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DOES MEDIEVAL TRADE STILL MATTER? HISTORICAL TRADE CENTERS, AGGLOMERATION AND CONTEMPORARY ECONOMIC DEVELOPMENT

Fabian Wahl

Universität Hohenheim | Forschungszentrum Innovation und Dienstleistung

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Fabian Wahl*

University of Hohenheim

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Abstract

This study empirically establishes a link between medieval trade, agglomeration and contemporary regional development in ten European countries. It documents a statistically and economically significant positive relationship between prominent involvement in medieval trade and commercial activities and regional economic development today. Further empirical analyses show that medieval trade positively influenced city development both during the medieval period and in the long run; they also reveal a robust connection between medieval city growth and contemporary regional agglomeration and industry concentration. A mediation analysis indicates that a long-lasting effect of medieval trade on contemporary regional development is indeed transmitted via its effect on agglomeration and industry concentration. This research thus highlights the long-run importance of medieval trade in shaping the development of cities as well as the contemporary spatial distribution of economic activity throughout Europe. The path-dependent regional development processes caused by medieval commercial activities help explain the observed persistent regional development differences across the European countries considered.

Keywords: Medieval Trade, Agglomeration, Regional Economic Development, Path-Dependency, New Economic Geography

JEL Classification: F14, N73, N93, O18, R12

*Department of Economics, University of Hohenheim. Chair of Economic and Social History, Speisemeisterflügel, Stuttgart, Germany. Fabian.Wahl@uni-hohenheim.de. The author would like to thank the participants of the 8th EHES Summer School at the University Carlos III. Madrid and of the EHES Conference 2013 at the London School of Economics. Furthermore, he is indebted to Bas van Bavel,T. Matthew Ciolek, Sibylle Lehmann, Alexander Opitz, Ulrich Pfister, Nadine Riedel, Alfonso Sousa-Poza, Oliver Volckart and Nicole Waidlein for their helpful comments, discussions and suggestions. Additionally, he thanks Maarten Bosker for sharing his data. The Appendices to the paper are available in the online version of this paper downloadable from `https://fzid.uni-hohenheim.de/fileadmin/einrichtungen/fzid/fzid_dp_2013_82_Lehmann.pdf`

1 Introduction

There is ample evidence that trade is an important determinant of both long- and short-run economic development. However, most of the existing literature focuses on the impact of 19th century trade on market integration or the "Great Divergence" (e.g., Galor and Mountford 2008 or O'Rourke and Williamson 2002), or on the impact of contemporary, Post-World War II trade activities on recent economic growth and development performance across countries (Dollar and Kraay 2003, Frankel and Romer 1999). There is only one study (Acemoglu et al. 2005) considering the effect of cross country trade in earlier periods, in which the authors investigate the impact of long-distance overseas trade for institutional developments and the pre-industrial development process across European countries.

Hence, until now there is no study exploring the possible long-lasting effects of trade and commerce in European cities during the High and Late Middle Ages. The importance of medieval trade for the development of cities and regions in the Middle Ages and the following centuries is well-known and widely accepted. Apart from this, no research has acknowledged the fact that medieval trade might also have long-term influences on regional development persisting until today; this despite the fact that medieval trade, through its potential impact on agglomeration and spatial concentration of industry, could have led to path-dependent regional development processes resulting in developmental differences surviving over the centuries.[1]

The aim of this study is to investigate whether medieval trade, as a result of its impact on agglomeration, has caused differences in regional development that remain visible today. If this is the case, it could provide a new explanation for the uneven distribution of economic activity and significant spatial concentration of industries throughout Europe (e.g., Chasco et al. 2012, Koh and Riedel 2012, Roos 2005). Furthermore, it can contribute to the understanding of the persistent differences in regional economic development (Becker et al. 2010, Maseland 2012, Tabellini 2010 or Waidlein 2011). Finally, this study contributes to a growing literature reporting on the persistence and path-dependent nature of spatial equilibria (e.g., in industry concentration) and city growth processes (Bosker et al. 2007, Bleakly and Lin 2012, Davis and Weinstein 2002, Davis and Weinstein 2008, Miguel and Roland 2011 and Redding et al. 2011). To establish a link between medieval trade, agglomeration and contemporary performance we link

[1] Van Zanden (2008) provides evidence for the medieval origins of the "Great Divergence". Thus, his study give rise to the conjecture that medieval developments, e.g. institutional differecnes between Europe and Southeast Asia had long lasting effects and persisted over centuries. In what follows, we will make similar arguments for medieval trade activities.

the typical characteristics of medieval trade and cities to the determinants of agglomeration suggested by New Economic Geography (NEG) and agglomeration economics (e.g., Krugman 1991, Glaeser et al. 1992). In a second step, based on studies combining NEG, endogenous growth models, and the theory of path-dependence (David 2007), we propose a positive connection between agglomeration, industrial concentration and contemporary development.

Afterwards, we test the causal chain from medieval trade through agglomeration and on to contemporary regional economic development by using rich regional and city level data sets and a wide range of empirical methods. In this empirical investigation we use three variables to capture medieval trade activities. First, based on several historical sources and trade route maps, we construct a dummy variable identifying cities that were important centers of trade and commerce during the medieval period. Second, we calculate a variable that shows the distance between each region or city and the closest of these trade cities. This variable enables us to test whether trade activities lead to the emergence of spatial core-periphery patterns as implied by our theoretical expectations. Third, we build an index of the medieval commercial importance of a city. Based on historically and empirically important predictors of medieval trade activities, this index is therefore able to provide a more complete and differentiated account of regional and urban medieval economic activities.

The results of the empirical estimations provide strong evidence for a significant relationship between medieval trade and contemporary regional economic performance. Furthermore, a detailed empirical investigation on city level shows that medieval trade and commercial activities are robustly positively associated with city development both during the medieval period and in the long run. Therefore, the observed path-dependent development process of European cities is partly rooted in the persistent effect of trade and commercial activity in the Middle Ages. Moreover, we also find that the effect of medieval trade on contemporary regional development can be explained by its influence on agglomeration patterns. This is shown by empirically establishing a link between city development in the medieval period and the regional industry concentration and agglomeration patterns of the present day. Finally, a mediation analysis reveals that medieval trade activities are strong direct predictors of today's spatial distribution of economic activity and population. It also enables us to demonstrate that the influence of medieval trade on contemporary regional GDP per capita is wholly attributable to the "agglomeration effect" of medieval trade.

Importantly, we show that our hypotheses are robust to the inclusion of many geographical, political, economical and historical covariates of development and agglomeration, as well as different samples, data sets and medieval trade measures; we also show they are not biased by endogeneity issues.

The remainder of the article proceeds as follows. First, we theoretically establish the link between medieval trade, agglomeration and the present-day's economic development. Afterwards, we introduce and discuss the most important variables and data and explain the empirical setting. Next, we conduct our empirical analysis and interpret and discuss the results in detail. Finally, we conclude and summarize the main findings.

2 Theory and Hypotheses

It is a well established idea that trade was a decisive factor in the development of medieval cities and the revival of city growth during the period of the so called "Commercial Revolution" (e.g., Börner and Severgnini 2012, Epstein 2000, Habermann 1978, Holtfrerich 1999, King 1985, Postan 1952, Pounds 2005 and van Werveke 1952). History provides many examples of cities owing their importance primarily to their function as centers of trade, such as the German cities of Nuremburg (Nicholas 1997), Frankfurt (Holtfrerich 1999) or Cologne (King 1985) or the Polish city of Gdansk.[2]

Using concepts developed by NEG (Krugman 1991) and agglomeration economics, one can explain why medieval trade was important for the rise of cities in medieval Europe. This is achieved by linking the characteristics of medieval trade and trade cities to second nature causes of agglomeration (for an overview over these see, e.g., Christ 2009, Glaeser et al. 1992, Henderson et al. 2001). In medieval times, the economy, especially the urban economy was characterized by a high degree of regional specialization (Ammann 1955, King 1985, Lopez 1952, Nicholas 1997, Postan 1952, Pounds 2005 and van Werveke 1963).[3] For instance, the Southern German cities that became important trade

[2] Obviously, there are exceptions to this story, i.e. cities and regions becoming large and important agglomerations without being important centers of medieval trade. For example, this is true for Stuttgart (the sixth largest German city today) and Munich two of the richest and economically most prosperous cities and agglomeration areas in present day's Germany. Stuttgart only became important after the Napoleonic Wars when it became the capital of the newly founded kingdom of Württemberg. The rise of Munich (today the third largest city in Germany) followed a similar pattern, albeit as the capital of a kingdom and residence of a bishop for a longer period (and later archbishop) Munich only began to become a large city after the late 18th century. Again, it experienced significant population growth in the nineteenth century after the Napoleonic Wars until World War I. Bavaria, and Munich as its center, remained relatively poor until the 1950s (when, e.g., the Siemens corporation moved its headquarter from Berlin to Munich). Additionally, the Ruhr Area, the largest agglomeration in Germany, largely results from its rich endowments in coal and iron making it one of the most important nucleus of German industrialization.

[3] A comprehensive illustration of medieval trade activities is provided in Postan (1952) and Lopez (1952).

centers in the later medieval era specialized in textiles (Barchent etc.) and paper production. Other areas had specialized in mining (for example, the Saxon town of Freiberg, or Liege in today's Belgium (which had the most productive coal fields), or in food and salt (of which the cities on the French Atlantic coast were the main exporters). The different regions exported what they specialized in —or had a comparative advantage in, e.g., due to natural resources— and imported what they did not have themselves.[4] This specialization of trade cities on a particular industry or sector gave rise to the existence of technological (non-pecuniary) externalities like Marshall-Arrow-Romer (MAR) externalities (Marshall 1890, Romer 1986) or Porter externalities.Furthermore, this emphasizes the close connection between industrial production and commercial activities that was typical for the medieval urban economy. [5] Those types of externalities arise as knowledge spillovers between firms in the same industry and therefore contribute to the growth of both industry and city (Glaeser et al. 1992).[6] Indeed Epstein (1998), and more broadly Epstein and Prak (2008) show that the guild as the dominant economic institution of the later medieval city could have fostered innovation and enabled knowledge spillovers and diffusion within the urban economy (and also through migration between cities).[7]

A second important characteristic of medieval trade cities was the comparatively high variety of goods that were available. Those assortments of goods were available first at the local markets, then at the large trade fairs in the Champagne region and other important trade cities (such as Frankfurt, Cologne, Ulm, etc.), and then, in the late medieval age, in the branches and kontors of the Hanseatic League and trading companies ("super-companies") like the Fugger in Augsburg.[8] The latter two in particular also supplied luxury goods and exotic commodities from the Far East, as long-distance trade

[4] A review of the general geographical patterns of trade and industry specialization in the Middle Ages is provided, among others, by King (1985).

[5] Nicholas (1997) additionally points to the fact that over the course of the Middle Ages the industry dominating in a city, e.g. the textile industry, increasingly diversified. This intra-industry diversification could be an additional channel through which technological externalities could have arisen.

[6] Such knowledge spillovers between firms might appear because of imitations, or from the transfer of skilled workers between different firms within the industry etc.

[7] For evidence about the high mobility of skilled craftsmen in this period, see Reith (2008). Of course, among historians there is little consensus about the role of the guilds and whether they had negative or positive effects for economic development. However, the more recent contributions have clearly offered evidence that guilds had significant positive impacts through their positive influence on innovativeness.

