Crawford School of Public Policy

CAMA

Centre for Applied Macroeconomic Analysis

Lives Versus Livelihoods in the Middle Ages: The Impact of the Plague on Markets over 400 Years

---

CAMA Working Paper 9/2022
January 2022

Jakob B. Madsen
University of Western Australia
Centre for Applied Macroeconomic Analysis, ANU

Peter E. Robertson
University of Western Australia

Longfeng Ye
RMIT University

Abstract

To what extent did outbreaks of bubonic plague disrupt daily economic activity? We estimate the impact of epidemics on regional markets over four centuries – from the Black Death in the 14th century, until the medieval form of the plague became extinct in the 17th century. Despite the extreme mortality risk of bubonic plague, we find that outbreaks only had a modest impact on trade costs and market integration, as measured by local variations in wheat prices. The results provide quantitative evidence on how the lives versus livelihoods tradeoff was managed through history and the extent to which people learned to live with plague. They suggest that economic activity in low income societies is very resilient to epidemics.

Keywords

Epidemics, Trade Costs, Social Distancing, Black Death, Public Health, COVID-19.

JEL Classification

I15, N33, I18, N13

Address for correspondence:

(E) cama.admin@anu.edu.au

ISSN 2206-0332

Lives Versus Livelihoods in the Middle Ages: The Impact of the Plague on Markets over 400 Years

Jakob B. Madsen
University of Western Australia

Peter E. Robertson*
University of Western Australia

Longfeng Ye
RMIT University

January 13, 2022

Abstract

To what extent did outbreaks of bubonic plague disrupt daily economic activity? We estimate the impact of epidemics on regional markets over four centuries – from the Black Death in the 14^{th} century, until the medieval form of the plague became extinct in the 17^{th} century. Despite the extreme mortality risk of bubonic plague, we find that outbreaks only had a modest impact on trade costs and market integration, as measured by local variations in wheat prices. The results provide quantitative evidence on how the lives versus livelihoods tradeoff was managed through history and the extent to which people learned to live with plague. They suggest that economic activity in low income societies is very resilient to epidemics.

Keywords: Epidemics, Trade Costs, Social Distancing, Black Death, Public Health, COVID-19.

JEL: I15, N33, I18, N13

*Corresponding author: Peter Robertson, Department of Economics, University of Western Australia, 35 Stirling Hwy, Crawley WA 6009, peter.robertson@uwa.edu.au

1 Introduction

The COVID-19 pandemic has no precedence in the post-WWII era and governments have had little experience to guide decision making, especially with respect to the trade-off between lives and livelihoods. The interaction between infectious diseases and economic livelihoods, nevertheless, has a very long history. In this paper, we examine the historical trade-off between health and economic outcomes during the Second Plague Pandemic, from the Black Death in the 14^{th} century until to the 17^{th} century.

Over this period thousands of plague outbreaks occurred, including at least one outbreak in every year until 1670 (Alfani and Murphy, 2017; Demeure et al., 2019; Barbieri et al., 2020; Susat et al., 2020). While many descriptive accounts exist of the social effects of the plague, it is nevertheless unclear how disruptive these outbreaks were in economic terms. Did they result in social and economic breakdown? Or did the necessity of daily work require that people learned to live with the plague, despite the extreme risks?

We aim to provide a quantitative answer to this question by measuring the extent to which outbreaks disrupted market activity. Specifically, we use a standard trade cost model to assess the extent to which local plague outbreaks increased wheat price differentials across districts. The data combine thousands of geo-coded observations of plague outbreaks and local wheat prices over four centuries.

Despite the many accounts of severe social disruption, we find that regional outbreaks of plague had little impact on regional wheat market integration. Specifically, a single instance of an epidemic is associated with only a 3.9% to 16% increase in contemporaneous price dispersion. This is shown to be a modest impact relative to other factors affecting trade costs, such as access to rivers, ports and Roman roads. Hence, while local economies suffered enormous demographic shocks, our evidence suggests that plague outbreaks had a relatively modest impact on trade and markets. Our results contrast with many descriptions of mass of social disruption – including people fleeing in panic, empty towns, abandoned farms and wandering livestock (Shrewsbury, 1970; Ziegler, 1972; Horrox, 1994; Defoe, 2003; Preest, 2012). While these may have happened, our results suggest they were, perhaps, relatively isolated and fleeting.

The association between plague outbreaks and wheat market integration also reveals how people behaved under the most acute circumstances of fear and economic necessity. Moreover the results provide a unique view of the endogenous fall in economic activity from an epidemic in the absence of significant coordinated government or civic interventions. They thus provide a useful historical benchmark that suggest that, in the absence of mandated lock-downs and non-pharmaceutical interventions, economic activity in poorer countries can be very resilient to a pandemic.[1]

Our paper complements related literature on historical trends in trade costs and the evolution of market integration. It is also related to an extensive literature on the effects of the Black Death on factor returns, long-run development, demographic transitions and unified growth theories. In contrast to this literature, our focus is on the contemporaneous impact of plague epidemics on price dispersion across markets. Thus, our study is the first to estimate the impact of plague outbreaks on trade costs and market integration in pre-industrial economies, as well as the first use of this pre-industrial pandemic to understand voluntary social-distancing and the lives versus livelihood trad-offs in subsistence economies.

The paper is organized as follows. Section 2 provides a more detailed overview of the related literature. Section 3 presents the model of trade integration and the data, and discusses the identification strategy. The results are discussed in Section 4. Section 5 discusses the implication of the results for understanding the costs of social distancing policies in contemporary subsistence economies, and Section 6 concludes.

2 Related Literature

The Black Death, 1346-1353 was the most severe pandemic in Western history with estimated fatality rates ranging from 30% of the population to more than 60% (Shrewsbury, 1970; Dyer, 2002; Benedictow, 2004, p.377; Broadberry et al., 2015; Clark, 2016). It was, however, only the start of the “second pandemic” which devastated Europe from the 14^{th} to the 17^{th} centuries with thousands of recorded plague outbreaks. These include, for example, the second wave plague (1361-2), the Children’s plague (1375), and an epidemic every decade from 1390 to 1500 (Dyer, 2002, p.274). The medieval strain of bubonic plague dramatically re-surfaced one final time in the Great Plague of London from 1665-1666 and the Great Plague of Marseille 1720-1722 before this strain became extinct (Bos et al., 2011; Alfani and Murphy, 2017; Demeure et al., 2019; Namouchi et al., 2019; Spyrou, 2019; Demeure, 2019; Susat et al., 2020; Barbieri et al., 2020).

Contemporary sources provide two quite distinct pictures of how plague outbreaks affected people’s livelihoods. English chronicles of the Black Death, for example, describe grass growing in the streets of Bristol and Oxford, sheep and cattle wandering, uncul-

[1] See below for a discussion of the history of quarantine in Europe.

tivated land and towns locking their gates.[2] There is also extensive evidence of social breakdown and mass hysteria, such as claims of "a breakdown of … the laws of God and man", and that "fathers and mothers refused to nurse and assist their own children" (Boccaccio, 2003). Similarly, Defoe's account of the Plague in London in 1665 describes how "… the children ran away from their parents … and … parents did the like to their children" and of "distressed mothers, raving and distracted, killing their own children" (Defoe, 1772).

Nevertheless chronicles may have exaggerated the facts, using clichéd grotesque imagery for literary impact (Dyer, 2002 p.231). Similarly, even if true, it is unclear how widespread such instances were.

Alternative evidence comes from Probate records from the court of Husting, and Guildhall records. These suggest that, even during the Black death, London's administration continued to function, dealing with an excess number of wills and property deeds, guardianship cases and replacements of clerics and guildhall officers. Likewise, sanitary concerns were addressed – Edward III ordered the streets to be cleared of "faeces and filth" to reduce "the mortality of by the contagious sickness"; new cemeteries were created outside of towns; and clerical vacancies were recorded (Ziegler, 1972, p.160; Dyer, 2002, p.273; Gummer, 2009, pp.104, 110, 369). Gloves were thought to offer protection from infection and ordinances were introduced in London to fix the price of gloves (Gummer, 2009, p.104). These records thus temper the image of social breakdown. Likewise by the 17^{th} century, Cummins et al (2016) suggest that plague outbreaks in London were treated just part of daily life amid other administrative and civic problems and there is evidence that by this stage plague was typically viewed as a disease of the poor and outer suburbs (Cummins et al, 2016, Newman, 2012).

Thus, widely differing accounts exit of how people responded and the resilience of everyday economic life. While clearly there were episodes of panicked self-preservation and suggestions of social and economic breakdown, we don't know how extensive or fleeting these episodes were and whether they applied to all segments of society or only to some, such as those wealthy enough to consider evasive actions.

[2]Grass growing in the streets of Bristol and Oxford is described by Seyer, Memoirs of Bristol, cited in Ziegler (1972, p.135) and in Chronicon Galfridi le Baker de Swynebroke, cited in Preest (2012). Untended stock is described in Knighton's Chronicle, p.120, cited in Gummer (2009, p.155), in Historia Roffensis, cited in Horrox (1994, p.72), and in Shrewsbury (1970, pp.62-63). The Chronicon Galfridi le Baker de Swynebroke (Preest, 2012), reports that "the people of Gloucester denied admission to people from Bristol, believing that the breath of those who had lived among the dying would be infectious"(Preest, 2012). For further discussion see also Gummer (2009, p.113, p137), Thompson (1889), Ziegler (1969), and Benedictow (2004, p.130).

We aim to bring evidence to bear on the question using data on wheat prices across regions to assess the level of market integration and how this was affected by epidemics. Hence, we obtain a quantitative measure of the extent of economic disruption caused by epidemics through history, as evidenced by the increased price dispersion across wheat markets. This measure of market and trade disruption can be compared with standard measures of trade costs to give an objective measure of the resilience of pre-industrial societies to infectious disease outbreaks.

Our paper contributes to an extensive literature on the effects of the Black Death. The primary focus of this literature is on the impact of the decimation of the population on factor returns and macroeconomic impacts – especially the effect of the loss in population on rising wages and falling rents (Dyer, 2002, pp.293-297; Pamuk, 2007; Clark, 2007; Clark, 2015; Broadberry et al., 2015; Clark, 2016; Humphries and Weisdorf, 2019; Jedwab et al., 2019). Related to this is the literature that explores the impact of labour scarcity on the feudal social system and other types of conflicts including persecutions (Hirsliefer, 1968; Clark, 2001; Cohn, 2007; Alfani and Murphy, 2017; Jedwab et al., 2020).[3]

Similarly, our paper is related to recent literature on the effects of plague on long term economic development and demographic transitions (Galor and Weil, 2000; Lagerlöf, 2003; Ashraf and Galor, 2011; Clark, 2016; Alfani, 2020b; Siuda and Sunde, 2021). This includes studies of the impact of epidemics on urbanization (Alfani and Percoco, 2019; Jebwab et al., 2019), institutions and human capital (Dittmar and Meisenzahl, 2020). Jedwab et al. (2020a), Jordà et al. (2021) and Alfani (2020a) provide overviews of different aspects of these studies that aim to understand the long run effects of epidemics. In contrast to this literature, our focus is on the contemporaneous and short run effects of successive plague outbreaks.

