ferrara	9
Augsburg	99	Firenze	119
Avignon	2	Franeker	5
Barcelona	19	Frankfurt (Am Main)	194
Barth	2	Frankfurt (An der Oder)	14
Basel	635	Freiburg	9
Bela pod Bezdezem	1	Gdansk	4
Bergamo	1	Geneva	174
Berlin	3	Genoa	6
Bern	4	Ghent	10
Biella	3	Goerlitz	4
Bologna	52	Granada	2
Bordeaux	13	Graz	1
Brasov	16	Haarlem	3
Brehan-Loudeac	1	Haguenau	48
Bremen	2	Hanau	2
Brescia	71	Heidelberg	26
Breslau	5	Helmstedt	22
Bruges	4	Imola	1
Brussels	1	Ingolstadt	28
Burgos	6	Innsbruck	1
Caen	4	Jena	1
Cambridge	9	Kaliningrad	2
Canterbury	1	Krakow	61
Chalons-en-Champagne	1	L'Aquila	2
Cluj	5	La Rochelle	3
Coimbra	12	Landshut	3
Colle di Valdelsa	1	Lausanne	11
Collio	1	Le Mans	1
Colmar	6	Leiden	60
Cologne	341	Leipzig	299
Copenhagen	7	Lemgo	1
Cosenza	1	Leuven	183
Cremona	3	Lich	4
Daventer	58	Liege	5
Delft	4	Limoges	3
Dillingen	3	Lisbon	7
Dole	2	London	208
Dortmund	5	Lucca	2
Douai	2	Luebeck	2

Notes: Data based on ancient Greek and Byzantine authors and places included in the USTC dataset (Part II).

Table A5 Printing Output from Ancient Greek Authors by Place: Part II

Place	Nr of Works	Place	Nr of Works
Lyon	1385	Reutlingen	4
Madrid	6	Rome	177
Magdeburg	13	Rostock	68
Mainz	30	Rouen	26
Malmoe	1	Saint-Denis	1
Mantova	8	Salamanca	39
Marburg	7	Sant'Orso	1
Medina del Campo	4	Scandiano	1
Memmingen	3	Schwaebisch Hall	2
Merseburg	1	Selestat	2
Messina	2	Sevilla	18
Milan	79	Siena	2
Modena	4	Solingen	3
Mondovi	2	Southwark	2
Montauban	1	Speyer	8
Muenster	4	St. Albans	1
Mulhouse	3	St. Gallen	2
Naples	21	Strasbourg	289
Nedelisce	1	Toledo	6
Neisse	1	Toscolano	2
Neustadt an der Weinstrasse	1	Toulouse	13
Nijmegen	1	Tournon	2
Niort	1	Tours	7
Nuremberg	65	Treviso	9
Oberursel	1	Tuebingen	15
Olmuetz	3	Turin	14
Orleans	7	Udine	1
Ortona	2	Ulm	6
Ostrog	1	Urach	5
Oxford	9	Urbino	1
Padova	34	Utrecht	7
Pamplona	2	Valencia	30
Paris	3450	Valladolid	3
Parma	13	Venice	1255
Pavia	22	Vercelli	2
Perugia	3	Verona	9
Pesaro	7	Vicenza	6
Piacenza	1	Vienna	42
Pilsen	1	Vienne	1
Pinerolo	1	Wittenberg	104
Poitiers	23	Wolfenbuettel	3
Prague	6	Worms	4
Prostejov	1	Zaragoza	17
Rees	1	Zuerich	25
Regensburg	2	Zwickau	1
Reggio	4	Zwolle	6
Reims	4		

Notes: Data based on ancient Greek and Byzantine authors and places included in the USTC dataset (Part II).

Table A6 Printing Output by Ancient Greek Scholars by Language

Language	Number	Frequency
Arabic	1	0.01
Catalan	2	0.02
Czech	13	0.12
Danish	1	0.01
Dutch	36	0.33
English	162	1.49
French	983	9.01
German	196	1.80
Greek	1,540	14.12
Hungarian	4	0.04
Italian	408	3.74
Latin	7,364	67.52
Polish	5	0.05
Portuguese	4	0.04
Spanish	92	0.84
Missing information	95	0.87
Total	10,772	100.00

Notes: Data comes from USTC (2020).

Table A7 Descriptive Statistics

Variable	Observations	Mean	SD	Min	Max
Log City Growth 1500-1600	399	0.276	0.501	-1.46	2.40
Greek Printing Output	399	20.9	185	0	3,342
Scientific Printing Output	399	24.9	121	0	1,610
Astronomical Printing Output	399	3.74	19.6	0	315
Mathematical Printing Output	399	4.02	25.1	0	423
Medical Printing Output	399	17.1	80	0	872
Births of Famous People 1500-1600	399	2.37	5.87	0	55
Invention 1500-1600	399	0.045	0.208	0	1
Bishop in 1517	399	0.404	0.491	0	1
Latitude	399	46.3	5.18	36.3	54.6
Latitude X Longitude	399	273	300	-356	1,105
Longitude	399	5.79	6.67	-8.43	20.3
Log Distance to a Trade Route	399	3.83	1.62	0	6.34
Log Distance to Constantinople	399	7.58	0.273	6.83	8.04
Log Distance to the Coast	399	3.86	1.7	0	6.12
Log Distance to Venice	399	6.55	0.686	2.72	7.51
Log Distance to Wittenberg	399	6.11	0.790	2.76	7.24
Printing Output Latin (pre 1600)	399	314	1,543	0	21,621
Printing Output Vernacular (pre 1600)	399	338	1,461	0	22,132
University in 1450	399	0.128	0.334	0	1