[8] For a detailed description of the business activities of the Hanseatic League, see Dollinger (1966). A discussion of the early medieval markets and fairs is found in van Werveke (1963). A comprehensive description of the medieval super companies is provided in Hunt and Murray (1999). A transaction economic analysis of the super companies (using the example of the Fugger Company) is provided by Börner (2002).

was reestablished at the beginning of the Late Middle Ages. We can consider this high variety of goods as an important demand-side driven agglomeration force, as it makes a city more attractive to settle in.[9]

Additionally, the large variety of goods and prospering industry gave rise to the self-reinforcing circular causation caused by backward and forward linkages and leading to agglomeration and core-periphery patterns in NEG models (Krugman 1991, Ottaviano and Thisse 2004). Because trade cities provided a higher variety of goods, employment for high-skilled specialized workers and —as consequence of the higher labor demand— higher wages, they attracted additional workers. When more and more workers made use of the opportunity to work in the city as, e.g. textile workers or craftsmen, employment and the number of firms increased. This decreased the price index, raised real wages and therefore resulted in the migration of even more workers to the city. Consequently, this pecuniary externality (forward linkage) resulted in increased agglomeration and industry concentration in the city. In addition, more workers led to a higher demand for goods produced and/or traded in the city. The higher demand once more led to the expansion of markets and industries, raising labor demand and real wages resulting again in additional immigration. This is the so-called "home market effect" or the backward linkage. In short, this amounts to the logic that industry will tend to concentrate where there is a large market, whereas the market is large at the area where industry is already located. Thus, forward and backward linkages constitute the virtuous circle that generates agglomeration and uneven spatial distribution of population and economic activity.[10]

Furthermore, as the process of agglomeration lasted for some time, other kinds of technological externalities occurred. Conditional on certain factors (i.e., geographical position or natural endowments) other industries located in the previously specialized cities, e.g. in the Southern German city of Ravensburg (an important trade center in the

[9] This follows clearly from the love of variety preferences commonly assumed in NEG models. Additionally, one can make a transaction cost argument: as living in a city means there are no costs of transporting the sold commodities back to the village.

[10] Of course, the medieval city was a highly cartelized and regulated economy with dominant guilds and significant rent-seeking activities (e.g., Braudel 1986). However, as Braudel (1986) concludes, since the 13th century something akin to market integration (to some extent) existed with prices varying in the markets of cities every week according to supply and demand. Furthermore, the increasing spread of the "Verlagssystem" might have limited the power of the guilds. Concerning the urban rural wage differential, evidence in general is limited for this period. Braudel (1986) notes that, in general, and due to the power of guilds, the wages in the city can usually be considered as higher than those in rural areas. Indeed Munro (2002), when comparing the real wages in England and Flanders between 1300 and 1500, found that the real wages in the cities were higher than in rural areas and showed a higher downward rigidity. In addition, van Bavel and van Zanden (2004) notice that in pre-industrial societies the relationship between city size and nominal wages was usually positive.

15th century) the traditional textiles industry was supplemented by paper production at the beginning of the 15th century (Schelle 2000). In addition, there were also incentives to be located in a trade city for firms using special commodities as inputs or firms that produced inputs used in the industry the city was specialized in.[11] Therefore, Jacobs externalities (Jacobs 1969) also occurred in the late medieval cities.[12]

However, the main argument of this paper is that medieval trade had significant consequences for economic development today. Reassuringly, the self-reinforcing nature of the described agglomeration and concentration processes implies a path-dependent process of city development. This path-dependent development process results in differences in concentration of economic activity and population that remain evident today. Cities that were involved in medieval trade activities over a sufficient period of time became locked onto a superior development path by comparison to other cities without that history. This is a typical characteristic of processes caused by increasing returns or positive feedback (David 2007). Several studies (e.g., Bosker et al. 2007 and Davis and Weinstein 2002, 2008) show that city growth (and therefore also city size) is characterized by a long-run persistence that is immune even to such shocks as the Second World War. Thus, there is a fair amount of empirical evidence pointing towards the path-dependent character of agglomeration processes and city development. In addition, there are numerous examples of historical events and phenomena with long-run impacts on economic development. For example: Colonization (e.g., Acemoglu et al. 2001, 2002); the Slave Trade (Nunn 2008, 2011); gender roles (Alesina et al. 2013); the Neolithic revolution (e.g., Ashraf and Galor 2011, Olsson and Hibbs 2005 or Putterman 2008); the capacity to adopt and develop new technologies (Comin et al. 2010); or the timing of human settlement (Ahlerup and Olsson 2012).[13] We argue that medieval trade can be added to the above list. Additionally, Maseland (2012) shows that regional development disparities in Germany are persistent and are largely explained by strong and increasing differences between core areas and the periphery.

Finally, the positive connection between agglomeration, industry concentration and regional economic growth is reported by several theoretical studies (e.g., Baldwin and Martin 2004, Martin and Ottaviano 2001, Yamamoto 2003 or Bertinelli and Black 2004) linking growth, e.g. through innovations and agglomeration by combining standard NEG and endogenous growth models. In addition, studies such as those of Hohenberg and

[11] The idea that vertical linkages along the supply chain can lead to agglomeration is developed in Krugman and Venables (1995).

[12] Jacobs externalities are knowledge spillovers arising between firms of different industries.

[13] A comprehensive review of such events causing path-dependent developments is Nunn (2009).

Lees (1995) or Fujita and Thisse (2002) also establish empirically the positive relationship between agglomeration and regional growth.

In conclusion, we postulate the following two hypotheses about the relationship between medieval trade and contemporary regional development:

Hypothesis 1. *There is a positive and significant relationship between involvement in medieval trade activities and regional economic performance today, i.e. cities that were centers of medieval trade show a higher GDP per capita today than cities that where not involved in medieval trade.*

Hypothesis 2. *Medieval trade activities influence contemporary regional economic development through their positive effect on agglomeration and industry concentration, i.e. there is a positive and significant relationship between medieval trade centers, agglomeration and industry concentration measures and current regional economic development.*

3 Data and Setting

3.1 Setting and Level of Analysis

Because medieval trade took place in cities and agglomeration is a regional phenomenon, we base our empirical analysis on regional level data. We adhere to the NUTS ("Nomenclature of Units for Territorial Statistic") regional classification, the official regional reference unit systematic used in the European Union (EU).[14] Furthermore, the official regional statistics of Eurostat are available for those territorial units. Additionally, different regions on the same NUTS level have the advantage of being relatively comparable to each other since they are defined according to a particular range of inhabitants.[15] We choose to conduct our analysis on the most disaggregated level for which our essential data (e.g., GDP per capita) is available. Therefore, we conduct our analysis with a NUTS-3 region as observational unit.

NUTS-3 regions are identical to existing administrative units in most of the countries in our sample, which is an additional advantage of using them. In Germany, for example, they are mostly identical to districts or district-free cities, in France to Departments

[14] A detailed description and overview of the NUTS classification scheme and the regions is given in the Data Appendix and in the references mentioned there.

[15] Although the population thresholds are defined very widely, e.g. a NUTS-3 region can have 150.000 and 800.000 inhabitants. Again, there are exceptions: some NUTS-3 regions show a larger population. From this it also follows that more densely populated regions cover on average a smaller area. To overcome potential biases resulting from this, we will control for the area of a region as well as a country's average region size and introduce dummy variables for city districts, city states and district-free cities (regions with a high population density, i.e. a large population but a small area).

and in Italy to Provinces. Potential bias, resulting from considering regions rather than actual cities that were subject to medieval trade, is limited as heterogeneity within NUTS-3 regions should not be of significant size. However, some control variables are available only at NUTS-2 or NUTS-1 level. In these cases, we include the respective variables at the level at which they are provided. Another advantage of adhering to the NUTS classification is that it facilitates the use of fixed effects for the different NUTS-levels (countries, federal states etc.). This allows us to appropriately handle all kinds of heterogeneity on country and regional levels. Furthermore, one can also account for cross-sectional and spatial dependence among the regions in the data set. The latter being an important advantage of regional empirical analyses, especially when compared to country level investigations.[16]

3.2 Dependent Variables and Agglomeration Measures

As dependent variable we use the natural logarithm (ln) of GDP per capita in a NUTS-3 region, originating from the Eurostat regional statistics database. We take the latest available values from the year 2009. All other time-variant variables also come from the year 2009 to enable comparability.

As measure of spatial industry agglomeration we follow Roos (2005), Chasco et al. (2012) and others in using the ln of the relative GDP density as measure for the spatial distribution of economic activity. The measure is calculated by dividing a region's share of GDP per capita through its share of the country's total area. This means it shows whether the concentration of economic activity in a region is below or above the country's average.[17] Additionally, we present results using the ln of a regions population density in 2009 as a more general measure of agglomeration, i.e. as a variable identifying more densely populated places. We hold that the relative GDP Density is a more direct measure of industry agglomeration and concentration and is therefore should more suitable for our empirical analysis. However, population density could capture additional aspects of agglomeration that might be important for economic activities indirectly and therefore can provide additional insights.

Table A.1 in the Data Appendix gives a descriptive overview of all variables used in the following empirical analysis. The exact sources and further explanations of these variables are also provided.

[16]Chasco et al. (2012) discuss further advantages of using NUTS-3 regions as observational units in the context of spatial economic analyses.

[17]The exact formula according to which the relative GDP Density is calculated is shown in the Data Appendix.

3.3 Independent Variables

This study aims to investigate the impact of trade between cities during the medieval age. To be able to identify the theoretically assumed effect of medieval trade on agglomeration we focus on the most important trade cities, i.e. the cities where trade was likely to have had the most powerful and long-lasting impact. Since agglomeration is a long-lasting process, its effects unfolding only after some time, it is important to ensure that trade took place long enough in a city to influence agglomeration in a sufficient way. Stated differently, trade had to take place for long enough that a city became locked on a superior development path. To account for this fact, we focus on important trade cities at the end of the medieval period (i.e., around 1500 AD). This is because the cities that were important at the end of the medieval period are those most likely to have experienced noticeable trade activities in the preceding years (i.e., over a longer time period).

Our main sources of information on important medieval trade activities are maps printed in historical atlases or monographs. We focus on maps because they provide a far more comprehensive source of information on trade cities and trade activities than historical monographs. In addition, the information they contain can often be assigned to a particular period —far more than that contained in books. In consequence, we collect information about cities prominently involved in trade from four historical maps providing information about cities located on "major" or "important" trade routes in around 1500 AD (i.e., the late medieval period). Because there is no consensus or quantitative evidence about the exact importance of trade cities and trade routes during the medieval period we consult several different sources to gather sufficiently reliable data.

The first is a map printed in Davies and Moorehouse (2002), the second is a map printed in King (1985). The third source is a map on Central European trade published in Magocsi's (2002) Historical Atlas of Central Europe.[18] Finally, we consult several maps included in "Westermanns Atlas zur Weltgeschichte" (Stier et al. (1956)). More information about the kind of information and the geographical and temporal scope of those maps is provided in the Data Appendix; we also list the primary sources on the basis of which the maps are drawn —where we were able to identify them. We include a city if it is mentioned in one of these maps. We include only those cities located in the EU since the Eurostat regional statistics database only provides data for EU countries.

[18]As we are not interested in information about only regionally important trade cities an additional reason for choosing this particular maps is that they provide cross-national information about trade activities.

Nonetheless, in certain cases we included cities in the sample not mentioned by the maps but by other sources of information. For example, we include the eastern German city of Zwickau as it is prominently recognized in Spufford's (2002) standard account of medieval commerce, and it is known for its importance in the salt trade. In other cases, we included cities that are not mentioned by the maps but in other sources for robustness checks. Furthermore, we use other qualitative information in our judgment of the importance of the trade cities included. For example, we look at whether a city was an important member of the Hanseatic League or the capital of a quarter or a third (like, e.g. Dortmund or Cologne). Information on this is provided by Dollinger (1966). Additionally, and especially for less prominent trade cities (Paderborn, Soest, Harfleur, Tarent etc.), we also look at whether they were situated along well-known trade routes like the "Hellweg" in Germany (as is the case, e.g., for Soest). Moreover, we consult several standard historical sources on medieval trade activities in different Central European regions (e.g., Dietze 1923, Hunt and Murray 1999, Schulte 1966, Spufford 2002 etc.) and look at whether they mention a city as being prominently involved in trade or as having over-regional importance as a market, fair, or trading city. Finally, we also draw on other historical atlases —such as that of Kinder and Hilgemann (1970)— and other regional trade route maps (e.g., Schulte 1966) as sources for validating the information in the primary maps. The Data Appendix offers a detailed description of how we construct our database of important late medieval trade cities. What is more, in Table A.4 in this Appendix we report and discuss all these sources and provide information about which city is mentioned by which source.

Overall, these sources have left us with 119 trade cities located in 10 European countries. Our data set encompasses all 839 NUTS-3 regions in these countries.[19]

Even when armed with the information in these sources, the relative importance of cities is not always clear. There is also a different degree of uncertainty about the extent and location of trade activities, and the course of main routes, i.e. the actual importance of a particular trade route at a certain point in time is not always clear. However, there are cities that were undoubtedly important centers of trade like the Northern Italian city-states (Milan, Genoa etc.), some Southern German imperial cities (like Augsburg, Nuremburg or Ulm), and the leading centers of the Hanseatic League (Hamburg, Bremen, Lübeck, Cologne etc.). On the other hand, there are cases where only some sources mention the city as an important trade center or as sitting along a major trade route,

[19] We exclude the islands of Elba, Corsica and Sicily from our sample because they are not comparable with regions on the continent with respect to trade flows. (This follows Chasco et al. 2012 who also exclude island regions).

as in the case of Paderborn, Minden, and certain port cities in France (e.g., Harfleur) or some smaller cities in Italy (Brindisi, Mantua or Udine). This uncertainty is a natural result of the qualitative —and therefore to some extent always subjective— nature of the collected information and the scarce amount of general information about the medieval period and the trade activities during that time.