Our paper is also relevant to an extensive literature on historical trends in trade costs and the evolution of market integration (see, for example, O'Rourke and Williamson, 1999, 2003; Jacks, 2005; Jacks et al., 2010). In particular, this literature examines on historical price differentials as a measure of trade costs or market integration. While most of this literature focuses on the 19^{th} century, several studies have also considered the evolution of market integration since the 14^{th} century (see, e.g. Bateman, 2011; Campbell and Ó Gráda,, 2011; Chilosi et al., 2013; Clark, 2015; Frederico et al., 2021). The

[3] Archaeological records also show a steep decline in building activity and church construction (Ljunqvist et al., 2018; Campbell, 2019; Buringh et al., 2020). In England disputes over wages culminated in the Ordinance of Labourers in 1349, which sought to reset nominal wages to pre-plague levels (Gummer, 2009, p.215; Rosenberg and Birdzell, 1986). For reviews of this literature on the socio-economic of the Black Death also see Ziegler (1972, ch.15), Benidictow (2004), Clark (2008), Campbell (2016) and Alfani and Ó Gráda (2018).

focus of this literature, however, is the importance of market integration as a precursor to industrialisation. In contrast, our focus is on the impact of epidemics on market integration, and not connection between market integration and economic development.

This paper also contributes to the recent literature on COVID-19 that seeks to understand its economic effects and, particularly, the extent of voluntary social distancing responses (for e.g. Brooks et al., 2020; Van Bavel et al., 2020; IMF, 2020; Rojas et al., 2020; Gupta, 2020b, and; Chetty et al., 2020). Understanding the economic impact of COVID in the absence of state mandated interventions has been an important part of evaluating the efficacy of mandated lockdowns. For low-income economies in particular, it has been suggested that mandated social-distancing laws may do more harm than good by denying people access to a means of living (Brown et al., 2020; Mobarak and Barnett-Howell, 2020; Ravallion, 2020; Decerf et al., 2020; Piper, 2020). Moreover, given the lack of contemporary experience of pandemics, many studies have looked to past pandemics to understand the economic impacts, especially the 1918 flu pandemic (Barro, 2020; Beach et al., 2020; Bodenhorn, 2020; Bridgman et al., 2020; Galletta and Giommoni, 2020; Correia et al., 2020a; Correia et al., 2020b; Chapelle et al., 2020; Lilley et al., 2020; Arthi et al., 2021). We also aim to use historical data to understand how people react to fear during epidemics. Rather than examining the 1918 flu, however, we employ data on the thousands of individual epidemic outbreaks that occurred over the Second Plague Pandemic from the 14^{th} to 17^{th} centuries.

The period of the Second Plague Pandemic period also offers two unique insights relative to the existing literature. First, it represents a time when there were few state interventions. Thus our sample provides a relatively pure measure of the impact of fear, and the inconvenience of excess mortality, uninhibited by different degrees of public health controls.[4]. Second, our data also reflect the impact on societies who lived at subsistence income levels, depending on daily work to survive. Thus, while our data is historical, the conditions mimic economic and health standards that are, unfortunately, still relevant today for 10-50% of the world's population.[5]

[4]Isolated quarantine experiments occurred during the Black Death, including people being entombed in their homes in Milan (Zielger, 1972, p.54, p.138.) Nevertheless, these were short lived and unsuccessful. Maritime quarantines were first established in Ragusa (Dubrovnik, Croatia) in 1377. Venice adopted the 'lazaretto' (quarantine station) in 1423, which was then emulated though Italy and French ports, but systems were still being adopted in the 16^{th} and 17^{th} centuries and were not widespread until the 18^{th} century (Gensini et al., 2004.) State quarantine measures were not adopted in England until 1663 (Mafart and Perret, 1998; Tognotti, 2013; Newman, 2012). These measures were primarily applied to the poor (Cummins et al, 2016)

[5]The World Bank (2020) reports approximately 10% of the world population live in extreme poverty of under $US 1.90 per day and about a quarter of the global population is living below the $US 3.20 poverty line, and almost half is living below the $US 5.50 line. Allen (2005), Clark (2005) and Galor (2011) compare living standards through history.

This study, therefore, represents the first attempt in the literature to measure the impact of the bubonic plague on trade costs and market integration, as well as the first study to use the long history of early to late medieval plague, to study the contemporaneous economic effects of epidemics.

3 Convergence of Wheat Prices

Pre-industrial European society was heavily dependent on grain which was produced in the manorial system and traded across an extensive network of markets and fairs that connected all towns economically by the 14^{th} century (Langdon and Masschaele, 2006; Campbell, 2009; Bateman, 2011). Since markets, along with the Church, were at the centre of social life, wheat market activity provides a useful perspective on total social and economic activity.

We consider two samples of wheat price data. The first covers English manors over the period 1348-1400. This market was highly integrated due to: well-developed transport networks, including stone and timber bridges; a network of river barges and cogs, and; an absence of tolls.[6] Moreover, the manorial districts in our data are almost all in Southern England, which served as an agricultural catchment for London (Galloway, 1995, pp.7-8). As such this specific market was well developed and, in particular, it was supported by regulatory institutions, such as standards for weights and measures, hygiene, credit and debt (Galloway, 2000; Dyer, 2002, p.24; Davies, 2011).[7]

The second sample is city price data for six European countries over the period 1348-1700, including the data for Southern England. This covers a larger range of regions and hence the level of integration of markets is more heterogeneous than that of the English sample. Nevertheless, grain was widely traded across Europe as early as the 14^{th} century (Bateman, 2011; Frederico et al., 2021). For this sample we use observations at the level of cities, where the number of cities within each country ranges between four and eighteen.

As shown by Jacks et al. (2010), trade costs can be estimated using both price and quantity models that are motivated by a wide array of different theoretical models of trade. Price data are ideal proxies for market integration in the pre-industrial period, partic-

[6] See Dyer (2002, pp.214-215) and Gummer (2002, p.136). A 150-mile trip from Gloucester to London by a horse drawn cart took eight days. River barges and cogs carried larger payloads at lower costs.

[7] Clark (2015) provides evidence that wheat markets were well integrated by the time the Black Death arrived in England rebutting McCloskey and Nash (1984) who had argued that the economy of the 14^{th} century has been characterised as being highly restricted under feudal order.

ularly grain price data, because of product homogeneity, storage possibilities and large trade volumes that resulted in efficient arbitrage opportunities across markets (Engel and Rogers, 1996; Jacks, 2006; Frederico et al., 2021).

Our model specification therefore follows an established literature in which variations in grain prices between districts or cities indicate the degree of market integration (O'Rourke and Williamson, 1999, 2003; Jacks, 2004, 2005, 2010; Chilosi et al., 2013; Federico et al., 2011, 2021). We measure price variation by the coefficient of variation, cv, which normalises price differences by the mean price level, to adjust for general changes in overall price levels. If markets are autarkic, then the upper limit of cv is set by natural variations in autarky prices across regions. If markets are completely integrated, then the law of one price applies and cv approaches zero. Hence, we are interested in how outbreaks of plague increase cv relative to the level implied by normal trade costs.

The following model is estimated for Southern England manorial districts,

$$cv_{ijt}^{Eng} = \alpha_0 + \alpha_1 epi_{ijt-1}^{Eng} + \alpha_2 \ln dis_{ij}^{Eng} + \Omega_{ij}^{Z} + \vartheta_i + \theta_j + \gamma_t + \varepsilon_{1,ijt}, \tag{1}$$

and for European cities we estimate the model,

$$cv_{ijt}^{EU} = \beta_1 epi_{ijt-1}^{EU} + \beta_2 \ln dis_{ij}^{EU} + \beta_3 \ln pop_{ct}^{EU} + \beta_4 temp_{ct}^{EU} + \Omega_{ij}^{Z} + \vartheta_i + \theta_j + \gamma_t + \varepsilon_{2,ijt}, \tag{2}$$

where: cv_{ijt}^{Eng} is the coefficient of variation of wheat prices across Southern English districts i and j at time t; cv_{ijt}^{EU} is the coefficient of variation of wheat prices across European cities i and j at time t; epi_{ijt-1}^{Eng} is a one-year lag of counts of epidemics across English districts i and j; epi_{ijt-1}^{EU} is a one-year lag of counts of epidemics across European cites i and j; dis_{ij}^{Eng} is the geographic distance between English districts i and j; dis_{ij}^{EU} is the geographic distance between European cities i and j; pop_{ct}^{EU} is the average of countrywide population size between countries, where i and j are located and the subscript "c" indicates the variable is measured at the country level; $temp_{ct}^{EU}$ is the average of countrywide temperature between countries where i and j are located; Ω_{ij}^{Z} is a dummy variable taking the value of one if both districts/cities i and j have advanced transport infrastructures, ($Z \in$ Roman roads, rivers, and coast) within a distance below the sample median; ϑ_i and θ_j are district/city-specific effects; γ_t are time-effects, and; ε is a stochastic error term. Note that the country fixed effects are omitted from the European sample because they are absorbed by the city-specific effects ϑ_i and θ_j.

Next, we need to consider the spatial impact of plague and the dimensions of a market.

As noted above, an extensive network of markets existed even by the 13^{th} century. Towns in England, for example, had a hinterland through which the population could regularly travel within a return-day's walk of a 16 km radius. Likewise, the distribution of local pottery in archaeological sites is concentrated within a 24 km radius of a town, suggesting an upper limit on the local market in geospatial terms (Dyer, 2002, p.191; Langdon and Masschaele, 2006; Campbell, 2009; Bateman, 2011). We therefore define the key variable epi_{ijt} as the sum of the recorded number of epidemics for district/city i and j at time t within a given radial distance from district/city i or j. In the baseline regressions, we limit the distance to a radius of 20 km and extend the distance setting in the robustness section.

Epidemics are measured in counts. If both districts/cities i and j have an epidemic outbreak, then $epi_{ij} = 2$; if district/city i has 1 epidemic while district/city j has 2 epidemics, then $epi_{ij} = 3$, etc. The temperature is measured as the difference between temperature at period t and the mean temperature over the period 1961-1990. The standard errors are clustered at the district/city-pair ij level to cater for potential heteroscedasticity and serial correlation in the error terms. Initially, we included the interaction between epidemics in districts/cities i and j; however, we excluded them from the model because their coefficients were insignificant.

The population size is included in the European sample to capture the lower trade costs that follow from positive scale effects in terms of transaction costs and better developed road networks. The expected effect deviates from contemporary gravity model estimates in which trade is assumed to be negatively related to population size because the number of domestically produced product varieties is increasing in the population size (see, e.g., Jacks et al., 2010). This argument does not apply in our case since we are considering a single commodity, wheat. We use countrywide population size because data on city populations are only available in 100-year intervals or longer and, therefore, cannot give sufficient identifying variation over time. Population is not included for Southern England because the population effect is captured by the time fixed effects.

The epidemics indicators are lagged one year to allow an epidemic outbreak to take effect on trade. The lag will also alleviate potential feedback effects from the dependent variable. Finally, the infrastructure effects, Ω^{Z}_{ij}, are included as controls in Eqs. (1) and (2) to ensure that the coefficients of epidemics are not biased against the null hypothesis as argued in the next sub-section.

3.1 Endogeneity

There is a possibility that the coefficient of *epi* is biased downwards because of potential feedback effects from trade to epidemics. To understand these potential feedback effects, it is important to understand the causes of the Black Death and Second Plague Pandemic of the 14^{th} to 17^{th} centuries and the disease transmission process.