Table A8 Greek Presence and City Growth: IV Results with Controlling for Greek Vicinity

	Panel A: Log City Growth 1500-1600			
	(1)	(2)	(3)	(4)
Greek Presence	0.796***	0.795***	0.698***	0.566***
	(0.297)	(0.229)	(0.261)	(0.203)
Observations	399	399	399	399
First-Stage F Statistic	27.359	40.118	36.275	42.810
	Panel B: First-stage Results			
	(1)	(2)	(3)	(4)
Log Distance to Constantinople	-1.232***	-1.330***	-1.469***	-1.618***
	(0.233)	(0.207)	(0.240)	(0.243)
Observations	399	399	399	399
R^2	0.213	0.244	0.284	0.302
Greek Vicinity	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes
Basic Geo Controls	Yes	Yes	Yes	Yes
Main Controls	No	No	Yes	Yes
Further Geo Controls	No	No	No	Yes

Notes: Instrumental variable regression results with standard errors clustered at the territory level in parentheses. The dependent variable in the second stage is log population growth at the city level over the period 1500 to 1600. A Greek presence is instrumented with the log distance to Constantinople. Basic geo controls include longitude, latitude, longitude*latitude and the log distance to Venice. Main controls include the presence of a bishop in 1517, the presence of a university in 1450, the log of 1 + the number of printed works in the vernacular and the log of 1 + the number of printed works in Latin. Further geographic controls include the log distance to Wittenberg, the log distance to the coast and the log distance to a trade route. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A9 Greek Presence and City Growth: IV Results Robustness Analysis

	Log City Growth 1500-1600					
	(1) Excluding Early Print. Cities	(2) Excluding UT HC Cities	(3) Excluding Roman Cities	(4) Excluding Market Pot. Cities	(5) Controlling for Migration	(6) Extended Sample
Greek Presence	0.863***	0.825***	1.047***	1.092***	0.868***	0.806***
	(0.287)	(0.237)	(0.350)	(0.182)	(0.239)	(0.266)
Observations	274	318	330	318	399	456
First-Stage F Statistic	32.704	26.423	33.857	65.283	30.175	26.645
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Basic Geo Controls	Yes	Yes	Yes	Yes	Yes	Yes
Main Controls	Yes	Yes	Yes	Yes	Yes	Yes
Further Geo Controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Instrumental variable regression results with standard errors clustered at the territory level in parentheses. The dependent variable in the second stage is log population growth at the city level over the period 1500 to 1600. A Greek presence is instrumented with the log distance to Constantinople. Basic geo controls include longitude, latitude, longitude*latitude and log distance to Venice. Main controls include the presence of a bishop in 1517, the presence of a university in 1450, the log of 1 + the number of printed works in the vernacular and the log of 1 + the number of printed works in Latin. Further geographic controls include the log distance to Wittenberg, the log distance to the coast and the log distance to a trade route. Column (1) excludes cities with a printing press in 1500. Column (2) excludes the top 20% cities with the largest levels of upper tail human capital, proxied by the births of famous people, in the fifteenth century. Column (3) excludes cities that have been founded by the Romans. Column (4) excludes the top 20% cities with the largest levels of market potential, as measured by Rubin (2014). Column (5) controls for a measure of general migration. Column (6) includes cities from countries without a known migration. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A10 Greek Presence and City Growth: IV Results Subsample Analysis

	Log City Growth 1500-1600					
	(1) Excluding Italy	(2) Excluding France	(3) Excluding HRE	(4) Excluding Spain	(5) Excluding England	(6) Excluding Low Countries
Greek Presence	1.110***	0.872***	1.039***	0.835***	0.885***	0.866***
	(0.332)	(0.233)	(0.231)	(0.261)	(0.230)	(0.222)
Observations	340	370	335	366	362	388
First-Stage F Statistic	26.557	46.178	35.018	41.421	51.294	58.791
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Basic Geo Controls	Yes	Yes	Yes	Yes	Yes	Yes
Main Controls	Yes	Yes	Yes	Yes	Yes	Yes
Further Geo Controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Instrumental variable regression results with standard errors clustered at the territory level in parentheses. The dependent variable in the second stage is log population growth at the city level over the period 1500 to 1600. A greek presence is instrumented with the log distance to Constantinople. Basic geo controls include longitude, latitude, longitude*latitude and log distance to Venice. Main controls include the presence of a bishop in 1517, the presence of a university in 1450, the log of 1 + the number of printed works in the vernacular and the log of 1 + the number of printed works in Latin. Further geographic controls include the log distance to Wittenberg, the log distance to the coast and the log distance to a trade route. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A11 Greek Presence and City Growth: Alternative IV Results