To deal with this uncertainties we re-estimate all the important results of the paper with four different alternative trade city samples, i.e. we construct alternative versions of the trade center dummy excluding cities that are mentioned only in one historical source or for which their actual importance is in doubt —given the history of the city. Conversely, we also include cities that are excluded from the original sample because they seem not to be as important as the other cities. Finally, we restrict the sample of trade centers to such cities for which historical evidence about trade activities in earlier periods is available. This ensures that the results are not biased by places that were involved in medieval trade only for a short time period. A detailed description of the construction of this alternative samples and the cities included or excluded is given in Appendix A (e.g., Table A.5) and Appendix B.

Overall, we consulted seventeen different sources to construct our different samples of trade cities. However, even with this number of sources one cannot be sure that the coding of the trade city dummy variables is perfect. Regardless of this fact, there seems to be no reason why the inclusion of cities that were likely to have been less important than others or that experienced trade activities only for a short time should more than downward bias our estimates. The estimates obtained using this kind of dummy variable should therefore be considered as a lower bound of the actual long-term effect of medieval trade.

Predominantly, we use two different variables as measures of late medieval trade and its impact on contemporary regional development. First, we will use a dummy variable "Trade Center" that is equal to one if a region includes at least one medieval trade city. The lack of quantitative information and the limited availability of qualitative judgments led us to use a simple dummy variable coding important trade cities. Of course, this implies that we treat all trade cities as the same with respect to the scale of trade activities and the agglomeration forces at work. However, since we try to focus on cities located on "major" or "important" cross-national trade routes, as well as relying on qualitative judgments of importance —when available— we should be able to reduce the heterogeneity among the trade cities. Additionally, the construction of a dummy variable also allows for the construction of a second variable "Distance to Trade Center" representing the distance (in degrees) between a region and the closest medieval trade region[20] This variable offers a very useful direct test of our hypothesis that medieval trade contributed to the emergence of time persistent core-periphery patterns and therefore can act as a notable explanation for contemporary regional income differences.

Table 1 provides a summary of our trade city data. For each country, the total number of NUTS-3 regions, the number of regions with trade cities, the share of trade center regions and the average distance of a region to the closest trade city is listed.

[Table 1 about here]

As reported in the table, the average distance to a medieval trade center is about 1.5 degrees ($e^{0.432}$) which is approximately 170 km. Overall, around 14% of all regions are considered as containing medieval trade centers. Table A.2 in the Data Appendix lists the name, NUTS-3 region, and country of all trade cities. Furthermore, Figure 1 shows a map that depicts all included NUTS-3 regions and the regions with medieval trade centers (reddish colored).[21]

[Figure 1 about here]

4 Empirical Analysis

4.1 Medieval Trade and Contemporary Development

4.1.1 Descriptive Evidence

Some first insights about the relationship between medieval trade centers, agglomeration and contemporary economic performance can be obtained from a descriptive look on the relevant variables.

At first, we consider simple bivariate correlations between the ln of GDP per capita, the trade center dummy, the ln of the distance to the next trade center and our two measures of agglomeration, ln population density and ln relative GDP density. These correlations are shown in Table 2.

[Table 2 about here]

In general, we see that there is a high and significant correlation between all the variables. Additionally, the sign of the correlation coefficients are as expected (i.e., there is a

[20] The variable is zero in regions coded as trade centers.

[21] The geographical distribution of medieval trade cities in the map is largely consistent with that which King (1985) stated about the location of leading trade and economic centers in medieval Europe.

strong positive relationship between agglomeration measures and GDP per capita. Vice versa we found a negative association between distance to a trade center and both agglomeration and GDP). The correlation between GDP per capita and the trade center dummy is significant and positive, but comparatively low. On the one hand, this low correlation could be the result of considerable heterogeneity of GDP per capita across regions and countries in the sample that is not accounted for in these simple pairwise correlations. On the other hand, the high correlation between the trade center dummy and the agglomeration measures on the on side and agglomeration measures and GDP per capita on the other indicates that the effect of trade centers largely runs through agglomeration. Therefore the observed correlations provide preliminary support for our theoretical reasoning.

Another way to illustrate the stylized relationship between medieval trade, agglomeration and the present day's regional economic development is to compare averages values of GDP per capita and agglomeration measures for late medieval trade centers and non-trade centers. This is done in Table 3 both separately for each country as well as for the whole sample of regions. From the last line of Table 3 we can infer that in total, i.e. pooled over all regions and countries in the sample, regions with late medieval trade cities have a significant "GDP Advantage", that is, their average GDP per capita is around 5000 Euro higher than that of regions without trade cities. Furthermore, they also exhibit significantly higher population and relative GDP densities.[22] This result holds true for all countries except from Lithuania where trade center regions show a higher GDP per capita but the differences is insignificant. For relative GDP Density the within country results are not so clear. In Belgium and the Netherlands the relative GDP Density is lower, although the difference is not significant.[23] However, in Austria, Germany, France and Poland the countries account for three quarters of the sample, there is a statistically and economically significant advantage of trade centers with respect to both regional economic development and relative GDP Density.

[Table 3 about here]

In sum, the descriptive analysis of the data delivers strong preliminary support for our hypotheses.[24]

[22]The significance of the Difference between trade regions and non trade regions is tested by a two-sample t test.

[23]In the smaller countries (such as Lithuania, the Czech Republic, or Belgium), the insignificance of the differences is probably attributable to the insufficient total number of regions/trade centers. Here, the numbers should be treated with caution.

[24]In the working paper version additional descriptive evidence supporting our hypotheses is presented.

4.1.2 OLS Regressions

To test our main hypothesis, that regions with cities involved in medieval trade exhibit higher levels of economic development today, we estimate the following regression using Ordinary Least Squares (OLS):

$$ln(GDP)_{cijk} = \alpha + \beta TC_{cijk} + \gamma_{\mathbf{1}}'\mathbf{X}_{cijk} + \gamma_{\mathbf{2}}'\mathbf{X}_{cij} + \delta_c + \theta_i + \lambda_j + \epsilon_{cijk} \qquad (1)$$

Where $ln(GDP)_{cijk}$ is the natural logarithm of GDP per capita in NUTS-3 region k NUTS-2 Region j in NUTS-1 region i of country c. TC_{cijk} is a dummy variable "Trade Center" that is equal to one if a NUTS-3 region includes a medieval trade city and zero otherwise. X_{cijk} and X_{cij} are vectors of NUTS-3 or NUTS-2 level covariates, respectively. δ_c, θ_i and λ_j are country, NUTS-1 and NUTS-2 region fixed effects. At last, ϵ_{cijk} is the error term capturing all unobserved factors.[25] Equation (1) is a straightforward way to establish a significant direct link between late medieval trade activities and contemporary economic performance. Our expectation is that $\beta > 0$ and significantly different from zero.

Yet, even when medieval trade still matters today, does its impact transmit via agglomeration and concentration of economic activities in the places it took place historically? A simple way to test this additional hypothesis is to look at whether GDP per capita lowers when the distance to medieval trade centers increases. Expressed differently, if the effect of trade works through agglomeration then a "classical" core-periphery pattern should emerge, with the medieval trade cities as core and the regions as periphery. One can therefore modify equation (1) by substituting the trade center dummy through a variable representing the distance between a region's centroid and the closest trade city. Equation (1) can be rewritten as:

$$ln(GDP)_{cijk} = \alpha + \rho ln(Dist\_TC)_{cijk} + \gamma_{\mathbf{1}}'\mathbf{X}_{cijk} + \gamma_{\mathbf{2}}'\mathbf{X}_{cij} + \delta_c + \theta_i + \lambda_j + \epsilon_{cijk} \qquad (2)$$

Where $Dist\_TC_{cijk}$ is the natural logarithm of the distance from a region's centroid to the closest trade city measured in degrees. We expect ρ to be negative and significant.

4.1.3 Baseline Results

First, we estimate equations one and two using NUTS-1, NUTS-2 and country fixed effects. They are included to account for shocks common to all observations at the re-

[25] As mentioned before, all time-variant variables are measured in the year 2009 so we do not report an index for the period of measurement.

spective geographical unit. Additionally, they are included to exploit the pure variation between NUTS-3 regions.[26] We also add a set of basic geographical controls, including latitude, longitude and altitude of a NUTS-3 region. The latter set of variables should capture the general geographical pattern of development in Central Europe. This means, that economic development roughly increases from South to North (i.e., with increasing latitude) and decreases, in our sample, from West to East (i.e., with increasing longitude). Furthermore, it is widely acknowledged that regions with higher altitude are more difficult to reach —which seems especially relevant for trade— and have less favorable climates, thus we expect a negative influence of altitude.

The results of these regressions are shown in Table 4. There, we report three different standard errors above each coefficient. First, in parentheses, heteroskedasdicity robust standard errors are reported. Below those, in brackets, we present standard errors obtained by multiway clustering on NUTS-1 and NUTS-2 region level according to the methodology of Cameron et al. (2011). Multiway clustering is justified as it seems very likely that development in NUTS-3 regions is not independent from that in NUTS-1 or NUTS-2 regions. Moreover, because multiway clustering allows for arbitrary residual correlation across both included dimensions, it also accounts for possible spatial correlation. Finally, the third standard errors (in curly brackets) are adjusted for two-dimensional spatial correlation using the method proposed by Conley (1999).[27]

[Table 4 about here]

A glance at the estimation results confirms our expectations and the descriptive evidence brought forward before. Regions with medieval trade centers (cities) show a significantly higher GDP per capita than regions without such cities. The coefficient of the trade center dummy remains relatively stable and significant at 1% level, regardless of which combination of control variables and fixed effects is used. According to column (3) of Table 4, where we include the full set of country and region dummies as well as the basic geographic controls, regions with medieval trade centers have a GDP per capita that is on average around 30% higher than regions without medieval trade centers. This means that the effect of medieval trade is not only statistically but also economically of considerable significance.

This also holds true for the coefficients of the distance to trade center. They are

[26] Overall, there are 49 NUTS-1 regions and 143 NUTS-2 regions in our dataset.

[27] Conley's (1999) standard errors are obtained using a cutoff point of 3 degrees (approx. 330 km) after which the spatial correlation is assumed to be zero. We experimented with several different cutoff points and this cutoff produced the most conservative standard errors.

always highly significant and, quantitatively, are in the same range as that of the trade center dummy. Furthermore, they show the anticipated negative sign.

The clear positive relationship between contemporary GDP per capita and medieval trade centers is also illustrated graphically in Figure 2a, showing a partial regression plot of the Trade Center Dummy based on the full baseline specification in column (3). In Figure 2b the same is done for the negative relationship between the distance to a medieval trade center and the present GDP per capita.

Regarding the geographical controls, latitude and longitude turn out to be insignificant throughout all estimations. Altitude, on the contrary, is always significant and its coefficient shows the expected negative sign. Furthermore, the NUTS-2 dummies are often insignificant and —according to the adjusted R^2— add nothing to the explanatory power of the model. For this reason, they would only introduce additional noise to the estimation and are therefore excluded from the remaining regressions.

In general, the three different types of standard errors do not vary substantially. If anything, the standard errors in brackets adjusted from multiway clustering are somewhat larger than the other two. In view of this, we will use standard errors clustered on NUTS-1 and NUTS-2 level, for all remaining specifications if possible.

[Figure 2 about here]

4.1.4 Controlling for Determinants of Agglomeration and Development

To ensure that the significant positive relationship between medieval trade and contemporary economic development is not driven by omitted variables bias we need to control for relevant determinants of both agglomeration and economic development. As a next step we therefore add several sets of control variables to the baseline specification. In agglomeration economics, the causes of agglomeration are categorized as first nature (physical and political geography, climate etc.) or second nature causes (man-made factors, i.e. agglomeration resulting from spatial spillovers or scale effects) (e.g., Chasco et al. 2012, Christ 2009, Ellison and Glaeser 1999, Krugman 1993, Roos 2005). This literature assumes that there are direct effects of both types of cause, as well as an additional indirect effect of second nature through its interaction with first nature. Because medieval trade is thought to be a second nature cause of agglomeration, an indirect effect that geography and other natural factors may exert on first nature causes is what we need to be especially careful to control for.