While the causes and origins are still debated, ancient DNA records suggest the medieval and late medieval plague, and plague throughout 5000 years of human history, is a form of modern bubonic plague caused by strains of the bacterium *Yersinia pestis*. Nevertheless it has been widely observed that the epidemiology of medieval plague does not fit with the characteristics of modern bubonic plague, which the modern variant apparently spreading much more slowly (Shrewsbury,1970; Cohn, 2008; Wood et al., 2003; Dean et al., 2018). Thus while modern bubonic plague is endemic in certain rodents such as rats and is transmitted by parasites such as animal fleas and lice, the transmission process in medieval plague may have differed.

The medieval form is believed to have originated from rodents in Asia and was transferred to Western Europe along Silk-Road trade routes via Russia and Crimea in 1346 and through Italian merchant ships in 1347. Similarly maritime trade routes appear to explain the initial distribution of the Black Death throughout Europe, with the Black Death arriving in Marseilles in November 1347, Mallorca in December, and Weymouth, England, in June 1348 before travelling back across Northern Europe (Benidictow, 2004, pp. 44, 72, 126). Beyond this, the causes of plague re-occurrence during the four-century long Second Plague Pandemic, are less clear.

One view is that plague was continually reintroduced to Europe from Asian animal populations through the fur trade and Silk-Road trade on camels and across the sea by rats, over the whole Second Plague Pandemic (Haensch et al., 2010; Schmid et al., 2015; Namouchi et al., 2019; Bramanti et al., 2021). Thus, for example Schmid et al. (2015) argue that climatic conditions in Asia affected plague outbreaks in Europe.

Nevertheless, the ancient DNA evidence also strongly suggests a single bacterium genotype persisted in Europe over the 14^{th}-17^{th} centuries. This in turn suggests that, while the bubonic plague was likely introduced to Europe via trade routes, it became established in natural rodent-populations within Europe that evolved and persisted until the 18^{th} century (Bos, 2016; Seifert et al., 2016; Spyrou et al., 2019). In this scenario, outbreaks of plague will only depend on local conditions that affect rodent and flea populations.

Likewise, the transmission mechanism from animal reservoirs to humans and between humans is unclear. The modern bubonic plague is spread when rodent parasites infect humans and it is argued this was also true for the Second Plague Pandemic (Haensch et al., 2010; Demeure et al., 2019; Benedictow, 2019). There is also evidence, however, that primary transmission during the Second Plague Pandemic Plague was human ectoparasites, such as human fleas or lice, rather than rodent ones (Drancourt et al., 2006; Hufthammer and Walløe, 2013; Dean et al., 2018; Barbieri et al., 2019, 2020, 2021). Again this emphasises the likelihood that plague was endemic in European, and didn't depend on the transportation of rats or fleas on ships and camel trains.

Thus, the dynamics of the plague and its causal factors are not well understood. The existence of local reservoirs in Europe would make outbreaks spontaneous, and the role of trade routes or Asian climatic factors beyond the initial introduction to Europe is unclear. Nevertheless, to alleviate the potential endogeneity of our key variable, epidemics, we control for the geographic proximity including the distance to the nearest Roman roads, main navigable rivers, and the coast, noting that the Roman network of roads was widespread in all the regions we consider. We use these variables as controls and not as instruments. Thus, we do not use the standard identification strategy in the literature in which geographic characteristics are often used as instruments for bilateral flows (trade, emigration, FDI, etc.), partly because of spatial correlation and violations of exclusion restrictions (Kelly, 2019; Deij et al., 2021).

Using the distance to the nearest Roman roads, main navigable rivers, and the coast as controls, instead of instruments, overcomes the potential inconsistency in 2SLS regressions that is driven by violations of the exclusion restriction: while a well-developed infrastructure may increase the transmission of diseases across markets, it is also associated with more trade through lower transport costs. Thus, if infrastructure instruments are used, the coefficients of epidemics may capture the effects of transport costs, not the potential spread of epidemics through trade. Inclusion of infrastructure effects, Ω_{ij}^{Z}, as controls in Eqs. (1) and (2) ensure that the coefficients of epidemics are not biased because any potential negative effect of travel costs on trade is captured by epidemics. Easier access to Roman roads, navigable rivers and the coast, for example, simultaneously reduces trade costs and, potentially, increases the incidence of disease – if we accept the thesis that plague was continually being reintroduced to Europe, as opposed to the thesis that it was endemic in local reservoirs of rodents and parasites. In this former scenario, excluding infrastructure from the regressions biases the coefficients of epidemics downward and, hence, reduces the likelihood of rejecting the null hypothesis that epidemics have no effect on trade costs and market integration.

3.2 Measurement

Following the literature (see, e.g., Federico et al., 2011, 2021; Chilosi et al., 2013), we measure market integration by the coefficient of variation between district/city i and j at time t:

$$cv_{ijt} = \frac{\sigma_{ijt}}{\overline{p}_{ijt}} = \frac{\sqrt{\left(p_{it} - \overline{p}_{ijt}\right)^2 + \left(p_{jt} - \overline{p}_{ijt}\right)^2}}{\overline{p}_{ijt}}, \tag{3}$$

where σ_{ijt} is the standard deviation of the wheat prices of district/city i and j, and $\overline{p}_{ijt}$ is the mean wheat price of district/city i and j. An increase in the coefficient of variation is associated with an increase in the wheat price dispersion across markets and hence a disruption of local trade networks. However, a general price rise in all prices due, for example, to inflation from labour shortages and wage rises, changes the numerator and denominator equally, leaving the coefficient of variation unchanged.

3.3 Data

This sub-section discusses the most important variables. Details and sources for all variables are relegated to the online Appendix. Figure 1 shows the locations of the markets/towns/cities included in the two datasets and summary statistics are given in Table 1.

Epidemics. Data on epidemic plague outbreaks are from Büntgen et al. (2012), which is a digitalized version of Biraben (1976).[8] These sources include annual spatial information, i.e., the geographic coordinates of the place where epidemics occurred. We use geocoding to map epidemic outbreaks to calculate the number of recorded epidemic outbreaks for each wheat district/city i or j.

Infrastructure. The distance of each wheat district/city i or j to the nearest Roman road, main navigable river, and coast is calculated using ArcGIS with the relevant shape files. The data on distance are then used to construct geographic proximity dummies that take the value of one if the distances to the nearest Roman road, river or coast for both districts/cities i and j are below the sample median.

[8] Given medieval medical knowledge some of the epidemics in the data may have been due to other highly infectious and deadly diseases. Other common diseases were cholera, typhus and smallpox (Shrewsbury, 1970; Cummins et al, 2016, Robb et al., 2021).

Wheat Prices, Southern England. We use several data sources as detailed in the online Appendix and the wheat price data predominantly pertain to manors. Wheat prices are for 15 districts located in Southern England (except for Durham) over the period 1348-1400. Later data are not available.

Wheat Prices, Europe. We use data over the period 1348-1700 for 66 cities distributed over the following six European countries: Britain (18), France (18), Germany (6), Italy (12), Portugal (4), and Spain (8), where the numbers in parentheses signify the number of cities that are included for each country. Wheat prices are expressed in silver grams per litre to ensure comparability across cities without resorting to transformations to a common currency (most Italian cities in our sample, for example, had different currencies). We draw primarily on the Global Prices and Incomes History (GPIH) group and the Allen-Unger global commodity database (the Allen-Unger database; Chilosi et al., 2013; Federico et al., 2018). The estimation period ends in 1700 since the number of recorded epidemics declined markedly after 1700.

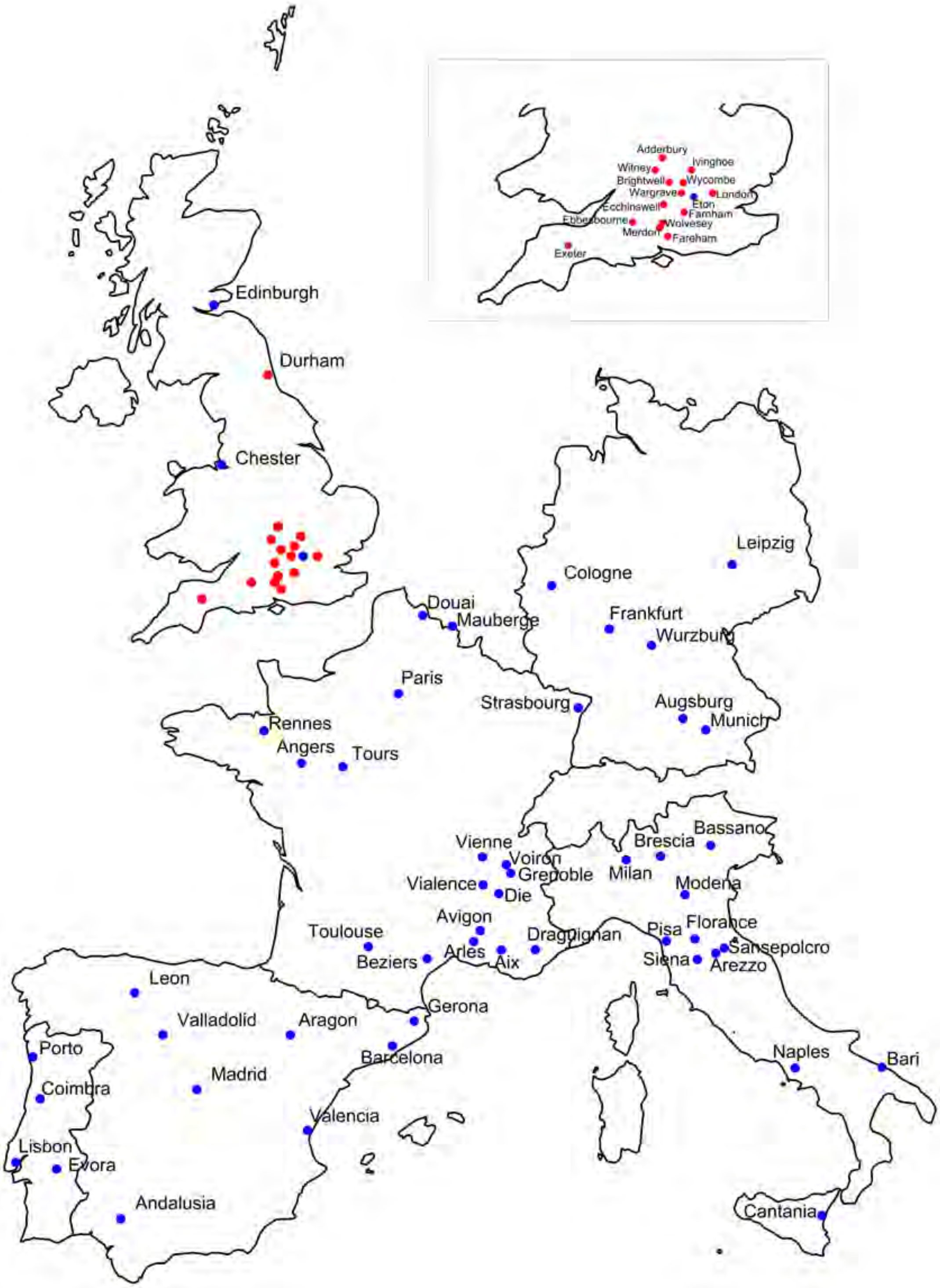

Figure 1: Locations of Markets

Notes: The Southern England sample consists of 15 wheat markets pertaining to manors located in Southern England (except for Durham) with wheat price data over the Black Death period. The European sample consists of 66 wheat markets (including markets in the Southern England sample) distributed over six countries with wheat price data over 1348-1700. See online appendix for more details.