	Log City Growth 1500-1600			
	(1)	(2)	(3)	(4)
Greek Presence	1.250*	1.012**	0.888*	1.065*
	(0.679)	(0.511)	(0.524)	(0.634)
Observations	399	399	399	399
First-Stage F Statistic	7.905	10.435	8.024	7.071
	Panel B: First-stage Results			
	(1)	(2)	(3)	(4)
Plague 1438-1462	0.165***	0.188***	0.168***	0.150***
	(0.057)	(0.056)	(0.057)	(0.054)
Country FE	No	Yes	Yes	Yes
Basic Geo Controls	Yes	Yes	Yes	Yes
Main Controls	No	No	Yes	Yes
Further Geo Controls	No	No	No	Yes
Plague Controls	Yes	Yes	Yes	Yes

Notes: Instrumental variable regression results with standard errors clustered at the territory level in parentheses. The dependent variable in the second stage is log population growth at the city level over the period 1500 to 1600. A Greek presence is instrumented with a dummy variable measuring plague shocks between 1438-1462. Basic geo controls include longitude, latitude, longitude*latitude and log distance to Venice. Main controls include the presence of a bishop in 1517, the presence of a university in 1450, the log of 1 + the number of printed works in the vernacular and the log of 1 + the number of printed works in Latin. Further geographic controls include the log distance to Wittenberg, the log distance to the coast and the log distance to a trade route. Plague controls include plagues occurring in a city closer to 100 km between 1438 and 1462, a dummy for a plague before 1500, a dummy for a plague between 1500 and 1600, and a dummy denoting if a city is located at the water (river or coast). *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A12 Greek Presence, Printing Output, Upper-tail Human Capital, and Inventions: OLS Results

	Greek Output 1500-1600	*Scientific Output 1500-1600*	*Famous People 1500-1600*	*Inventions 1500-1600*
	(1)	(2)	(3)	(4)
Greek Presence	0.482^{***}	0.466^{***}	0.505^{***}	0.205^{***}
	(0.170)	(0.130)	(0.126)	(0.052)
Observations	399	399	399	399
R-squared	0.706	0.845	0.554	0.418
Country FE	Yes	Yes	Yes	Yes
Basic Geo Controls	Yes	Yes	Yes	Yes
Main Controls	Yes	Yes	Yes	Yes
Further Geo Controls	Yes	Yes	Yes	Yes

Notes: OLS regression results with standard errors clustered at the territory level in parentheses. Basic geo controls include longitude, latitude, longitude*latitude and the log distance to Venice. Main controls include the presence of a bishop in 1517, the presence of a university in 1450, the log of 1 + the number of printed works in the vernacular and the log of 1 + the number of printed works in Latin. Further geographic controls include the log distance to Wittenberg, the log distance to the coast and the log distance to a trade route. In columns (1) and (2) the dependent variables are the log of 1 + the number of books printed in a specific category between 1500 and 1600 in a city. In column (3), the dependent variable is the log of 1 + the number of births of famous people in the sixteenth century. Additionally, the log of 1 + the number of births of famous people from 1350 to 1450 is added as a control in column (3). In column (4), the dependent variable is a dummy denoting the presence of at least one invention in the sixteenth century. Additionally, the presence of at least one invention from 1350 to 1450 is added as a control in column (4). $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A13 Greek Presence and Printing Output: Detailed Categories

	Panel A: IV Results					
	Mechanisms			*Placebo*		
	(1) Astronomy	(2) Mathematics	(3) Medicine	(4) Hebrew	(5) Religion	(6) Poetry
Greek Presence	1.101***	0.714***	1.072***	0.112	0.159	0.091
	(0.303)	(0.261)	(0.365)	(0.123)	(0.174)	(0.364)
Observations	399	399	399	399	399	399
First stage F-statistic	52.799	52.799	52.799	52.799	52.799	52.799
	Panel B: OLS Results					
	Mechanisms			*Placebo*		
	(1) Astronomy	(2) Mathematics	(3) Medicine	(4) Hebrew	(5) Religion	(6) Poetry
Greek Presence	0.323***	0.392**	0.461***	0.104	0.050	0.186
	(0.114)	(0.173)	(0.156)	(0.112)	(0.044)	(0.138)
Observations	399	399	399	399	399	399
R-squared	0.626	0.602	0.819	0.262	0.964	0.830
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Basic Geo Controls	Yes	Yes	Yes	Yes	Yes	Yes
Main Controls	Yes	Yes	Yes	Yes	Yes	Yes
Further Geo Controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Instrumental variable regression results with standard errors clustered at the territory level in parentheses in Panel A. A greek presence is instrumented with the log distance to Constantinople. OLS regression results with standard errors clustered at the territory level in parentheses in Panel B. Basic geo controls include longitude, latitude, longitude*latitude and the log distance to Venice. Main controls include the presence of a bishop in 1517, the presence of a university in 1450, the log of 1 + the number of printed works in the vernacular and the log of 1 + the number of printed works in Latin. Further geographic controls include the log distance to Wittenberg, the log distance to the coast and the log distance to a trade route. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.