In addition to standard economic agglomeration and growth literature, we must also account for potentially important historical causes of agglomeration and development.

This clearly follows from our argument that medieval trade influenced regional development processes through its impact on agglomeration and industry concentration.

In conclusion, we decided to group the control variables into four sets of variables that we add separately to the baseline specification (without NUTS-2 dummies).

The first set of variables controls for the "geographic centrality" of regions. It includes variables measuring the distance of a region to the closest important infrastructure facilities (airports, roads and railroads) and to important political and physical geographic features (coastlines and borders).[28] In particular, the latter two are important first nature determinants of agglomeration (according to, e.g., Roos 2005, Ellison and Glaeser 1999). Additionally, the ln of the distance of each region to the geographically nearest major river is included as control.[29] Rivers are geographical features important for both medieval trade, industry and city location (Börner and Severgnini 2012, Bosker and Buringh 2012, Ellison and Glaeser 1999, Roos 2005 and Wolf 2009). The idea behind this set of controls is to ensure that we do not simply capture the impact of many medieval trade cities being located at geographically favorable places, either today or in the past.

A second set of variables controls for relevant contemporary characteristics of the included regions. It comprises dummy variables for district-free cities in Germany (which are, by definition, larger or more densely populated places than others), for the regions that include a country's capital or the capital of an autonomous region.[30] Additionally, a categorical variable identifying the degree to which a region may be considered a "mountain region" is included. Furthermore, the set includes dummies for regions with coal or ore mines (or mining firms); for regions located in the former GDR; and for regions located in Eastern European post-communist transition countries. Finally, it includes the ln of a region's area. In consequence, this set of controls accounts for many important first nature causes of agglomeration (political geography and resource endowments) as well as for relevant historical facts that might influence the contemporary economic performance of a region (such as a communist history).

The next set of controls captures the historical characteristics of regions that could be relevant for both present day's agglomeration and economic performance. Here we consider dummy variables indicating regions with a university founded before 1500 AD and regions that adopted printing technology before 1500 AD. As Cantoni and Yuchtman

[28]Holl (2004) and Martin and Rogers (1995) establish empirical and theoretical evidence on the importance infrastructure facilities for industry location. This justifies the inclusion of distance to road, airports and railroads as control variables.

[29]In Germany, for example, we consider the Elbe, Danube, Rhine and the Oder as major rivers.

[30]An autonomous region is considered to be a Belgian or Italian Region or a German or Austrian federal state ("Bundesland").

(2012), Dittmar (2011), and Rubin (2011) have demonstrated, both universities and printing technology are important factors in explaining the late medieval commercial revolution and city growth. To account for the positive impact that Protestantism probably had on economic development (Woesmann and Becker 2009, Rubin 2011) we also include ln distance to Wittenberg as a variable in this set of controls. Furthermore, we also include dummies for regions containing at least one imperial city or at least one city that was member of the Hanseatic League. Finally, we also control for the possible long-lasting effect of a Roman Empire legacy and low transport costs for trade and agglomeration by including a dummy for cities located along or near to an important imperial road (Postan 1952).[31]

The fourth set controls for the most important covariates of economic growth and development. Here we use the share of people aged between 25 and 64 with tertiary education (on NUTS-2 level) as a measure for regional human capital.[32] As a variable to measure the quality of regional economic and political institutions we use the quality of government index developed by the Quality of Government Institute at the University of Gothenburg, which provides a measure for regional institutional quality design similar to the World Governance Indicators (WGI) of the World Bank. To measure for regional inequality we construct the ratio of average workers compensation to GDP per capita. As measure of innovative activity within a region we use the number of patents registered by a region's firms at NUTS-2 level. Furthermore, we include a region's unemployment rate, ln of the average workers compensation and the ln of the average fixed capital of a region's firm.

Finally, the last set of controls includes all robust covariates from the previous regressions. The robust controls are obtained by including all variables in one regression that were significant when added with one of the four sets of controls to the baseline specification. In the next step, we remove the variables that become insignificant in that regression. We repeat this procedure until only significant controls remain in the specification. This procedure results in a set of 12 variables robustly associated with GDP per capita. These are: altitude, the ln distances to airports, railroads and rivers, dummies for district free cities, capital cities, capital cities of autonomous regions, post-communistic transition countries, Eastern Germany, the ln of a region's area, the share of people with tertiary education, the inequality measure and the printing press before 1500 AD dummy. This highlights, once again, the importance of human capital and

[31] This variable considers the Via Regia, the Via Regia Lusatiae Superioris and the Via Imperii as the probably important imperial roads —that more or less following the route of former Roman roads.

[32] Again, we take the values for the year 2009.

political geography. Furthermore the robust influence of printing confirms Dittmar's (2011) claim that printing technology fostered —similar to medieval trade— localized spillovers and forward- and backward-linkages.

The results of the regressions are shown in Table 5. First, we add the four sets of controls separately to the baseline specification and then we include as a fifth set all robust covariates to the country and NUTS-1 region fixed effects. We see that the coefficient of the trade center dummy and the distance variable remain significant in each of the specifications, although the sizes of the coefficients are reduced considerably when compared to the baseline estimates.

[Table 5 about here]

The coefficient is smallest (e.g., 0.045 in the case of the trade center dummy) in the specification with all robust covariates added to the baseline model. This is unsurprising given that in this specification we added to the regression only those variables with the highest explanatory power. It suggests that medieval trade center regions today have a GDP per capita of some 4.5% higher than other regions. Based on the average regional GDP per capita in our sample this corresponds to a GDP per capita that is approximately 1100 Euros higher. When looking at the different set of controls it is evident from the adjusted R^2, that region characteristics and growth covariates add the most additional explanatory power to the model. Apart from the mountain and mining region dummies, each variable in the regional characteristics set is significant and the effects of political geography in particular (capital regions or regions with a capital of a autonomous region) seem to be important. Regarding the growth covariates, especially inequality (with a remarkable negative sign) and human capital exerts a strong effect on GDP per capita.[33] In general, the regions' historical characteristics are of the least importance when explaining contemporary regional economic development, nevertheless regions with universities and cities that adopted printing technology before 1500 AD seem to have a significantly higher GDP per capita, even today, highlighting once again the importance of human capital.[34] However, the university before 1500 AD dummy becomes insignificant when added to the measure of current regional human capital. This suggests that universities lead to advantages among regions concerning their human capital that

[33] This finding is for example in line with Simon (1998) and Gennaioli et al. (2013) who highlight the importance of human capital for regional development and city growth.

[34] In the specification with the distance to trade center variable and historical region characteristics (column (7)), the other historical region characteristics also seem to be significant (at least at the 10% level). This indicates that some of the effects captured in distance to trade centers are in fact, e.g. attributed to the course of important imperial roads like the Via Regia.

have persisted until today. Finally, the robustly negative impact of the distance to river variable again reveals the already widely acknowledged role of first nature geography for regional economic development.

Overall, we see that the relationship between medieval trade and contemporary regional development is robust to the inclusion of a wide range of control variables and other important determinants of agglomeration and economic performance. The one exception is the estimation in column (10) where distance to trade center becomes insignificant.

4.1.5 Accounting for Endogeneity

Even after controlling for many factors, endogeneity of the medieval trade variables remains a serious issue. Endogeneity could arise primarily through unobserved factors, influencing both contemporary regional development and medieval trade. Geography might be a prominent factor for which this holds true. However, we can control for geography in our regressions; whereas there are many other unobservable factors that might affect both our right- and left-hand side variables. A prominent example is institutional quality in medieval cities an important factor in medieval trade and the commercial revolution (e.g., Greif, 1992, 1993 and 1994). Other examples are cultural differences between regions and countries or historical differences in politics between regions.

To resolve the endogeneity issue, we therefore run IV Regressions using the Limited Information Maximum Likelihood (LIML) method.[35]

In order to be able to test the validity of the exclusion restriction we choose two instrument variables.

The first instrument variable considered is a categorical variable (taking the values zero, one, two, and three) indicating whether a region is classified as a mountain region by the official EU regional statistics. If a region is not classified as a mountain region the variable is zero. It is equal to two or three if the region is a mountain region according to two different sets of criteria (for details about the exact definition consult the Data Appendix).[36] The idea behind this variable is fairly intuitive: in mountainous regions,

[35] This estimation method has better small sample properties and is often more efficient than the standard 2SLS method,especially in the presence of weak instruments. Its confidence intervals are more reliable and it is unbiased in the median when the instruments are weak (Stock and Yogo 2005).

[36] Although this variable is of a categorical nature, we choose to include it as a single variable and not by using three different dummies as instruments. This is primarily motivated by guaranteeing a parsimonious set of instruments since the IV estimates are biased towards the OLS estimates when the number of instruments increases. Furthermore, the test of overidentifying restrictions wouldn't be valid if one included several instruments following the same reasoning or originating from the same phenomenon as excluded instruments in the first stage. However, the results are fully robust to using

characterized by higher trade costs, less favorable climates, and many other adverse features, trade activities were lower than in regions located at large rivers, along the coast or in low altitude areas with fertile soils and less rugged terrain. During the medieval age in particular, where no advanced transport technologies were available —especially for over-land transport— mountains constituted a severe hindrance to trade (Spufford 2002). Furthermore, as highlighted by Bosker and Buringh (2012) high elevation (as well as differences in elevation between places) has a considerable negative effect on city growth and urban potential of a place. The exogeneity of this geographical characteristic of a region should not be a concern.

The second instrument variable we will use is a dummy variable for cities that were the residential cities of bishops before 1000 AD. The church as a political, spiritual and economical power had a significant impact on the development of cities in the medieval age (e.g., Baker and Holt 2004, Isenmann 1988, King 1985). In light of this, it is probable that ecclesiastical centers, like the residential cities of bishops, did grow larger and had a higher probability of becoming a trade center. In line with this reasoning, Börner and Severgnini (2012) have demonstrated that trading activity (in- and outflows of commodities) were higher in bishop residence cities. Additionally, Bosker and Buringh (2010) found that the presence of a bishop was an important factor in the foundation and development of cities during the Middle Ages. The exogeneity of this measure is not as sure as in the case of distance to river. Nevertheless, since we can control for geography it is difficult to find a variable that could potentially influence both the location of bishop residences in 1000 AD and contemporary regional development. First, in 1000 AD most of the political and economical institutions that would emerge in the late medieval era did not yet exist. Even the central political power of our sample countries during the Middle Ages, the Holy Roman Empire, was only founded in the second half of the 10th century and could not therefore have had a significant influence on bishops residences founded before 1000 AD. This is especially true because many of the considered dioceses or archbishoprics were already established when the Empire was found in 962 AD. Second, we control for many other historical factors such as being located on an important imperial road or the early adoption of printing that might had influenced both the location of trade cities, bishop residences, and economic development today. Third, as explained by, e.g., Pounds (2005) the dioceses built in the early medieval period were virtually identical to the territory of predated Roman cities. In consequence,

the three different categories of the mountain region variable as separate instruments. They are also robust to recoding the three categories to one and include the variable as binary dummy variable. Results not shown but are available from the author upon request.

their location was determined centuries before the early medieval period, making it even more unlikely that they are endogenous to contemporary economic development.

In other words, there are many reasons to conclude that bishop residences before 1000 AD are exogenous and thus may be used as instrument.

In addition to those instruments, we make use of Lewbel's (2012) approach that exploits heteroskedastic first stage errors terms to generate artificial instruments not correlated with the product (covariance) of the first stage's heteroskedasdic errors. This method can provide more reliable estimates if it is doubtful that the instruments meet the exclusion restriction or are weak. Since the exogeneity of the bishop seats can at least be disputed in principle, this method ensures that we do not produce invalid IV estimates. The strength of these generated instruments depends on the amount of scale heteroskedasdicity in the error. The presence of heteroskedasdicity in our first stage regression is tested with a Pagan-Hall test. The test clearly rejects the presence of a homoskedasdic disturbance (p-value < 0.000). Therefore, the method can yield reliable estimates although first stage statistics are not available.