Table 1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Southern England					
cv_{ijt}^{Eng}	5,095	0.150	0.123	0	0.777
epi_{ijt}^{Eng}	5,095	0.054	0.241	0	2
$\ln dis_{ij}^{Eng}$	5,095	4.463	0.851	2.178	6.153
$road_{ij}$	5,095	0.183	0.387	0	1
$river_{ij}$	5,095	0.250	0.433	0	1
$coast_{ij}$	5,095	0.250	0.433	0	1
Europe					
cv_{ijt}^{EU}	132,437	0.282	0.216	0	1.34
epi_{ijt}^{EU}	132,437	0.137	0.391	0	7
$\ln dis_{ij}^{EU}$	132,437	6.508	0.836	2.178	7.811
$\ln pop_{ct}^{EU}$	132,437	9.25	0.443	6.925	9.93
$temp_{ct}^{EU}$	132,437	-0.439	0.158	-0.86	0.077
$road_{ij}$	132,437	0.201	0.401	0	1
$river_{ij}$	132,437	0.367	0.482	0	1
$coast_{ij}$	132,437	0.226	0.418	0	1

Notes: The identical summary statistics for 'river' and 'coast' for is not an error. $road_{ij}$ is access to Roman roads within a distance below the sample median; $river_{ij}$ is access to rivers within a distance below the sample median; $coast_{ij}$ is access to the coast within a distance below the sample median. See the first paragraph after Eqs. (1) and (2) for definitions of the non-infrastructure variables.

4 Results

4.1 Empirical estimates for Southern England

The results of estimating Eq. (1) are shown in Table 2. The coefficient of epi_{ijt-1} is significantly positive at the 1% level in all regressions and the magnitude of the coefficient is largely insensitive to the inclusion of district-effects, time-effects, and infrastructure variables, suggesting that the estimated coefficients of epidemics, epi_{ijt-1}, are driven by within district-effects, and other common factors that are progressing at the same rate across districts. The coefficient of epi_{ijt-1} shrinks from 0.24 to 0.19 but is significant at the 5% level in the model in column (4) if Durham, as a geographic outlier, is excluded from the sample.

The coefficients of geographic distance are significantly positive at the 1% level in the regressions in the first three columns, suggesting that geographic distance reduces trade through increasing resistance/trading costs, as we would expect. However, the coefficient of geographic distance is rendered insignificant when the infrastructure variables (access to Roman roads, rivers and coast) are included in the regression (column (4)). These results suggests that the quality of infrastructure dominates geographic distance as a determinant of transport costs; a result that is consistent with the finding of Limao and Venables (2001) based on estimates of the gravity model using contemporaneous cross-country data. The results are also consistent with the analysis of Jones (2000), showing that carriage by land (non-Roman roads) could be more than ten times the cost of transport by water during the medieval period. The Thames waterways greatly extended the market for grain and fuel supplied to the capital around 1300 (Jones, 2000).

Table 2: Estimates for Southern England, 1348-1400

dep var = cv_{ijt}^{Eng}	(1)	(2)	(3)	(4)
epi_{ijt-1}	0.026***	0.025***	0.024***	0.024***
	(0.007)	(0.007)	(0.008)	(0.008)
$\ln dis_{ij}$	0.035***	0.052***	0.052***	0.009
	(0.004)	(0.009)	(0.009)	(0.008)
$road_{ij}$				-0.037***
				(0.009)
$river_{ij}$				-0.060***
				(0.010)
$coast_{ij}$				-0.070***
				(0.011)
ϑ_i, θ_j	N	Y	Y	Y
τ_t	N	N	Y	Y
Obs	5,095	5,095	5,095	5,095
R^2	0.062	0.170	0.275	0.295

Notes. ϑ_i and θ_j are district-specific effects and τ_t is time-effects. Robust standard errors, clustered at the ij level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

While the key coefficients are significant we want to establish how large the impact of epidemics was on price dispersion. In our model, a regional plague outbreak can be interpreted as an additional localized barrier to trade. Hence for context, and economic significance, we compare the effect of epidemics against the other observable trade barriers in the model, Roman roads, and access to rivers and coast lines. These comparisons are reported in Table 3, which are based on the reported coefficients from our preferred model (column (4), Table 2).

The effect on price-dispersion of a one standard deviation increase in the infrastructure variables for Southern England can be seen to be: -24.7% for access to Roman roads; -40% for access to rivers, and; -40.6% for access to the coast. The equivalent value for a single plague outbreak is 0.024/0.150 = 16%. Thus lack of access to Roman roads has an effect that is more than 50% larger than a plague outbreak and access to a river or coast has an effect that is 2.5-3 times larger. The joint effects of infrastructure on price-dispersion are approximately seven times larger than the impact of an epidemic ((24.7+40+46.7)/16 = 7). Hence the price variation between London which has rivers, coast and roman roads, and a village that is off the beaten track, would be around 7 times larger than the effect of a plague outbreak in either location.

Comparing the effect of an epidemic with distance is less straightforward since it is log linear and continuous. However the impact of an increase in the log of distance (in this case from Column (3) of Table 2) is 0.052/0.150 = 34.7%, relative to the mean cv^{Eng}. As an example this means that for two markets that are 20 km apart, a plague outbreak is estimated to have a similar impact on the price gap of adding an additional 11.7 kilometres to the distance (estimated as $e^{\ln(20)+0.024/0.052} - 20$). Thus again based on an equivalent increase in distance on trade costs, the impact of a plague outbreak appears to be relatively small.

We can likewise compare the impact of a one standard deviation change in the regressors. This measure takes into account the frequency of epidemics, relative to the variance in other factors, as a contributing factor to price dispersion. It can be seen that mean coefficient of variation, cv^{Eng}, increases by $0.024 \times 0.241/0.150 = 4\%$, in response to a one standard deviation increase in the epidemics. The effects on price-dispersion of one standard deviation increases in the infrastructure variables for Southern England are again much larger than the effect of epidemics: -9.5% for access to Roman roads; -17.3% for access to rivers, and; -20.2% for access to the coast. Overall, therefore, the evidence from this Southern England sample suggests that the impact of epidemics was relatively small in economic terms.

4.2 Empirical estimates for Europe

Turning to the European sample, the number of observations increases from 5095 (for Southern England) to 132,284. However, this increased sample size comes at the cost of greater heterogeneity in the degree of market development and larger distances than the Southern England sample. The results of estimating Eq. (2) over the periods 1348-1700 and 1348-1600 are shown in Table 4.

Consider first the results in columns (1)-(3) where the regressors are restricted to epidemics and geographic distance. The coefficients of epidemics and distance are significantly positive in all cases and their significance declines slightly when city- and time-effects are included in the estimates. Their significance remains insensitive to the inclusion of all the control variables in column (4). Turning to the results in columns

Table 3: Impact of Key Regressors on Price Dispersion Across Markets

	Coefficient	Mean cv	Marginal effect on cv (%)	Std. Dev.	Effect of one Std. Dev. on cv (%)
Southern England					
epi_{ijt-1}	0.024	0.15	16.0	0.241	3.9
$\ln dis_{ij}$	0.052	0.15	34.7	0.851	29.5
$road_{ij}$	-0.037	0.15	-24.7	0.387	-9.5
$river_{ij}$	-0.06	0.15	-40.0	0.433	-17.3
$coast_{ij}$	-0.07	0.15	-46.7	0.433	-20.2
Europe					
epi_{ijt-1}	0.011	0.282	3.9	0.391	1.5
$\ln dis_{ij}$	0.038	0.282	13.5	0.836	11.3
$road_{ij}$	-	-	-	-	-
$river_{ij}$	-	-	-	-	-
$coast_{ij}$	-0.06	0.282	-21.3	0.418	-8.9
Europe ($dis_{ij} \leq 246$ km)					
epi_{ijt-1}	0.016	0.172	9.3	0.322	3
$\ln dis_{ij}$	0.015	0.172	8.7	0.652	5.7
$road_{ij}$	-	-	-	-	-
$river_{ij}$	-0.143	0.172	-83.1	0.453	-37.7
$coast_{ij}$	-0.104	0.172	-60.5	0.422	-25.5

Notes. For Southern England, the coefficients are from column (4) in Table 2, except that the coefficient of $\ln dis_{ij}$ is from column (3) of Table 2. The coefficients for Europe and Europe ($dis_{ij} \leq$ 246 km) are from columns (4) and (7) in Table 4, respectively. The marginal effects refer to the percentage change in cv in response to a unit increase in the explanatory variable, for instance, an outbreak of an epidemic results in a 16% increase in cv.

(4)-(6), the coefficients of temperature are only significantly negative in one of the four cases. The coefficients of population are significantly negative in all cases, confirming our expectation of scale advantages in trade from a higher degree of population density (note that the population is based on unaltered borders throughout the estimation period). The coefficients of distance remain significantly positive at the 1% level in all columns. Of the infrastructure variables, the coefficients of proximity to coast are significantly negative and comparable to the estimates for Southern England, while the coefficients of proximity to Roman roads and navigable rivers do not significantly influence the price dispersion.

Next we consider a sub-sample that is more comparable to the market distances in the Southern England sample by focusing on the within-country city pairs that are 246 km or less apart (column (7), Table 4) over the period 1348-1600, where the benchmark

Table 4: Estimates for Europe, 1348-1700

dep var = cv_{ijt}^{EU}	(1)	(2)	(3)	(4)	(5)	(6)	(7)
epi_{ijt-1}	0.020***	0.016***	0.011**	0.011***	0.016***	0.005*	0.016**
	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.006)
$\ln dis_{ij}$	0.047***	0.037***	0.039***	0.038***	0.039***	0.036***	0.015*
	(0.003)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.008)
$temp_{ct}$				-0.063**	-0.008	-0.016	0.160
				(0.032)	(0.042)	(0.042)	(0.097)
$\ln pop_{ct}$				-0.109***	-0.078**	-0.066***	-0.430***
				(0.018)	(0.026)	(0.024)	(0.107)
$road_{ij}$				0.002	0.004	-0.004	-0.000
				(0.009)	(0.009)	(0.011)	(0.010)
$river_{ij}$				-0.005	-0.002	-0.012	-0.143**
				(0.009)	(0.010)	(0.010)	(0.071)
$coast_{ij}$				-0.060***	-0.040***	-0.066***	-0.104***
				(0.009)	(0.010)	(0.012)	(0.013)
ϑ_i, θ_j	N	Y	Y	Y	Y	Y	Y
γ_t	N	N	Y	Y	Y	Y	Y
$dis_{ij} \leq 246$ km	-	-	-	-	-	-	Y
Period	1348-1700	1348-1700	1348-1700	1348-1700	1348-1600	1600-1700	1348-1600
Obs	132,284	132,284	132,284	132,284	71,479	61,708	9,151
R^2	0.034	0.132	0.180	0.186	0.215	0.185	0.389

Notes. The sample consists of cities in six countries. ϑ_i and θ_j are city-specific effects and γ_t is time-effects. Robust standard errors, clustered at the ij level, are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

number of 246 km represents the sample median distance between cities within a country. Compared to the results with a comparable sample period in column (5), the coefficient of proximity to rivers becomes significant while the coefficient of geographic distance loses some of its significance; a result that is comparable with the regressions for Southern England. This result is intuitive: rivers are comparatively more viable transport routes at short than long distances, perhaps reflecting low transaction costs in terms of loading and off-loading goods. Furthermore, the coefficient of population is more significant at short (column (7)) than at long distances (column (5)), suggesting agglomeration effects between relatively close markets.