We run LIML IV regressions using the instruments outlined above and using Lewbel's (2012) approach with generated instruments for the trade center dummy and the distance variable. We include the set of robust covariates as well as NUTS-1 region and country fixed effects as controls, i.e. we re-estimate columns (5) and (10) of Table 5. The results of these estimations are shown in Table 6.

The first important result is that throughout all specifications the trade center dummy and the distance to trade center variable are significant and retain their signs. Even more significant, the size of the coefficients increased remarkably, at least in the case of the conventional IV regressions in columns (1) and (3). Moreover, the distance to trade center variable that was insignificant before in column (10) of Table 5 regains significance at 1% level. This can be interpreted as endogeneity downward biased the OLS results, probably due to a measurement error or a negative correlation between an unobserved factor and our medieval trade measures. Concerning the validity of the instruments, the over identification tests (Hansen J-statistic) inform us that the validity of the exclusion restriction cannot be rejected in almost all case at the common levels of significance. The exception is the last specification where we cannot reject the null at all levels of significance. Due to this, one should be cautious of interpreting the results from the last columns here. Nevertheless, in line with our arguments above it seems to be the case that being a mountainous region and a bishop's residence before 1000 AD affects contemporary levels of development solely through their impact on which cities became medieval trade centers. Furthermore, at least in the case of the trade center dummy, Lewbel's (2012) approach shows that our results hold even when we do not use external instruments but instruments that are exogenous by construction. However, the coefficients obtained with LIML IV are much larger than those resulting from Lewbel's (2012) approach that are much closer to the original OLS estimates. Since Lewbel's (2012) approach relies on second moment conditions and additionally produces a comparatively large number of instruments it is likely that this results reflect the lower bound of the true estimates.

Turning to the first stage results, it emerges that both instruments are indeed significant and strong predictors of medieval trade. The bishop dummy is highly significant in both specifications. This is also true for mountain region dummy, although it is only marginally significant when the trade center dummy is instrumented . The underidentification test and the Angrist-Pischke F statistic of excluded instruments always indicate that the instruments are strong and relevant.

Altogether, the IV estimations show that endogeneity does not affect the detected significant relation between medieval trade and contemporary economic development. If anything, endogeneity downward biases the OLS estimations and therefore leads us to underestimate the true effect.[37]

[Table 6 about here]

4.2 Further Results — Index of Medieval Commercial Importance

Although the evidence offered in the previous section provides robust empirical support for a significant relationship between medieval trade and contemporary regional development, the data upon which the results are based has its limitations. First and foremost, the evidence thus far is solely based on a dummy variable constructed according to whether a city was located at an important trade route and few other qualitative judgments about their importance. In treating all trade cities as equal, it is unlikely that this approach is able to capture all the dimensions and factors that made a city an important center of commercial activity throughout the medieval age. In consequence, we may not capture the true effect of medieval trade or commercial activities on contemporary development levels.

However, based on the data set at hand and historical evidence about important determinants of trade, economic and commercial activities in the Middle Ages one can construct an "Index of Commercial Importance" for each region in our sample. Among

[37] A test of endogeneity of the instrumented variables rejects the null of actual exogeneity in at 1 % level in every LIML IV regression.

the many potential determinants of medieval commercial activity, we choose eight to construct the index. At first, we include out trade center dummy, representing cities located on important trade routes. Second, we consider the variable indicating cities that were the residence of a bishop or archbishop before 1000 AD. As already outlined, the church was found to be one of the most important factors in the development of medieval cities and trade. Hence, the presence of a bishop should be a valid proxy variable for cities of notable commercial importance. Third, we include the ln distance to the coast of each region's centroid, representing the distance of each city to a potential seaport and the significant trade cities located at the coast (like, e.g., many of the Hanseatic cities). Fourth, we include the dummy variable identifying important members of the Hanseatic League. Since the Hanseatic League was one of the leading actors in medieval commerce, its important members cities were very likely to be subject to significant commercial activity. Fifth, we adopt the dummy variables representing cities that had the status of an imperial city or that were located at an important imperial road. As transport cost were a crucial factor in medieval trade, the presence of a paved and protected road should be an important economic advantage for the cities located along it (e.g., Spufford 2002). On the other hand, most of the important trade cities in the Holy Roman Empire that were not members of the Hanseatic League were free or imperial cities. Due to this, imperial cities —with their political and institutional microcosms— may be seen as the early buds of commercial activity in the medieval period (Cantoni and Yuchtman 2012). Sixth, we include a variable depicting regions in which medieval mining activities (copper and salt mining) took place. This accounts for the fact that salt and copper —as raw materials in general— were some of the major trade commodities in medieval Europe (e.g., Postan 1952, King 1985, Spufford 2002). Finally, we follow the reasoning of a recent study by Cantoni and Yuchtman (2012) showing that universities decisively fostered commercial activities and market establishment in the surrounding area. Consequently, we include the dummy variable reporting cities with universities founded before 1500 AD as last variable. The index is constructed by simply adding up the variables, combining them in one index ranging from zero to eight. Thereafter, we subtract the mean of the index from all its values so that the average region would have a value of zero. Regions with a below average value therefore have a negative and regions with an above average value have a positive value. We also construct an alternative version in which we include the ln distance to trade center variable instead of the trade center dummy.[38]

[38]We recode this variable so that it is positively associated with economic development and agglomeration, as are the other seven variables in the index.

Clearly, there are other determinants of commercial activity in the Middle Age. Nevertheless, we choose this set of variables because these variables are significant predictors of the original trade center dummy when jointly included in a probit model. Together, they produce a pseudo R^2 of around 0.2.[39] This result serves as a initial hint confirming the relevance of our variables for explaining commercial activity in the medieval age.

We now perform OLS and instrumental variable regressions (as before with the LIML and Lewbel's (2012) method) using both versions of the index of medieval commercial importance as independent and the ln of GDP per capita in 2009 as dependent variable. We include the complete baseline specification (NUTS-1, NUTS-2 and country fixed effects as well as the basic geographic controls) and the set of robust covariates employed in Tables 5 and 6 supplemented by NUTS-1 region and country fixed effects. This ensures that the results are comparable to those obtained before using the simple trade center dummy and the distance variable. The results are shown in Table 7.

[Table 7 about here]

Overall, the index of commercial importance, in both its original and alternative versions, is significant with a positive sign in every regression. Reassuringly, the LIML IV regressions using the same instrumental variables as before and a version of the index without the bishop before 1000 AD dummy, yield a more significant and remarkably higher coefficient. This is similar to the IV regressions using the dummy variable. The coefficient obtained with Lewbel's (2012) generated instruments is much closer to the original OLS estimate but keeps its significance. Furthermore, the Lewbel estimate has to be treated with some care since the overidentification test does reject the null of a valid exclusion restriction at the marginal significance level.

To sum up, the index of commercial importance confirms the results of the regressions using a simple dummy variable. Therefore, it is fair to conclude that exists a statistically robust relationship between medieval trade and commerce and today's regional economic development.

4.3 Medieval Trade, Agglomeration and Contemporary Economic Development — Establishing Causality

Until now, we have only indirectly shown that medieval trade influences today's regional economic development through its impact on agglomeration. We did so by showing that the distance of a region to the next trade city is robustly negatively associated

[39] Regression not shown but available from the author.

with regional GDP per capita. In this section we will conduct a more direct test of the proposed causal chain, going from medieval trade activities to medieval city growth, to contemporary agglomeration patterns and from there to regional economic performance.

4.3.1 Medieval Trade and City Development

The first building block of our argument is that there should be a positive association between involvement in medieval trade activities and city growth during that period. To illustrate that the theoretically proposed relationship between medieval trade and city growth does actually exist, we run a set of regressions in which we explain ln city growth in the medieval period by the trade center dummy and other covariates of medieval city growth identified in the literature. The population data on which city growth variable is based originates from the historical city population data compiled by the Centre for Global Economic History (CEGH) at Utrecht University. This database provides the most comprehensive and recent population figures for European cities between 1500 and 2000 AD.[40] For population estimates prior to 1500 AD (1200, 1300 and 1400 AD) we rely on data from Bairoch et al. (1988).[41] We include every city for which there is population data in Bairoch et al. (1988) in 1500 AD and that is located in one of our ten sample countries. This leaves us with 372 cities from which 92 are coded as trade cities based on the same information than in the NUTS-3 region sample. A list of all included trade cities is provided in the Data Appendix.

We then run cross-sectional OLS regressions with the ln of city growth between 1500 AD (the end of the medieval period) and 1200 AD, 1300 AD and 1400 AD. We choose these three variables to demonstrate that the results are not dependent on the chosen period. In each of the regressions we include country fixed effects as well as a set of historical determinants of city development as controls. We control for first nature agglomeration forces by including the distance of a city to the closest river or coast and also a city's latitude and longitude and whether it is classified as a mountain region and was therefore difficult to reach (e.g., Bosker and Buringh 2010, Spufford 2002). Furthermore, we consider several dummy variables indicating whether a city was residence of a bishop before 1000 AD; had the status of imperial city; was located at an important imperial road; or was a member of the Hanseatic League. All the control variables used here and throughout all estimations in this section are coded on city level and are oth-

[40]Details about the data base are available in the Data Appendix of the paper. The data base includes the city population for every fifty years between 1500 and 2000 AD.

[41]We follow the recent update of the Bairoch et al. (1988) population figures by Bosker et al. (2013) and include the new, smaller figures for Bruges and Paris.

erwise similar to the variables used in the previous regional level analysis.[42] At last, we always include the ln of the initial city population at the beginning of the considered growth period. This accounts for the fact that city growth is concave in city size and in consequence the growth rate of a city strongly depends on the city's initial size.[43] This is, we estimate the following regression specification:

$$ln(\frac{POP_{ic,1500}}{POP_{ic,t}}) = \alpha + \beta TC_{ic} + \gamma POP_{ic,t} + \delta' \mathbf{X}_{ic} + \theta_c + \epsilon_i \quad (3)$$

Where $ln(\frac{POP_{ic,1500}}{POP_{ic,t}})$ is the ln the growth in population in a city between 1500 AD and period t with t=1200, 1300 or 1400 AD. TC_{ic} is the trade center dummy $POP_{ic,t}$ is the ln city population begin of the period and X_{ic} is a set of time-invariant covariates and θ_c are country fixed effects. We also estimate this equation using the Index of Commercial Importance instead of the trade center dummies. These results, which do not generally differ from that reported here are available in Appendix C (Table C.1).[44]

The estimation results are depicted in Table 8, columns (1)–(3). We clearly find that the trade cities show significantly higher growth throughout the medieval period than non trade cities. This is clear evidence in favor of our theoretical reasoning that medieval trade contributed to city growth and agglomeration. Furthermore, we also see a highly significant and negative effect of the initial population level showing, indeed, that already large cities did grow at a slower rate.

What is more, in columns (4) and (5) we also run random effect (RE) estimations using a panel data set comprising out of the same sample and variables as the cross section.[45] In these estimations we first regress the ln of the city population in each of our considered years (1200, 1300, 1400, and 1500 AD) on the trade center dummy. However, this time we exploit the available historical information about the earliest occurrence of trade in a respective city (see Table A.5 in the Data Appendix) to take into account the dynamics of trade activities throughout the medieval period. That is, we code the trade center dummy as one beginning with the earliest year for which important trade activities in a city are reported by our sources (i.e., 1200, 1300, 1400, or 1500 AD) so that it becomes a time varying variable. We use the same set of controls as previously used in the cross sectional estimates and additionally we add year fixed effects. Furthermore, the imperial

[42] That is, they originate from the same source and are coded according to the same criteria.

[43] A descriptive overview over all variables used in the city level estimations is available in Table A.2 in the Data Appendix

[44] In the regressions using the index of commercial importance we do not include the controls used to construct the index. This is the set of control variables is reduced. The exact set of included covariates is listed in the notes to Table C.1 and in Appendix C.

[45] Due to the time-invariant nature of important control variables we prefer the random effects method.

city dummy and Hanseatic League are also coded by taking into account the exact date at which the city become an imperial city or member of the Hanseatic League, i.e. they are now time varying variables during the medieval period.[46] Thus, we estimate the following equation:

$$ln(POP)_{ic,t} = \alpha + \beta TC_{ic,t} + \delta_{\mathbf{1}}'\mathbf{X}_{ic} + \delta_{\mathbf{2}}'\mathbf{X}_{ic,t} + \theta_c + \pi_t + \epsilon_i \quad (4)$$

Where $ln(POP)_{ic,t}$ is the ln of a city's population as described above and $\delta_{\mathbf{2}}'\mathbf{X}_{ic,t}$ represents the time varying control variables (the imperial city and Hanseatic league dummy).π_t are the year fixed effects. All other variables are the same as in the case of equation (3). Again, pooled over all years, the population of a city is significantly higher if the city is an important medieval trade center. Finally, we regress the growth in ln population between each of our base years on the trade center dummy and additionally include the lagged population in the regression (which is similar to the cross sectional estimations). Thus, equation (4) is modified to:

$$ln(\frac{POP_{ic,t+1}}{POP_{ic,t}}) = \alpha + \beta TC_{ic,t} + \gamma ln(POP_{ic,t}) + \delta_{\mathbf{1}}'\mathbf{X}_{ic} + \delta_{\mathbf{2}}'\mathbf{X}_{ic,t} + \theta_c + \pi_t + \epsilon_i \quad (5)$$

With $ln(\frac{POP_{ic,t+1}}{POP_{ic,t}})$ is ln of the city's population growth between two base years and $ln(POP_{ic,t})$ is the city population in the contemporary period. Once more, we found a significantly positive association between being a trade center and changes in population throughout the period from 1200 AD to 1500 AD. All other variables are analogous to equation (4).

In sum, these results suggest that medieval trade can indeed be regarded as an important determinant of city growth and agglomeration during the Middle Ages. Having established this, in the following we will focus on a detailed investigation of the relationship between medieval trade activities, contemporary agglomeration patterns and regional economic growth.

[Table 8 about here]

In addition, the city level data allows to shed light on the impact medieval trade had on city development (i.e., city size and growth) over the long-run. If our claim that medieval trade and economic activities cause a path-dependent city development process

[46] A descriptive overview of the panel data set is given in Table A.3 in the Data Appendix.

and therefore have long-run effects is correct, medieval trade should have a significant influence on city size and growth also in the periods after the medieval.

To test this empirically, we conduct three different types of regression. First, we re-estimate the panel RE regressions in columns (4) and (5) of Table 8, this time also using the city population data for the years after the medieval period. In particular, we use the city population levels in 1200, 1300, 1400, 1500, 1550, 1600, 1650, 1700, 1750, 1800, 1850, 1900, 1950 and 2000 AD as dependent variable. For those estimations, we used the same set of controls as in Table 8 but (since we now focus on later periods) supplemented with a time varying version of the university before 1500 AD dummy as well as the printing press before 1500 AD dummy.[47] Alternatively, we use the growth in city population between these years as measure for city development. Second, we return to the cross-sectional framework and regress the ln of a city's population in 1500 AD, 1600, 1700, 1800, 1900 and 2000 AD on the trade center dummy and the city population in 1300 AD.[48] Again, we use the time varying version of our trade city dummy and the control variables. This is, we estimate the following cross sectional equation using OLS for each of the above mentioned years separately:

$$ln(POP)_{ic} = \alpha + \beta TC_{ic} + \gamma ln(POP_{ic,1300}) + \delta_{\mathbf{1}}' \mathbf{X}_{ic} + \theta_c + \epsilon_i \tag{6}$$

In equation (6) $ln(POP)_{ic}$ represents the ln of a city's population in the respective considered year and $ln(POP_{ic,1300})$ is the ln of the city's population in 1300 AD. The other variables are analogously to equation (5).

Third, we estimate equation (6) using the growth in city population between 1500 AD and 2000 AD, respectively. Thus, we look whether medieval trade and economic activity is positively related to long-run city growth. In those regressions, we include the initial city population (i.e, in 1500 AD). In doing so, equation (6) becomes to:

$$ln(\frac{POP_{ic,2000}}{POP_{ic,1500}}) = \alpha + \beta TC_{ic} + \gamma ln(POP_{ic,1500}) + \delta_{\mathbf{1}}' \mathbf{X}_{ic} + \theta_c + \epsilon_i \tag{7}$$

With $ln(\frac{POP_{ic,2000}}{POP_{1500}})$ being the growth in city population between 1500 AD and 2000 AD. Complementary, $ln(POP_{ic,1500})$ is the city population in 1500 AD. The estimations are shown in Table 9.

[47]However, the printing press before 1500 AD dummy does not take into account the exact date of adoption (i.e., the earliest year for which a book printed in the city is known). The reason for this is that the invention of the printing press was in 1450 and therefore these dates completely fall between two of our observation periods.

[48]We choose 1300 AD as year for the initial population levels since for 1200 AD the data about city populations is far more limited.

[Table 9 about here]

The results show that indeed, trade cities show a significantly higher population or city growth than non trade centers throughout the entire period from 1200 to 2000 (as shown by the panel regressions) as well as for the considered base years. Thus, it is fair to conclude that medieval trade has a long lasting and persistent effect on the development of central European cities (although this is not equally significant in every period). Moreover, in columns (3) to (8) we see that the initial city population in 1300 AD is a significant predictor of city population until 1900 and in column (9) the initial level of population still significantly influences the long-run growth rate of cities.

The results are similar, when one uses a city level version of the index of commercial importance instead of the trade city dummy. Though regressions using this alternative measure are not shown in the main text due to space restrictions they are reported in Appendix C (Table C.2).[49]

Finally, we estimate equations (6) and (7) using the data set of Bosker et al. (2013), which contains city population figures for the years 800—1800 AD and a large set of variables representing important determinants of city development. Using this data offers the possibility to additionally control for urban potential, i.e. the urban environment in which a city is integrated, as well as controlling for climatic conditions, political institutions and short-run shocks like the plunder of a city. Moreover, all the non-geographical variables are time varying throughout the whole observation period. Consequently, in using this data one is able to capture the full dynamics of city development. We estimate equation (6) and (7) with this data set, all important controls and both the trade city dummy and an alternative version of our index of commercial importance. This alternative version is coded using the variables in their data set. The estimations are shown in Appendix C, Table C.4. In Appendix C the estimations, variables, and results are also discussed in more detail. In general, the trade city dummy and the index of commercial importance remain robustly significant predictors of city population and city growth with this data set and control variables.

In conclusion, the development of the considered cities follows a path-dependent process that is significantly influenced by the long-run effects of medieval trade and economic activity. Thus, the empirical evidence about medieval trade and city development fully confirms our theoretical reasoning.

[49] In the regressions using the index of commercial importance we do not include the controls used to construct the index. Thus, the set of control variables is reduced. The exact set of included covariates is listed in the notes to Table C.2 and in Appendix C.

4.3.2 The Medieval Legacy of Contemporary Economic Agglomeration Patterns

The next step in our causal chain is to link medieval city growth and contemporary economic agglomeration patterns. In other words, we need to establish that there is a significant amount of path-dependency in city development throughout the regions in our sample. To do so, we regress the ln of the relative GDP density of a region on the three medieval city growth variables used in the previous subsection, the initial city population at the beginning of the considered growth period and again NUTS-1 region and country fixed effects and the robust covariates already used in the preceding estimations. Expressed more formally, the following regression equation is estimated using OLS:

$$ln(RGDPD)_{cijk} = \alpha + \beta ln(\frac{POP_{ic,1500}}{POP_{ic,t}}) + \gamma POP_{cijk,t} + \delta' \mathbf{X}_{cijk} + \theta_c + \lambda_i + \epsilon_{cijk} \quad (8)$$

Where $ln(RGDPD)_{cijk}$ is the ln of the relative GDP Density in a NUTS-3 region, $ln(\frac{POP_{ic,1500}}{POP_{ic,t}})$ is the ln of a city's population in 1500 AD divided by its population in t with t being either 1200, 1300 or 1400 AD. $\gamma POP_{cijk,t}$ represents the ln of the city's population at the t, i.e. the beginning of the considered growth period. X_{cijk} is the set of robust covariates used several times before. θ_c and λ_i are NUTS-1 or country fixed effects, respectively. ϵ_{cijk} finally is the error term.

The final step is to establish the relationship between medieval trade, contemporary economic agglomeration (via path dependent agglomeration processes as shown above) and regional economic development.

We will achieve this by conducting a causal mediation analysis (estimation of mediation effects) following the method developed by Imai et al. (2010, 2011). Mediation analysis enables us to disentangle direct and indirect effects —via determining agglomeration— of medieval trade on contemporary development. Since we cannot rule out the possibility that there are direct effects or —amounting to the same— indirect effects of medieval trade working via other channels, this methodology seems to be appropriate for our setting. The estimation of mediation effects is based on a set of three different linear estimation equations (Imai et al. 2010):

$$Y_{cijk} = \alpha_1 + \beta_1 T_{cijk} + \gamma'_{11} \mathbf{X}_{cijk} + \gamma'_{12} \mathbf{X}_{cij} + \delta_c + \theta_i + \lambda_j + \epsilon_{cijk1} \quad (9)$$

$$M_{cijk} = \alpha_2 + \beta_2 T_{cijk} + \gamma'_{21} \mathbf{X}_{cijk} + \gamma'_{22} \mathbf{X}_{cij} + \delta_c + \theta_i + \lambda_j + \epsilon_{cijk2} \quad (10)$$

$$Y_{cijk} = \alpha_3 + \beta_3 T_{cijk} + \pi M_{cijk} + \gamma'_{31} \mathbf{X}_{cijk} + \gamma'_{32} \mathbf{X}_{cij} + \delta_c + \theta_i + \lambda_j + \epsilon_{cijk3} \quad (11)$$

Where Y_{cijk} represents ln GDP per capita in a NUTS-3 region, T_{cijk} represents our variables of interest (treatment variable), i.e. the trade center dummy, the ln distance to trade center measure and the index of medieval commercial importance. M_{cijk} represents the mediating variable, that is ln relative GDP density as a measure of the spatial distribution of economic activity. $\mathbf{X}_{cijk}$ is defined as before and stands for a set of NUTS-3 level covariates. Accordingly, $\mathbf{X}_{cij}$ is a set of NUTS-2 level covariates. δ_c, θ_i and λ_j are again country, NUTS-1 and NUTS-2 region fixed effects. The epsilons represent the error terms. This means that equation (9) is identical to equation (1) or (2) respectively, while in equation (10) we regress the medieval trade variables on the agglomeration measures and in equation (11) finally we include both the medieval trade variables and the agglomeration measures in one regression on ln GDP per capita.

The "average causal mediation effect" (ACME) is estimated by the product of the coefficients β_2 and π ($\beta_2\pi$) and is obtained through a two-step procedure described in detail in Imai et al. (2011). The ACME represents the indirect effect of medieval trade on contemporary GDP per capita, i.e. that part of the overall effect of medieval trade running through agglomeration. Correspondingly, β_1 measures the total (average) effect of medieval trade on regional GDP per capita and β_3 represents the direct effect of medieval trade, i.e. that part of the effect not mediated by agglomeration (but perhaps by other factors). In consequence, this methodology of separating direct and indirect effects enables us to calculate how far the total effect of medieval trade works via increased agglomeration. We expect $\beta_2 > 0$ in the case of the trade center dummy and $\beta_2 < 0$ in the case of the distance to trade center variable. Moreover, we also hypothesize that, on average, the majority of the effect of medieval trade should run through agglomeration. This leads us to expect the ACME to be significantly different from zero and greater than the direct effect ($|\beta_2\pi| > |\beta_3|$). Moreover, since it holds that $\beta_1 = \beta_2\pi + \beta_3$ equation (9) is redundant given equations (10) and (11) and we therefore only estimate those two equations.[50] Last, we assume $\pi > 0$, i.e. a significant positive direct effect of agglomeration on regional GDP per capita.

The results of both the regressions of medieval city growth on ln GDP density and the mediation analysis are presented in Table 10. Supplementary to those results, we estimated Table 10 with ln population density as mediating agglomeration measure. The results are similar and available in Appendix C (Table C.3).

[Table 10 about here]

[50]Finally, this also implies that the share of the total effect of medieval trade running through agglomeration is $\frac{(\beta_2\pi)}{\beta_1}$.

Columns (1) to (3) show the results for the estimation of equation (8). We see clearly that there is a robust and positive relationship between medieval city growth in different time periods and the contemporary relative GDP density of the NUTS-3 regions in which the cities are located. The smallest estimate, resulting from the estimation with city growth between 1400 and 1500 AD as regressor, implies that on average, one percentage of city growth in this period leads to around a 0.17 percent higher relative GDP density. This shows that there is indeed a considerable amount of path-dependency in the development of European cities, i.e. the cities that grew larger during the medieval age due to trade are the economic centers and agglomeration areas of today.