Returning to Table 3, we again compare the economic size of these coefficients. The impact of epidemics is 3.9% for the full European sample and 9.3% when the sample is restricted distance below 246 km. Both values are lower than the 16% effect estimated for Southern England, which likely reflects the higher level of market integration in the Southern England sample. Similar to the finding for Southern England, the impact of an epidemic is found to be much smaller than the impact of our transport infrastructure variables when we compare, either, individual effects or the impact of a one standard deviation change. The impact of epidemics in the restricted European sample is now close in size to the impact of distance, but the size of the distance coefficient in this sample is, likewise, much smaller than the Southern England sample and represents only the marginal effect of distance after controlling for other transport variables.

Thus the European results support the earlier results for Southern England in showing a significant but relatively modest impact of epidemics on price dispersion. Overall we find hat the impact of a single incidence of plague ranged from an increase in price dispersion of 3.9% to 16% for different samples and in each case these are small impacts relative to other measures of trade cost variables in the model.

4.3 Robustness Checks

First we consider the sensitivity of the coefficients of epidemics to variations in the radius used in the definition of a local district for Southern England and Europe, recalling that the radius used in the baseline regressions is 20 km. The results for alternative definitions of this local region are shown in Table 5. For both samples, the coefficients of epidemics are significantly positive at market distances of up to approximately 35 km, after which the coefficients lose most of their significance. The coefficients of epidemics are relatively unaffected by maximum distance of up to 35 km, but, beyond 35 km the coefficient declines sharply. This accords with our descriptive evidence suggesting a local market has a radius of around 20km given road conditions and that walking was the main mode of transport.

Table 5: Variations in the Radius for Southern England, 1348-1400 and Europe, 1348-1700

dep var = cv_{ijt}	10 km	20 km	30 km	40 km	50 km
Southern England					
epi_{ijt-1}	0.021**	0.024***	0.021***	0.007	0.005
	(0.010)	(0.008)	(0.007)	(0.005)	(0.005)
Europe					
epi_{ijt-1}	0.014***	0.011***	0.005***	0.002*	0.002**
	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)

Notes. All confounding variables and fixed effects are included in the regressions. The full results are reported in the Appendix Tables A1 and A2. Robust standard errors, clustered at the ij level, are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Next, we allow for the time varying effects of bilateral geographical distance through an interaction between the pairwise geographic distance and the decade dummies to capture the time varying impact of distance as a result of changes/improvements in the transport infrastructure by land and rivers (only very few canals were built before the 18^{th} century). We do the same for the transport infrastructure variables. As shown in the columns (1) in Tables A3 and A4 in the Appendix, the coefficients of epi_{ijt-1} are close to the baseline values, suggesting that epidemics are not biased because of time-variation in the distance resistance terms.

Finally, we check whether the coefficient of epidemics is sensitive to three alternative measures of epidemics in the regression models. First, we include the number of epidemics for districts/cities i and j separately. As shown in columns (2) in Tables A3 and A4 in the Appendix, the estimates of epidemics are both statistically significant with a magnitude similar to that of the baseline regressions. Second, epidemics, epi_{ij}, defined in a dummy variable that takes the value of one if any of the districts/cities i and j records an instance of an epidemic. The results, which are presented in columns (3) in Appendix Tables A3 and A4 remain close to those of the baseline regressions. Third, the models with epidemics are measured in 3-year overlapping intervals to allow for gradual adjustment of market price gaps to epidemic outbreaks and potential mis-recordings of years of epidemic outbreaks. The coefficients of epidemics remain comparable to those of the baseline regressions (columns (4) in Tables 2 and 4).

5 Policy and Contemporary Pandemic Responses

From evidence of thousands of occurrences of plague over four centuries, we have found that local outbreaks had a statistically significant, but quantitatively small, impact on local wheat price variations. The 400 year period also covers a time when there was very little in the way of organized public health interventions. The small estimated impact of epidemics on markets is therefore almost entirely the result of voluntary behaviour, suggesting little voluntary social distancing occurred. It may even simply reflect the economic inconvenience of excess mortality as manor owners had to replenish their workforce and perhaps new mongers had to be found. Thus the results suggest that any avoidance of markets or stifling of inter-village trade was relatively modest.[9]

This apparent resilience of market and trade activity in the face of plague is informative in the context of current debates about the resilience of the economic activity in the face of the COVID-19 pandemic. Several studies that suggested that economic activity was

[9]We can rule out ignorance as a explanation. While there was little understanding of the causes of the plague and means of transmission, superstition was mixed up with a very healthy degree of intuition toward avoiding close contact with the infected and the belief was that the plague was spread by breath or touch. See for example Cohn (2010).

very susceptible to fear of COVID-19 (Rojas et al., 2020; Kahn et al. 2020; Goolsbee and Syverson, 2020; Maloney and Taskin, 2020; Gupta et al., 2020).[10]

Summarising this literature, IMF (2020) found that mandated lockdown measures account for only 50% of the total economic impact of Covid-19, with the remainder due to voluntary or self-imposed mobility and work restrictions. This has also been argued to be the experience of the 1918-1920 flu pandemic (Bodenhorn, 2020; Correia et al., 2020a, 2020b).[11]

Our evidence from the Second Plague Pandemic, however, provides an alternative perspective of human behaviour. Specifically, because they lived close to subsistence, medieval and pre-industrial societies generally had less means to support themselves without work; less savings or stores; greater vulnerability to incremental effects of increased hunger or malnutrition, and a higher probability of job loss due to informal or casual contracts.

These conditions also apply to people in lower income countries, and lower segments of society, today. Hence our results, from the middle-ages through to the dawn of industrialisation, also support recent studies that emphasise the high cost of social distancing in developing economies.[12] Specifically the apparent resilience of economic activity to plague indicates the necessity of economic activity over fear of infection and the potential costs of mandated social distancing policies when people's incomes are close to subsistence.

6 Conclusion

We investigate the extent to which outbreaks during the Second Plague Pandemic disrupted market integration, using data on thousands of geo-coded observations of plague outbreaks and local wheat prices, over four centuries. We find outbreaks of plague during

[10]Rojas et al. (2020) and Kahn et al. (2020) argue that the US state-wide pattern of increasing unemployment was mainly due to voluntary absenteeism based on unemployment insurance claims. Similarly, Goolsbee and Syverson (2020) find that, while consumer traffic fell 60% in the USA, only 7 percentage points of this is explained by restrictions. Gupta et al. (2020) find that 45% of the increase in hours at home was unrelated to stay-at-home policies. Maloney and Taskin (2020) using Google mobility data find that voluntary reductions in population movements are far greater than mandated reductions. See also Brooks et al. (2020) and Van Bavel et al. (2020) for reviews of the evidence around psychological responses to quarantine and related measures.

[11]Lilley et al. (2020) and Bridgman et al. (2020) offer a different interpretation of the evidence.

[12]These include Brown et al. (2020); Bargain and Ulugbek, (2020); Mobarak and Barnett-Howell, (2020); Maloney and Taskin, (2020); Ravallion, (2020); Decerf et al., (2020); Piper, (2020); Miguel and Mobarak, (2021).

the 400-year Second Plague Pandemic, starting with the Black Death in 1348, only had a modest effect on wheat price variations across Southern England and Europe. Specifically we find a single epidemic increases the coefficient of variation of wheat prices by 3.9 - 16 percent. Since this is a quantitatively modest impact and is a smaller effect than the impact of other trade cost variables, such as distance, Roman roads, coastal access and river access, we infer that the impact of plague outbreaks on wheat market integration was relatively small.

The results thus suggest that plague outbreaks had relatively little impact on village and city trade and market activities. In contrast to numerous dramatic historical narratives describing social breakdown, it seems people still attended markets, corn-mongers' carts still travelled along the roads, barges still followed the towpath and towns still opened their gates. Incidents of social disruption – including people fleeing in panic and blockading towns may well have happened, but the quantitative results suggest that these were too fleeting to have a large impact on market activity.

In lieu of many contemporary counterfactuals, the 400-year history of the Second Plague Pandemic is invaluable in understanding how people manage their fear of infection. Despite the frightening fatality rates, economic necessity dominated health risks in these pre-industrial times when daily work was a necessity. This is relevant to many societies today who unfortunately still only pre-industrial standards of living.

Appendix

Appendix Tables

Table A1: Variations in the Radius for Southern England, 1348-1400

dep var = cv_{ijt}^{Eng}	10 km	20 km	30 km	40 km	50 km
epi_{ijt-1}	0.021**	0.024***	0.021***	0.007	0.005
	(0.010)	(0.008)	(0.007)	(0.005)	(0.005)
$\ln dis_{ij}$	0.009	0.009	0.009	0.009	0.009
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
$road_{ij}$	-0.037***	-0.037***	-0.037***	-0.037***	-0.037***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$river_{ij}$	-0.060***	-0.060***	-0.060***	-0.060***	-0.060***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$coast_{ij}$	-0.070***	-0.070***	-0.070***	-0.070***	-0.070***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
ϑ_i ,θ_j	Y	Y	Y	Y	Y
τ_t	Y	Y	Y	Y	Y
Obs	5,095	5,095	5,095	5,095	5,095
R^2	0.306	0.306	0.306	0.305	0.305

Notes. ϑ_i and θ_j are district-specific effects and τ_t is time-effects. Robust standard errors, clustered at the ij level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2: Variations in the Radius for Europe, 1348-1700

dep var = cv_{ijt}^{EU}	10 km	20 km	30 km	40 km	50 km
epi_{ijt-1}	0.014***	0.011***	0.005***	0.002*	0.002**
	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)
$\ln dis_{ij}$	0.038***	0.038***	0.038***	0.038***	0.038***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$temp_{ijt}$	-0.064**	-0.063**	-0.062*	-0.061*	-0.061*
	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)
$\ln pop_{ijt}$	-0.108***	-0.109***	-0.109***	-0.109***	-0.109***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
$road_{ij}$	0.002	0.002	0.002	0.002	0.002
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$river_{ij}$	-0.005	-0.005	-0.005	-0.005	-0.005
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$coast_{ij}$	-0.060***	-0.060***	-0.060***	-0.060***	-0.060***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
ϑ_i, θ_j	Y	Y	Y	Y	Y
τ_t	Y	Y	Y	Y	Y
Obs	132,284	132,284	132,284	132,284	132,284
R^2	0.186	0.186	0.186	0.186	0.186

Notes. ϑ_i and θ_j are district-specific effects, and τ_t is time-effects. Robust standard errors, clustered at the ij level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A3: Robustness Tests for Southern England, 1348-1400

dep var = cv_{ijt}^{Eng}	(1) Time varying effects	(2) Separate *epi*	(3) Dummy *epi*	(4) $3-yr$ overlapping
epi_{ijt-1}	0.025***	-	0.027***	0.023*
	(0.008)	-	(0.009)	(0.012)
epi_{it-1}	-	0.029**	-	-
	-	(0.013)	-	-
epi_{jt-1}	-	0.022***	-	-
	-	(0.011)	-	-
$\ln dis_{ij}$	0.008	0.009	0.009	0.008
	(0.008)	(0.008)	(0.008)	(0.008)
$road_{ij}$	-0.032***	-0.037***	-0.037***	-0.038***
	(0.010)	(0.009)	(0.009)	(0.009)
$river_{ij}$	-0.075***	-0.060***	-0.060***	-0.061***
	(0.010)	(0.010)	(0.010)	(0.010)
$coast_{ij}$	-0.078***	-0.070***	-0.070***	-0.071***
	(0.012)	(0.011)	(0.011)	(0.011)
Time varying effects	Y	N	N	N
ϑ_i, θ_j	Y	Y	Y	Y
θ_{ij}	N	N	N	N
γ_t	Y	Y	Y	Y
Obs	5,095	5,095	5,095	4,885
R^2	0.344	0.295	0.295	0.419

Notes. The average coefficients of distance and infrastructure variables are reported in column (1). ϑ_i and θ_j is district-specific effects, θ_{ij} are the district-pair effects, and γ_t is time-effects. Robust standard errors, clustered at the ij level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A4: Robustness Tests for Europe, 1348-1700

dep var = cv_{ijt}^{EU}	(1) Time varying effects	(2) Separate *epi*	(3) Dummy *epi*	(4) $3-yr$ overlapping
epi_{ijt-1}	0.011***	-	0.012***	0.019***
	(0.002)	-	(0.003)	(0.004)
epi_{it-1}	-	0.009***	-	-
	-	(0.003)	-	-
epi_{jt-1}	-	0.013***	-	-
	-	(0.003)	-	-
$\ln dis_{ij}$	0.037***	0.038***	0.038***	0.038***
	(0.011)	(0.005)	(0.005)	(0.005)
$temp_{ijt}$	-0.069**	-0.063**	-0.063**	-0.102***
	(0.033)	(0.032)	(0.032)	(0.030)
$\ln pop_{ijt}$	-0.084***	-0.109***	-0.109***	-0.108***
	(0.020)	(0.018)	(0.018)	(0.018)
$road_{ij}$	-0.008	0.002	0.002	0.002
	(0.012)	(0.009)	(0.009)	(0.009)
$river_{ij}$	0.001	-0.005	-0.005	-0.005
	(0.023)	(0.009)	(0.009)	(0.009)
$coast_{ij}$	-0.079***	-0.060***	-0.060***	-0.061***
	(0.014)	(0.009)	(0.009)	(0.009)
Time varying effects	Y	N	N	N
ϑ_i, θ_j	Y	Y	Y	Y
θ_{ij}	N	N	N	N
γ_t	Y	Y	Y	Y
dis_{ij}*d_t	Y	N	N	N
Obs	132,284	132,284	132,284	129,657
R^2	0.200	0.186	0.186	0.241

Notes. The average coefficients of distance and infrastructure variables are reported in column (1). ϑ_i and θ_j is city-specific effects, θ_{ij} is the city-pair effects, and γ_t are time-effects. Robust standard errors, clustered at the ij level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

References

Alfani, G., 2020a. Epidemics, inequality and poverty in pre-industrial and early Industrial times. Stone Center on Socio-Economic Inequality Working Paper Series number 23 October.

Alfani, G., 2020b. Pandemics and asymmetric shocks: Evidence from the history of plague in Europe and the Mediterranean. *Journal for the History of Environment and Society*, 5, pp.197-209.

Alfani, G. and Murphy, T.E., 2017. Plague and lethal epidemics in the pre-industrial world. *The Journal of Economic History*, 77(1), pp.314-343.

Alfani, G. and Ó Gráda, C., 2018. *Famine and disease in economic history: A summary introduction* (No. WP18/03). UCD Centre for Economic Research Working Paper Series.

Alfani, G., and Percoco, M., 2019. Plague and long-term development: The lasting effects of the 1629-30 epidemic on the Italian cities. *The Economic History Review*, 72(4), pp.1175-1201.

Allen, R.C., 2005. Real wages in Europe and Asia: A first look at the long-term patterns. in Allen, R.C., Bengtsson, T., and Dribe, M. (eds), *Living Standards in the Past: New Perspectives on Well-Being in Asia and Europe*, Oxford University Press, Oxford UK, pp.111-131.

Arthi, V. and Parman, J., 2021. Disease, downturns, and wellbeing: Economic history and the long-run impacts of COVID-19. *Explorations in Economic History*, 79, pp.101-381.

Ashraf, Q. and Galor, O., 2011. Dynamics and stagnation in the Malthusian epoch. *American Economic Review*, 101(5), pp.2003-2041.

Barbieri, R., Drancourt, M., and Raoult, D., 2019. Plague, camels, and lice. *Proceedings of the National Academy of Sciences*, 116(16), pp.7620-7621.

Barbieri, R., Signoli, M., Chevé, D., Costedoat, C., Tzortzis, S., Aboudharam, G., .and Drancourt, M., 2020. Yersinia pestis: the natural history of plague. *Clinical Microbiology Reviews*, 34(1), e00044-19.

Barbieri, R., Drancourt, M., & Raoult, D., 2021. The role of louse-transmitted diseases in historical plague pandemics. *The Lancet Infectious Diseases*, 21(2), e17-e25.

Bargain, O. and Ulugbek, A., 2020. Between a rock and a hard Place: Poverty and

COVID-19 in developing countries. IZA Discussion Paper, IZA DP No. 13297.

Barro, R.J., 2020. Non-pharmaceutical interventions and mortality in US cities during the great Influenza pandemic, 1918-1919. NBER Working Papers w27049.

Bateman Victoria N., 2011. The evolution of Markets in early modern Europe, 1350-1800: A study of wheat prices. *The Economic History Review*, 64(2), pp.447-471.

Beach, B., Clay, K. and Saavedra, M.H., 2020. The 1918 influenza pandemic and its lessons for COVID-19. NBER Working Papers w27673.

Benedictow, O.J., 2004. *The Black Death*, 1346-1353, Boydell Press, Woodbride U.K.

Benedictow, O.J., 2019. Epidemiology of plague: Problems with the use of mathematical epidemiological models in plague research and the question of transmission by human fleas and lice. *Canadian Journal of Infectious Diseases and Medical Microbiology*, 2019, 1542024.

Boccaccio, G., 2003. *The Decameron*, Penguin, UK.

Bodenhorn, H., 2020. Business in a time of Spanish influenza. National Bureau of Economic Research Working Papers w27495.

Bos, K.I., Herbig, A., Sahl, J., Waglechner, N., Fourment, M., Forrest, S.A., Klunk, J., Schuenemann, V.J., Poinar, D., Kuch, M. and Golding, G.B., 2016. Eighteenth century Yersinia pestis genomes reveal the long-term persistence of an historical plague focus. *Elife*, 5, p.e12994.

Bos, K.I., Schuenemann, V.J., Golding, G.B., Burbano, H.A., Waglechner, N., Coombes, B.K., McPhee, J.B., DeWitte, S.N., Meyer, M., Schmedes, S. and Wood, J., 2011. A draft genome of Yersinia pestis from victims of the Black Death. *Nature*, 478(7370), pp.506-510.

Bramanti, B., Wu, Y., Yang, R., Cui, Y., and Stenseth, N.C., 2021. Assessing the origins of the European plagues following the Black Death: A synthesis of genomic, historical and ecological information. *Proceedings of the National Academy of Science*, 118(36), e2101940118.

Bridgman, B. and Greenaway-McGrevy, R., 2020. The economic impact of the 1918 Influenza pandemic: Evidence from US states. Unpublished mimeo.

Broadberry, S.N., Campbell, B.M., Klein, A., Overton, M. and Leeuwen, B.V., 2015. *British Economic Growth, 1270-1870.* Cambridge: Cambridge University Press.

Brooks, S.K., Webster, R.K., Smith, L.E., Woodland, L., Wessely, S., Greenberg, N. and Rubin, G.J., 2020. The psychological impact of quarantine and how to reduce it: Rapid review of the evidence. *The Lancet*, 395(10227), pp.912-920.

Brown, C.S., Ravallion, M. and Van de Walle, D., 2020. Can the world's poor protect themselves from the new Coronavirus? NBER Working Papers w27200, National Bureau of Economic Research.

Būntgen, U., Ginzler, C., Esper, J., Tegel, W., & McMichael, A. J., 2012. Digitizing historical plague. *Clinical Infectious Diseases*, 55(11), pp.1586-1588.

Campbell, B.M.S., 2009. Factor markets in England before the Black Death. *Continuity and Change*, 24(1), pp.79-106.

Campbell, B.M.S, 2016. *The Great Transition.* Cambridge University Press, Cambridge UK.

Campbell, B.M.S., Galloway, J.A., Keene, D.J., and Murphy, M., 1993. *A Medieval Capital and its Grain Supply: Agrarian Production and its Distribution in the London region c.1300.* Historical Geography Research Series, Number 30, Institute of British Geographers, UK.

Campbell, B.M.S., and Ó Gráda, C.., 2011. Harvest shortfalls, grain prices, and famines in pre-industrial England. *The Journal of Economic History*, 71(4), pp.859-886.

Chapelle, G., 2020. The Medium run impact of non-pharmaceutical interventions: Evidence from the 1918 flu in US cities. April 16, SSRN: https://ssrn.com/abstract=3573562.

Chetty, R., Friedman, J.N., Hendren, N., Stepner, M., 2020. How did COVID-19 and stabilization policies affect spending and employment? A new real-time economic tracker based on private sector data. National Bureau of Economic Research, Cambridge, MA.

Chilosi, D., Murphy, T.E., Studer, R., an Tunçer, A.C., 2013. Europe's many integrations: Geography and grain markets, 1620-1913. *Explorations in Economic History*, 50(1), pp.46-68.

Clark, G., 2005. The condition of the working class in England, 1209-2004. *Journal of Political Economy*, 113(6), pp.1307-1340.

Clark, G., 2008. *A Farewell to Alms.* Princeton University Press, Princeton, NJ.

Clark, G., 2015. Markets and economic growth: The grain market of medieval England. *Cliometrica*, 9(3), pp.265-287.

Clark, G., 2016. Microbes and markets: Was the Black Death an economic revolution? *Journal of Demographic Economics*, 82(2), pp.139-165.

Cohn, S.K., 2007. After the Black Death: Labour legislation and attitudes towards labour in late-medieval Western Europe. *The Economic History Review*, 60(3), pp.457-485.

Cohn, S.K., 2008. Epidemiology of the Black Death and successive waves of plague. *Medical History*, 52(S27), pp.74-100.

Cohn, S.K., 2010. *Cultures of plague: medical thinking at the end of the Renaissance.* Oxford University Press, Oford U.K..

Correia, S., Luck, S., and Verner, E., 2020a. Pandemics depress the economy, public health interventions do not: Evidence from the 1918 flu. June 5. SSRN: https://ssrn.com/abstract=3561560.

Correia, S., Luck, S., and Verner, E., 2020b. Response to Lilley, Lilley, and Rinaldi. MIT Department of Finance, mimeo.

Cummins, N., Kelly, M., and Ó Gráda, C. 2016. Living standards and plague in London, 1560–1665. *The Economic History Review*, 69, 1, 3-34.

Davies, J., 2011. Market regulation in 15^{th} century England, In Dodds, B. and Liddy, C.V. (eds.) *Commercial Activity, Markets and Entrepreneurs in the Middle Ages: Essays in Honour of Richard Britnell*, Boydell Press Woodbridge, UK, pp.81-106.