Turning to the results of the mediation analysis (columns (4) to (6)) again we find strong empirical support for our theory. As expected, and based on the previous empirical results, all three measures of medieval trade (the dummy, the distance variable and the index of commercial importance) are strong predictors of contemporary relative GDP density. The coefficients are both significant from a statistical and economical point of view. The coefficient of the trade center dummy for instance implies that regions with an important medieval trade center shows on average around a 40% higher relative GDP density than non trade center regions. What is more, the results clearly show that a higher distance to a trade center largely corresponds to a higher distance to areas where the economic activity is concentrated. Thus, according to those estimates, there is a significant and robust positive relation between present day's spatial distribution of economic activity and medieval trade. Moreover, from the estimations of equation (11) we see that the significant effect of the medieval trade measures on the ln GDP per capita does completely disappear when we include the relative GDP density in the regression estimation. The relative GDP density by contrast, enters with a positive and significant sign in each of the three regressions. Thus, areas with a high concentration of economic activity are also the regions with a higher GDP per capita. Most importantly, this also implies that most of the observed strong effect of medieval trade on regional development levels works through its impact on the patterns of spatial industry agglomeration. In line with this, the ACME is always significant and on average above 100% —indicating that the insignificant remaining effect of medieval trade is even negative in some cases.

Thus, it is fair to conclude that the effect of medieval trade indeed runs through agglomeration as proposed in this paper.

4.4 Robustness of the Results

Our results have proven to be robust to the inclusion of many important covariates and to endogeneity issues. However, there remain some additional concerns about the robustness of the obtained estimates. To account for these issues, we conduct various robustness checks. Further discussions and explanations of these tasks are available in Appendix B, where also the results are reported in Tables B.1 to B.7

We conduct regressions including additional control variables (e.g., a dummy for residence cities and medieval mining), excluding influential observations and accounting for the considerable differences in the size of the NUTS-3 regions of the respective countries (Tables B.1 to B.3). Furthermore, we re-estimate the regressions using the alternative samples of trade cities introduced in the data section (Tables B.4 to B.7).

Overall, we find that none of these robustness checks changed the results in a way that would contradict the conclusions drawn from the main regressions. Therefore, our theoretical postulates can considered to be supported by robust empirical evidence.

5 Conclusion

This paper argues that medieval trade led to agglomeration and a concentration of economic activities within the region it took place. It further postulates that the observed spatial distribution of population and economic activity across Europe today is still shaped by the self-reinforcing and long-lasting agglomeration processes that have their origins in medieval trade activities.

Empirical tests of these hypotheses confirmed, as expected, that there is a statistically and economically significant positive relationship between medieval trade activities and contemporary regional economic development. The analysis further revealed that this relationship is indeed caused by the influence that medieval trade exerted on the emerging patterns of agglomeration and spatial concentration of industrial activities throughout European regions. Based on the result of this paper we are able to confirm a causal chain running from medieval trade activities through medieval city growth to contemporary industry concentration and regional economic development. Medieval trade can therefore be considered as an important determinant of modern economic development and long-run city development. Further quantitative analyses of medieval trade activities based on detailed historical data will clearly improve our understanding of the sources of long-lasting economic and social prosperity —a subject that is of interest to researchers in a number of academic fields.

Tables and Figures

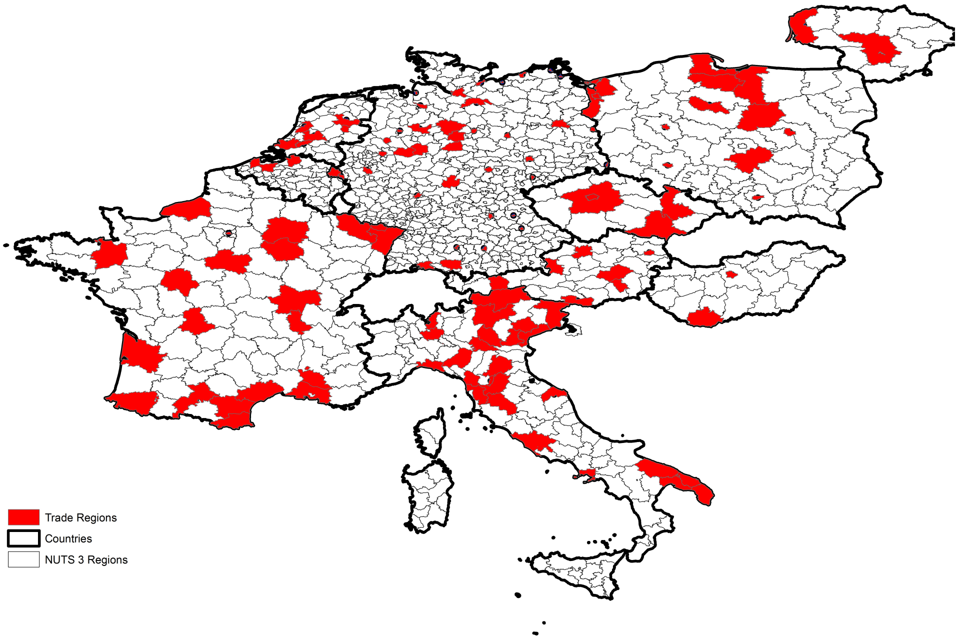
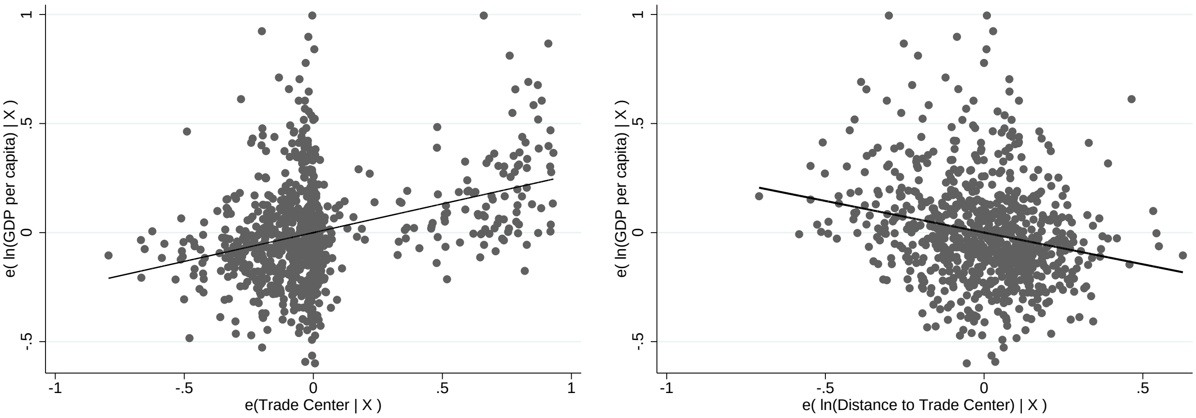


Figure 1: NUTS-3 Regions with Medieval Trade Cities



(a) Trade Center

(b) Distance to Trade Center

Figure 2: GDP p.c and Medieval Trade - Partial Regression Plots

Table 1: The Data on Medieval Trade Centers

Country	No. of Regions	No. of Trade Centers	Share Trade Centers	Mean ln(Distance to Trade Center)
Austria	35	7	20	0.36
Belgium	44	3	6.8	0.41
Czech Republic	14	4	28.6	0.43
France	94	20	21.3	0.53
Germany	429	37	8.6	0.39
Hungary	20	2	10.0	0.69
Italy	90	25	27.8	0.41
Lithuania	7	2	28.6	0.56
Netherlands	40	7	17.5	0.29
Poland	66	12	18.18	0.55
Total	**839**	**119**	**14.8**	**0.425**

Table 2: Bivariate Correlations of the Main Variables

	Trade Center	ln(Distance to Trade Center)	ln(Population Density)	ln(GDP per capita)	ln(Relative GDP Density)
Trade Center	1				
ln(Distance to Trade Center)	-0.529*** (0.000)	1			
ln(Population Density)	0.228*** (0.000)	-0.36*** (0.000)	1		
ln(GDP per capita)	0.12*** (0.000)	-0.356*** (0.000)	0.461*** (0.000)	1	
ln(Relative GDP Density)	0.218*** (0.000)	-0.303*** (0.000)	0.921*** (0.000)	0.434*** (0.000)	1

Notes. Correlation coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. Reported are pairwise correlation coefficients using the whole sample of NUTS-3 regions.

Table 3: Medieval Trade, Agglomeration and Regional Development — Mean Comparisons

country	Av. GDP p.c. trade centers	GDP p.c. non trade centers	"GDP Advantage" trade centers	Rel. GDP Dens. trade centers	Rel. GDP Dens. non trade centers	"Rel. GDP Dens. Advantage" trade centers
Austria	37428.71	26885.71	10542.28***	19.21	0.453	18.76**
			(2569.8)			(8.5)
Belgium	35566.66	25014.6	10552.03**	1.02	3.00	-1.98
			(4669.6)			(8.43)
Czech Republic	15950	11100	4850*	31.94	0.247	31.7
			(2574.7)			(18.79)
France	29680	24513.5	5166.48**	137.07	13.71	123.36*
			(2267.2)			(72.72)
Germany	34381.08	26342.86	8038.22***	14.02	5.91	8.1***
			(1692.8)			(2.5)
Hungary	13500	6677.78	6822.23***	75.51	.174	75.34***
			(2049)			(18.73)
Italy	27576	24095.38	3480.62***	3.04	2.23	0.818
			(1220.9)			(1.73)
Lithuania	8200	6439.99	1760	1.64	0.71	0.924
			(2397.35)			(0.471)
Netherlands	36142.86	30430.3	5712.56*	1.81	2.97	-1.15
			(2883.3)			(2.0)
Poland	10475	6822.22	3652.78***	42.9	4.16	38.74***
			(921.2)			(9.00)
Total	**28652.9**	**23779.2**	**4873.77*** **	**35.99**	**5.48**	**30.51*** **
			(1050.28)			**(9.7)**

Notes. The statistical significance of differences in GDP per capita, population density and relative GDP density between trade centers and non trade centers is tested by a two-sample t test (assuming equal variances). Differences between trade centers and non trade centers are statistically different from zero at the ***1 %, **5 % and *10 % level. Standard errors of the t tests are reported in parentheses.

Table 4: Medieval Trade and Contemporary Economic Development — Baseline Estimates

Dep. Var.	ln(GDP per capita)					
	(1)	(2)	(3)	(4)	(5)	(6)
Trade Center	0.244***	0.272***	0.264***			
	(0.026)	(0.028)	(0.028)			
	[0.03]	[0.033]	[0.031]			
	{0.03}	{0.029}	{0.27}			
ln(Distance to Trade Center)				-0.232***	-0.31***	-0.29***
				(0.039)	(0.046)	(0.046)
				[0.047]	[0.053]	[0.055]
				{0.038}	{0.045}	{0.043}
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes
NUTS-1 Dummies	Yes	Yes	Yes	Yes	Yes	Yes
NUTS-2 Dummies	No	Yes	Yes	No	Yes	Yes
Basic Geographic Controls	No	No	Yes	No	No	Yes
Obs.	839	839	839	839	839	839
Adj. R^2	0.78	0.778	0.778	0.765	0.762	0.763

Notes. Below each coefficient three standard errors are reported. First, heteroskedasdicty robust standard errors are reported in parentheses. Second, standard errors adjusted for two-way clustering within NUTS-1 and NUTS-2 regions are reported in square brackets. Third, standard errors adjusted for two-dimensional spatialcorrelation according to Conley's (1999) method are reported in curley brackets. The standard errors are constructed assuming a window with weights equal to one for observations less than 3 degrees apart and zero for observations further apart. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The basic geographic controls include a NUTS-3 region's latitude, longitude and altitude. Each regression contains a constant not reported.

Table 5: Medieval Trade and Contemporary Economic Development — Adding Further Controls

Dep. Var.	ln(GDP per capita)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Trade Center	0.175***	0.105***	0.1791***	0.0701***	0.045**					
	(0.025)	(0.024)	(0.03)	(0.027)	(0.021)					
ln(Distance to Trade Center)						-0.105**	-0.0857*	-0.135**	-0.138***	-0.0529
						(0.044)	(0.044)	(0.053)	(0.041)	(0.041)
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NUTS-1 Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Basic Geographic Controls	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Geographic Centrality Controls	Yes	No	No	No	No	Yes	No	No	No	No
Region Characteristics	No	Yes	No	No	No	No	Yes	No	No	No
Historical Region Characteristics	No	No	Yes	No	No	No	No	Yes	No	No
Growth Covariates	No	No	No	Yes	No	No	No	No	Yes	No
All Robust Controls	No	No	No	No	Yes	No	No	No	No	Yes
Obs.	839	839	839	518	818	839	839	839	518	818
Adj. R^2	0.809	0.873	0.784	0.878	0.878	0.798	0.859	0.776	0.872	0.877

Notes. Standard errors adjusted for two-way clustering within NUTS-1 and NUTS-2 regions are reported in parentheses. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a NUTS-3 region. The basic geographic controls include a region's latitude, longitude and altitude. The geographic centrality controls include the ln distances of a region's centroid to the nearest airport, railroad, road, border and coast point. Region characteristic controls include a dummies for regions in Germany that are district-free cities, for regions including a country's capital, are classified as mountain regions, with ore or coal mines, located in the former GDR and located in an Eastern European post-communistic transition country. Furthermore it encompasses the ln of a regions area. The historical region characteristics consist of a dummy variables indicating regions with a university founded before 1500 AD, that adopted printing technology before 1500 AD, contain cities that were members of the Hanseatic League, with former imperial cities and were located on an imperial road. Moreover it includes the ln of the distance of a region's centroid to Wittenberg. The growth covariates encompass a region's unemployment rate, number of registered patents, average firm ln fixed capital stock, average worker compensation. Furthermore, it includes the share of people aged between 25-64 with tertiary education on NUTS-2 level, the quality of government index on NUTS-1/ NUTS-2 level and the ratio of an average workers compensation to a region's GDP per capita as inequality measure. The set of all robust covariates encompasses altitude, the ln distances to airports, railroads and rivers, dummies for district free cities, capital cities, capital cities of autonomous regions, post-communistic transition countries, Eastern Germany, the ln of a region's area, the share of people with tertiary education, the inequality measure and the printing press before 1500 AD dummy. Each regression includes a constant not reported.

Table 6: Medieval Trade and Contemporary Economic Development — IV Regressions

	(1)	(2)	(3)	(4)
Method	LIML	Lewbel (2012)	LIML	Lewbel (2012)
	2. Stage Results			
Dep. Var.	ln(GDP per capita)			
Trade Center	0.306***	0.0787***		
	(0.105)	(0.025)		
ln(Distance to Trade Center)			-0.519***	-0.155***
			(0.173)	(0.05)
R^2 (centered)	0.563	0.632	0.508	0.880
F-value	55.02	86.43	51.52	131.85
Overidentification Test (Hansen J statistic)	0.307	66.64	0.0981	78.26
p-value	0.580	0.116	0.754	0.008
	1. Stage Results			
Dep. Var.	Trade Center		ln(Distance to Trade Center)	
Mountain Region	-0.0232*		0.0259***	
	(0.013)		(0.01)	
Bishop before 1000 AD	0.2553***		-0.1342***	
	(0.071)		(0.039)	
Country Dummies	Yes	Yes	Yes	Yes
NUTS-1 Dummies	Yes	Yes	Yes	Yes
All Robust Controls	Yes	Yes	Yes	Yes
Obs.	818	818	818	818
Angrist-Pischke F statistic of excluded IV's	8.39	44.51	9.32	13.47
p-value	0.000	0.000	0.000	0.000
R^2(centered)	0.273	0.837	0.206	0.699
Underidentification Test	14.06	194.6	16.25	158.2
p-value	0.000	0.000	0.000	0.000

Notes. Robust standard errors are reported in parentheses. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a NUTS-3 region. The set of all robust covariates encompasses altitude, the ln distances to airports, railroads and rivers, dummies for district free cities, capital cities, capital cities of autonomous regions, post-communistic transition countries, Eastern Germany, the ln of a region's area, the share of people with tertiary education, the inequality measure and the printing press before 1500 AD dummy. Each regression includes a constant not reported. The Overidentification test reports the Hansen J-statistic and the Underidentification test reports the Kleibergen-Paap rk LM statistic (null hypothesis: equation is underidentified). Lewbel's (2012) approach uses a vector of generated instruments that are uncorrelated with the product of the heteroskedasdic first stage's errors as instruments. These instruments are not included in the table due to space restrictions, but their coefficients and standard errors are available from the author upon request.

Table 7: Medieval Commercial Importance and Contemporary Regional Development

Dep. Var	ln(GDP per capita)					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS				LIML IV	Lewbel (2012)
Commercial Importance	0.0963***	0.0209**			0.149***	0.0232**
	(0.014)	(0.009)			(0.053)	(0.01)
Commercial Importance Alternative			0.0974***	0.0179*		
			(0.016)	(0.011)		
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes
NUTS-1 Dummies	Yes	Yes	Yes	Yes	Yes	Yes
NUTS-2 Dummies	Yes	No	Yes	No	No	No
All Robust Controls	No	Yes	No	Yes	Yes	Yes
Obs.	839	818	839	818	818	818
$Adj.R^2 \backslash R^2$	0.776	0.877	0.77	0.877	0.508	0.621
Underidentification Test					17.02	224.5
p-value					0.000	0.000
Overidentificaton Test					0.109	69.41
p-value					0.741	0.077
AP F-statistic of excluded IV's					9.53	32.72
p-value					0.000	0.000

Notes. Standard errors adjusted for two-way clustering within NUTS-1 and NUTS-2 regions are reported in parentheses. In column (5) and (6) heteroskedasdicity robust standard errors are reported. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a NUTS-3 region. The index of commercial importance of a medieval city is constructed by adding up the coast region dummy, the trade center, bishop in 1000 AD, imperial city and road, hanseatic league, medieval mining region and university before 1500 AD dummy variables. The alternative index of commercial importance includes the distance to trade center variable instead of the dummy (recoded to be positively related to GDP). In the case of the LIML IV regression a version of the index is used that does not include the bishop before 1000 AD dummy since this variable is used as excluded instrument in that estimation. The set of covariates encompasses altitude, the ln distances to airports, railroads and rivers, dummies for district free cities, capital cities, capital cities of autonomous regions, post-communistic transition countries, Eastern Germany, the ln of a region's area, the share of people with tertiary education, the inequality measure and the printing press before 1500 AD dummy. Each regression includes a constant not reported. The Overidentification test reporst the Hansen J-statistic and the Underidentification test reports the Kleibergen-Paap rk LM statistic (null hypothesis: equation is underidentified). Lewbel's (2012) approach uses a vector of generated instruments that are uncorrelated with the product of the heteroskedasdic first stage's errors as instruments. These instruments are not included in the table due to space restrictions, but their coefficients and standard errors are available from the author upon request. The first stage regressions are also not reported but are available from the author.

Table 8: Trade Activity and City Growth in the Medieval Period

Dep. Var.	$\ln(\frac{Population_{1500}}{Population_{1200}})$ (1)	$\ln(\frac{Population_{1500}}{Population_{1300}})$ (2)	$\ln(\frac{Population_{1500}}{Population_{1400}})$ (3)	ln(Population) (4)	$\ln(\frac{Population_{t+1}}{Population_t})$ (5)
Method		OLS		RE	
Trade City	0.503**	0.367***	0.293*	0.665***	0.28***
	(0.227)	(0.12)	(0.148)	(0.071)	(0.094)
ln(Population 1200)	-0.66***				
	(0.148)				
ln(Population 1300)		-0.614***			
		(0.064)			
ln(Population 1400)			-0.401***		
			(0.078)		
ln(Population$_t$)					-0.415***
					(0.055)
Obs.	86	207	183	879	451
Adj. R^2\overall R^2	0.353	0.401	0.175	0.354	0.263
Number of Clusters				372	209

Notes. Robust standard errors are reported in parentheses in columns (1) - (3). Standard errors clustered at city level are reported in parentheses in columns (4) and (5). Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a city. In columns (1) and (2) the overall R^2 is reported, in all other columns, the Adj. R^2 is shown. The set of covariates encompasses the ln distances of a city to the next river or coast, dummies indicating cities that were residence of a bishop before 1000 AD, had the status of an imperial city, were located at a main imperial road, were member of the Hanseatic League or are classified as a mountain region by the EU regional statistics. Furthermore, we control for a city's latitude and longitude and include country fixed effects. In columns (4) and (4) we additionally include year fixed effects. Each regression includes a constant not reported.

Table 9: Medieval Trade and Long-run City Development

Dep. Var.	ln(Population)	$\ln(\frac{Population_{t+1}}{Population_t})$	ln(Population 1500)	ln(Population 1600)	ln(Population 1700)	ln(Population 1800)	ln(Population 1900)	ln(Population 2000)	$\ln(\frac{Population_{2000}}{Population_{1500}})$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Trade City	0.622***	0.0991***	0.33***	0.398***	0.585***	0.454***	0.498***	0.634***	0.714***
	(0.104)	(0.029)	(0.118)	(0.103)	(0.14)	(0.132)	(0.165)	(0.153)	(0.146)
ln(Population 1300)			0.347***	0.321***	0.155*	0.209***	0.213**	0.0947	
			(0.067)	(0.06)	(0.084)	(0.079)	(0.103)	(0.09)	
$\ln(Population_t)$		-0.104***							
		(0.014)							
ln(Population 1500)									-0.81***
									(0.067)
Obs.	3,501	2,336	207	173	178	205	190	203	359
overall R^2\Adj. R^2	0.613	0.294	0.461	0.593	0.45	0.426	0.28	0.302	0.408
Number of Clusters	372	369							

Notes. Robust standard errors are reported in parentheses in columns (3) - (10). Standard errors clustered at city level are reported in parentheses in columns (1) and (2). Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a city. In columns (1) and (2) the overall R^2 is reported, in all other columns, the Adj. R^2 is shown. The set of covariates encompasses the ln distances of a city to the next river or coast, and a dummy whether a city lies in a region classified as a mountain region by the EU regional statistics. In the estimations of column (3) onward the dummy variable indicating whether a city adopted printing technology prior to 1500 AD is additionally included. Furthermore, we control for a city's latitude and longitude and include country fixed effects. In columns (4) and (4) we additionally include year fixed effects. Each regression includes a constant not reported.

Table 10: Medieval Trade, Relative GDP Density and Regional Economic Development

	(1)	(2)	(3)	(4)	(5)	(6)
Method		OLS			Mediation Analysis	
City Growth from to	1200–1500	1300–1500	1400–1500		Equation (11)	
Dep. Var.		ln(Relative GDP Density)			ln(GDP per capita)	
$\frac{Population_{1500}}{Population_t}$	0.341***	0.186***	0.175***			
	(0.101)	(0.064)	(0.059)			
ln(Relative GDP Density)				0.202***	0.203***	0.205***
				(0.011)	(0.011)	(0.011)
Trade Center				0.0048		
				(0.017)		
ln(Distance to Trade Center)					0.0103	
					(0.023)	
Commercial Importance						-0.0074
						(0.007)
R^2	0.964	0.955	0.948	0.919	0.919	0.919
ACME				0.0661***	-0.0786***	0.0317***
Direct Effect				0.0054	0.0111	-0.0072
Total Effect				0.0715***	-0.0675**	0.0246***
% of total mediated				92.1***	115.1**	128.1***
					Equation (10)	
					ln(Relative GDP Density)	
Trade Center				0.3316***		
				(0.063)		
ln(Relative GDP Density)					-0.3799***	
					(0.103)	
Commercial Importance						0.1565***
						(0.023)
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes
NUTS-1 Dummies	Yes	Yes	Yes	Yes	Yes	Yes
All Robust Controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	85	182	203	818	818	818
R^2				0.939	0.938	0.94

Notes. Robust standard errors are reported in parentheses. Coefficient is statistically different from zero at the ***1 %, **5 % and *10 % level. The unit of observation is a NUTS-3 region. The set of all robust covariates encompasses altitude, the ln distances to airports and railroads, dummies for district free cities, capital cities, capital cities of autonomous regions, post-communistic transition countries, Eastern Germany, the ln of a region's area, the share of people with tertiary education, the inequality measure and the printing press before 1500 AD dummy. Each regression includes a constant not reported. ACME is the "Average Causal Mediation Effect" and means how much of the effect of medieval trade is mediate, i.e. works indirectly through the relative GDP density.

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