Dean, K.R., Krauer, F., Walløe, L., Lingjærde, O.C., Bramanti, B., Stenseth, N.C., and Schmid, B.V., 2018. Human ectoparasites and the spread of plague in Europe during the Second Pandemic. *Proceedings of the National Academy of Sciences*,115(6), pp.1304-1309.

Decerf, B., Ferreira, F.H., Mahler, D.G. and Sterck, O., 2020. Lives and livelihoods. World Bank Policy Working Paper 9277. https://openknowledge.worldbank.org/bitstream/handle/10986/33938/ Lives-and-Livelihoods-Estimates-of-the-Global-Mortality-and-Poverty-Effects-of-the-Covid-19-Pandemic.pdf.

Defoe, D., 2003. *A Journal of the Plague Year*, Penguin, UK.

Deij, S., J.B. Madsen, and L. Puzzello., 2021. Does trade matter for growth when the geographical instruments are randomly generated? *Journal of Applied Econometrics*, 36(4), 437-452.

Demeure, C.E., Dussurget, O., Fiol, G.M., Le Guern, A.S., Savin, C. and Pizarro-Cerdá, J., 2019. Yersinia pestis and plague: An updated view on evolution, virulence determinants, immune subversion, vaccination, and diagnostics. *Genes & Immunity*, 20(5), pp.357-370.

Dittmar, J.E., and Meisenzahl, R., 2020. Public goods institutions, human capital, and growth: Evidence from German history. *Review of Economic Studies*, 87(2), pp.959-996.

Drancourt, M., Houhamdi, L. and Raoult, D., 2006. Yersinia pestis as a telluric, human ectoparasite-borne organism. *The Lancet Infectious Diseases*, 6(4), pp.234-241.

Driscoll, J.C., and Kraay, A.C., 1998. Consistent covariance matrix estimation with spatially dependent panel data. *Review of Economics and Statistics*, 80(4), pp.549-560.

Dyer, C., 2002. *Making a Living in the Middle Ages: The People of Britain 850-1520*, Yale University Press, New Haven.

Engel, C., Rogers, J.H., 1996. How wide is the border? *American Economic Review*, 86(5), pp.1112-1125.

Federico, G., Schulze, M.S. and Volckart, O., 2021. European goods market integration in the very long run: From the Black Death to the First World War. *The Journal of Economic History*, 81(1), pp.276-308.

Galletta, S. and Giommoni, T. 2021, The effect of the 1918 influenza pandemic on income inequality: Evidence from Italy.

Galloway, J. A., 2000. One market or many? London and the grain trade of England, in J.A. Galloway, ed., Trade, Urban Hinterlands and Market Integration c.1300–1600, Centre for Metropolitan History, working papers no.3, Institute of Historical Research, University of London, pp. 23-42.

Galor, O., 2011. *Unified Growth Theory*, Princeton University Press, Princeton, New Jersey.

Galor, O. and Weil, D.N., 2000. Population, technology, and growth: From Malthusian stagnation to the demographic transition and beyond. *American Economic Review*, 90(4), 806-828.

Gensini, G.F., Yacoub, M.H. and Conti, A.A., 2004. The concept of quarantine in history: From plague to SARS. *Journal of Infection*, 49(4), pp.257-261.

Goolsbee, A. and Syverson, C., 2021. Fear, lockdown, and diversion: Comparing drivers of pandemic economic decline 2020. *Journal of Public Economics*, 193, pp.104-311.

Gummer, B,. 2009. *The Scourging Angel: The Black Death in the British Isles.* The Bodley Head, London UK.

Gupta, S., Nguyen, T.D., Rojas, F.L., Raman, S., Lee, B., Bento, A., Simon, K.I. and Wing, C., 2020a. Tracking public and private response to the covid-19 epidemic: Evidence from state and local government actions. NBER Working Papers, w27027.

Gupta, S., Simon, K. and Wing, C., 2020b. Mandated and voluntary social distancing during the COVID-19 epidemic. *Brookings Papers on Economic Activity*, 2, pp.269-326.

Haensch S, Bianucci R, Signoli M, Rajerison M, Schultz M, Kacki S, et al., 2010. Distinct clones of Yersinia pestis caused the Black Death. *PLoS Pathogens*, 6(10), e1001134.

Hirschleifer, J., 1966. Disaster and recovery: The Black Death in Western Europe, Rand Corporation, Memorandum RM-4700-TAB.

Hoechle, D., 2007. Robust standard errors for panel regressions with cross-sectional dependence. *The Stata Journal*, 7(3), pp.281-312.

Horrox, R., 1994. *The Black Death.* Manchester University Press, Manchester.

Hufthammer A.K. and Walløe, L., 2013. Rats cannot have been intermediate hosts for Yersinia pestis during medieval plague epidemics in Northern Europe. *Journal Archaeological Science*, 40, pp.1752-1759.

Humphries, J. and Jacob W.,2019. Unreal wages? Real income and economic growth in England, 1260-1850. *Economic Journal*, 129(623), pp.2867-2887.

International Monetary Fund, 2020. The great Lockdown: Dissecting the economic effects. In *World Economic Outlook: A Long and Difficult Assent.*, October, IMF: Washington D.C. pp. 65-84.

Jacks, D.S., 2004. Market integration in the North and Baltic Seas, 1500-1800. *Journal of European Economic History*, 33(3) pp.285-329.

Jacks, D. S., 2005. Intra- and international commodity market integration in the Atlantic economy, 1800-1913. *Explorations in Economic History*, 42, pp.381-413.

Jacks, D.S., 2006. What drove 19^{th} century commodity market integration? *Explorations in Economic History*, 43(3), pp.383-412.

Jacks, D. S., Meissner, C. M., and Novy, D., 2010. Trade costs in the first wave of globalization. *Explorations in Economic History*, 47(2) pp.127-141.

Jedwab, R., Johnson, N.D. and Koyama, M., 2019. Negative shocks and mass persecutions: Evidence from the Black Death. *Journal of Economic Growth*, 24(4), pp.345-395.

Jedwab, R., Johnson, N.D. and Koyama, M., 2020. The economic impact of the Black Death. CEPR Discussion Paper DP15132.

Jones, E.T., 2000. River navigation in medieval England. *Journal of Historical Geography*, 26(1), pp.60-75.

Jordà, Ò., Singh, S.R. and Taylor, A.M., 2021. Longer-run economic consequences of pandemics? *The Review of Economics and Statistics*, DOI:10.1162/rest_a_01042.

Kelly M., 2019. The Standard errors of persistence. UCD Centre for Economic Research, Working Paper Series, No. 19/13, University College Dublin.

Lagerlöf, N.-P., 2003. From Malthus to modern growth: Can epidemics explain the three regimes? *International Economic Review*, 44(2), pp.755-777.

Langdon, J. and Masschaele, J., 2006. Commercial activity and population growth in medieval England. *Past & Present*, 190(1), pp.35-81.

Lilley, A., Lilley, M. and Rinaldi, G., 2020. Public health interventions and economic growth: Revisiting the Spanish flu evidence. SSRN 3590008.

Limao, N. and Venables, A.J., 2001. Infrastructure, geographical disadvantage, transport costs, and trade. *The World Bank Economic Review*, 15(3), pp.451-479.

Mafart, B., & Perret, J. L., 1998. History of the concept of quarantine. *Medecine Tropicale: Revue du Corps de Sante Colonial,* 58(2 Supplement), pp.14-20.

Maloney, W.F. and Taskin, T., 2020. Determinants of social distancing and economic activity during COVID-19: A global view. World Bank Policy Research Working Paper, 9242.

Mann, M.E., Zhang, Z., Rutherford, S., Bradley, R.S., Hughes, M.K., Shindell, D., Ammann, C., Faluvegi, G. and Ni, F., 2009. Global signatures and dynamical origins of the Little Ice Age and Medieval Climate Anomaly. *Science*, 326(5957), pp.1256-1260.

McCloskey, D. and Nash. J., 1984. Corn at interest: The extent and cost of grain storage in medieval England. *American Economic Review*, 74(1), pp.174-187.

Miguel, E. and Mobarak, A.M., 2021. The economics and the COVID-19 pandemic in poor countries. NBER Working Papers w29339.

Mobarak, A. and Barnett-Howell, Z., 2020. Poor countries need to think twice about social distancing. *Foreign Policy.* 10 April 2020. https://foreignpolicy.com/2020/04/10/poor-countries-social-distancing-coronavirus.

Namouchi, A., Guellil, M., Kersten, O., Hänsch, S., Ottoni, C., Schmid, B.V., Pacciani, E., Quaglia, L., Vermunt, M., Bauer, E.L. and Derrick, M., 2018. Integrative approach using Yersinia pestis genomes to revisit the historical landscape of plague during the medieval period. *Proceedings of the National Academy of Sciences*, 115(50), e11790-e11797.

Nef, J.U., 1977. An early energy crisis and its consequences. *Scientific American*, 237(5), pp.140-151.

Newman, Kira L. S., 2012. Shutt up: Bubonic plague and quarantine in early modern England. *Journal of Social History*, 45(3), pp.809-834.

O'Rourke, K.H., Findlay, R., 2003. Commodity market integration, 1500-2000. In Bordo, M.D., Taylor, A.M. and Williamson, J.G. (eds.), *Globalization in Historical Perspective.* University of Chicago Press, Chicago, pp.13-62.

O'Rourke, K. H. and Williamson, J. G., 1999. *Globalization and History: The Evolution of A Nineteenth Century Atlantic Economy*, MIT Press, Cambridge MA.

Pamuk, S., 2007. The Black Death and the origins of the 'Great Divergence' across Europe, 1300-1600. *European Review of Economic History*, 11(3), pp.289-317.

Piper, K., 2020. The devastating consequences of coronavirus lockdowns in poor countries. Vox.: https://www.vox.com/future-perfect/2020/4/18/21212688/coronavirus-lockdowns-developing-world.

Preest, D., and Richard W.B., 2012. The Chronicle of Geoffrey le Baker of Swinbrook, by Geoffrey Le Baker. Woodbridge: Boydell Press.

Ravallion, M., 2020. Pandemic responses in poor places. CGD Note (April 24), Center for Global Development, Washington, DC.

Robb, J., Cessford, C., Dittmar, J., Inskip, S. A., & Mitchell, P.D. (2021). The greatest health problem of the Middle Ages? Estimating the burden of disease in medieval England. *International Journal of Paleopathology*, 34, pp.101-112.

Rojas, F.L., Jiang, X., Montenovo, L., Simon, K.I., Weinberg, B.A. and Wing, C., 2020. Is the cure worse than the problem itself? Immediate labor market effects of COVID-19 case rates and school closures in the U.S. NBER Working Papers w27127.

Schmid, B.V., Büntgen, U., Easterday, W.R., Ginzler, C., Walløe, L., Bramanti, B. and Stenseth, N.C., 2015. Climate-driven introduction of the Black Death and successive plague reintroductions into Europe. *Proceedings of the National Academy of Sciences*, 112(10), pp.3020-3025.

Seifert, L., Wiechmann, I., Harbeck, M., Thomas, A., Grupe, G., Projahn, M., Scholz, H.C. and Riehm, J.M., 2016. Genotyping Yersinia pestis in historical plague: Evidence for long-term persistence of Y. pestis in Europe from the 14^{th} to the 17^{th} century. *PLoS One*, 11(1), e0145194.

Shrewsbury, J. D. F., 1970. *A History of the Bubonic Plague In the British Isles*, Cambridge University Press, Cambridge, UK.

Siuda, F., and Sunde, U., 2021. Disease and demographic development: The legacy of the plague. *Journal of Economic Growth*, 26(1), pp.1-30.

Spyrou, M.A., Keller, M., Tukhbatova, R.I., Scheib, C.L., Nelson, E.A., Valtueña, A.A., Neumann, G.U., Walker, D., Alterauge, A., Carty, N. and Cessford, C., 2019. Phylogeography of the Second Plague Pandemic revealed through analysis of historical Yersinia pestis genomes. *Nature Communications*, 10(1), 4470.

Spyrou, M.A., Tukhbatova, R.I., Feldman, M., Drath, J., Kacki, S., de Heredia, J.B., Arnold, S., Sitdikov, A.G., Castex, D., Wahl, J. and Gazimzyanov, I.R., 2016. Historical Y. pestis genomes reveal the European Black Death as the source of ancient and modern plague pandemics. *Cell Host and Microbe*, 19(6), pp.874-881.

Susat, J., Bonczarowska, J.H., Pētersone-Gordina, E., Immel, A., Nebel, A., Gerhards, G. and Krause-Kyora, B., 2020. Yersinia pestis strains from Latvia show depletion of the plague virulence gene at the end of the Second Plague Pandemic. *Scientific Reports*, 10(1), 14628.

Tognotti, E., 2013. Lessons from the history of quarantine, from plague to influenza. *Emerging Infectious Diseases*, 19(2), p.254-259.

Van Bavel, J.J., Baicker, K., Boggio, P.S., Capraro, V., Cichocka, A., Cikara, M., Crockett, M.J., Crum, A.J., Douglas, K.M., Druckman, J.N. and Drury, J., 2020. Using social and behavioural science to support COVID-19 pandemic response. *Nature Human Behaviour*, 4(5), pp.460-471.

Wood, J. W., et al., 2003. The temporal dynamics of the fourteenth-century Black Death: New evidence from English ecclesiastical records. *Human Biology*, 75(4), pp.427-49.

World Bank, 2020. *Poverty and Hared Prosperity 2020: Reversals of Fortune*, World Bank Publications, The World Bank Group, Washington, DC.

Zielger, P., 1972. *The Black Death.* Collins, London UK.

Online Appendices for Lives versus Livelihoods in the Middle Ages: The Impact of the Plague on Markets over 400 Years

Jakob B. Madsen
University of Western Australia

Peter E. Robertson*
University of Western Australia

Longfeng Ye
RMIT University

January 12, 2022

*Corresponding author: Peter Robertson, Department of Economics, University of Western Australia, 35 Stirling Hwy, Crawley WA 6009, peter.robertson@uwa.edu.au

Appendix 1: Wheat Price Data for Southern England Sample

This appendix details the data sources for wheat prices (shillings per quarter) data for Southern England sample (12 places that belonged to the Bishopric of Winchester, plus Durham, Exeter, and London) over 1300-1400.

Various Bishopric of Winchester places (1300-1400)

Keene, D. et al., Metropolitan Market Networks, c.1300-1600; London, its Region and the Economy of England [computer file]. Colchester, Essex: UK Data Archive [distributor], July 2002. SN: 4245, http://dx.doi.org/10.5255/UKDA-SN-4245-1. Keene et al. obtained the prices from D.Farmer unpub. mss, University of Saskatchewan archives, MG145.III.c.5. We selected a total of 12 places with the number of wheat price observations above 50. These 12 places include: Adderbury, Brightwell, Ebbesbourne, Ecchinswell, Fareham, Farnham, Ivinghoe, Merdon, Wargrave, Witney, Wolvesey, and Wycombe.

Durham: 1295-1408

Gemmill, E., Dodds, B. and Schofield, P. R., 2010. Durham Grain Prices, 1278-1515. *Archaeologia Aeliana*, 39, PP.307-327.

Exeter/Devon: 1316-1411

Mitchell, B.R., 2011. *British Historical Statistics.* Cambridge, UK: Cambridge University Press.

London: 1277-1370

Keene, D. et al., Metropolitan Market Networks, c.1300-1600; London, its Region and the Economy of England [computer file]. Colchester, Essex: UK. Data is for 4 London 'places': Pavement, Billingsgate, Queenhithe, and London others. The prices are monthly data and thus are adjusted for seasonal factors when being converted to the annual data.

Appendix 2: Wheat Price Data for European Sample

This appendix details the data sources for wheat prices (silver gram per litre) data for six European countries: The United Kingdom, Italy, France, Germany, Spain and Portugal.

The United Kingdom

In addition to the wheat price data in the Southern England sample, we further collected wheat prices for the following locations over the post-1400 period.

<u>*Chester: 1378-1502*</u>

Public Record Office, Class SC6; Manuscript notes held by Victoria County History (Chester). Data accessed via the Allen-Unger Global Commodity Database (hereafter A-U database).

<u>*Edinburgh: 1626-1780*</u>

Gibson, A. J. S. and Smout, T. C., 1995. *Prices, Food and Wages in Scotland 1550-1780.* Cambridge: Cambridge University Press. Data accessed via the A-U database.

<u>*Eton: 1594-1816*</u>

Mitchell, B.R., 1971. *Abstract of British Historical Statistics.* Cambridge: Cambridge University Press. Data accessed via the A-U database.

<u>*Exeter: 1316-1816*</u>

Mitchell, B.R., 1971. *Abstract of British Historical Statistics.* Cambridge: Cambridge University Press. Data compiled by the authors and it is the same as the data by the A-U database.

Italy

<u>*Arezzo: 1529-1718*</u>

Damsholt, T., 1964. Some observations on four series of Tuscan corn prices 1520–1630. *Scandinavian Economic History Review*, 12(2), pp.145-164. Data accessed via the A-U database.

<u>*Bari: 1502-1649*</u>

Mira, G., 1942. *Contributo per una storia dei prezzi in alcune provincie delle Puglie.* Arti Grafiche Panetto & Petrelli. Data accessed via the A-U database.

<u>*Bassano: 1501-1799*</u>

Lombardini, G., 1963. *Pane e denaro a Bassano tra il 1501 e il 1799.* Venice: Neri Pozza Editore. Data accessed via the A-U database.

<u>*Brescia: 1685-1799*</u>

1886. *Movimento dei prezzi di alcuni generi alimentari dal 1862 al 1885.* Rome: Eredi Botta. Data accessed via the A-U database.

<u>*Cantania: 1512-1630*</u>

Petino, A., 1950. *I prezzi del grano dell'orzo dell'olio del vino del cacio a Caania dal 1512 al 1630.* Milan. Data accessed via the A-U database.

Florence: 1321-1566

Goldthwaite, R.A., 1975. I prezzi del grano a Firenze dal XIV al XVI secolo. *Quaderni storici*, 10, pp. 5-36. Data accessed via the Global Prices and Incomes History (hereafter GPIH database) with the link: www.iisg.nl/hpw/allen.rar

Modena: 1458-1705

Basini, G.L., 1974, *Sul Mercato di Modena Tra Cinque e Seicento: Prezzi e Salari.* Milano: Dott A Giuffre. Data accessed via the A-U database.

Naples: 1536-1803

Coniglio, G., 1952. La revoluzione dei prezzi nella citta de Napoli nei secoli XVI e XVII. *Spoleta*, pp. 204-240. Romano, R., 1965. *Prezzi, salari e servizi a Napoli nel secolo XVIII.* Milan. Data accessed via the GPIH database with the link: www.iisg.nl/hpw/allen.rar.

Sansepolcro: 1500-1631

Fanfani, A., 1940. *Indagini sulla: rivoluzione dei prezzi.* Milano Societa Editrice-Vita e Pensiero. Data accessed via the A-U database.

Siena: 1546-1765

Parenti, G., 1942. *Prezzi e mercato del grano a Siena 1546-1765.* Facolta di Economia e Commercio XIX-Casa Editrice del Dott. Carlo CYA. Florence: Universia degli studi di Firenze. Data accessed via the GPIH database with the link: www.iisg.nl/hpw/poynder-italy.xls

Pisa:1548-1819

Malanima, P., 1976. Aspetti di mercato e prezzi del grano e della segale a Pisa dal 1548 al 1818, in *Ricerche di storia moderna*, I, Pisa, Pacini, pp.288-327. Data accessed via the GPIH database with the link: www.iisg.nl/hpw/grainprices.xls

Germany

Augsburg: 1668-1800

Elsas, M.J., 1936. *Umriss einer Geschichte der Preise und Loehne in Deutschland.* Vol. I. A.W. Sijthoff's: Leiden. Data accessed via the GPIH database with the link: https://gpih.ucdavis.edu/files/Augsburg_1500-1800.xls

Cologne:1531-1796

Ebeling, D. and Irsigler, F., 1977. *Getreideumsatz Getreide und Brotpreise in Kaaln 1368-1797.* Cologne. Data accessed via the A-U database.

Frankfurt: 1501-1800

Elsas, M.J., 1940. *Umriss einer Geschichte der Preise und Loehne in Deutschland.*

Vol. I. A.W. Sijthoff's: Leiden. Data accessed via the GPIH database with the link: https://gpih.ucdavis.edu/files/Frankfurt_1500-1800.xls

Munich: 1507-1913

Elsas, M.J., 1936. *Umriss einer Geschichte der Preise und Loehne in Deutschland*. Vol. I. A.W. Sijthoff's: Leiden. Data accessed via the GPIH database with the link: https://gpih.ucdavis.edu/files/Allen_Munich_1400-1914.xlsx

Wurzburg: 1500-1799

Elsas, M.J., 1936. *Umriss einer Geschichte der Preise und Lohne in Deutschland vom ausgehenden mittelalter bis zum beginn des neunzehnten jahrhunderts*. Leiden: A.W. Sijthoff's Uitgeversmaatschappij N.V. Data accessed via the A-U database.

Leipzig: 1564-1810

Elsas, M.J., 1940. *Umriss einer Geschichte der Preise und Löhne in Deutschland*. Vol. 2, Leiden. Data accessed via the GPIH database with the link: https://gpih.ucdavis.edu/files/Allen_Leipzig_1564-1914.xlsx

France

Aix: 1570-1789

Baehrel, R., 1961. *Une croissance: La Basse Provence rurale de la fin du VIe siecle a 1789*. Paris: SEVPEN. Data accessed via the A-U database.

Angers: 1580-1789

Hauser, H., 1936. *Recherches et Documents sur l'histoire des prix en France de 1500 a 1800*. Paris: Les Presses Modernes. Data accessed via the A-U database.

Arles: 1570-1789

Baehrel, R., 1961. *Une croissance: La Basse Provence rurale de la fin du VIe siecle a 1789*. Paris: SEVPEN. Data accessed via the A-U database.

Avignon: 1570-1789

Baehrel, R., 1961. *Une croissance: La Basse Provence rurale de la fin du VIe siecle a 1789*. Paris: SEVPEN. Data accessed via the A-U database.

Beziers:1587-1758

Le Roy Ladurie, E. L. R., 1966. *Les paysans de languedoc Vol II Annexes Sources Graphiques*. Paris: SEVPEN. Data accessed via the A-U database.

Die:1501-1613

Hauser, H., 1985. *Recherches et documents sur l'histoire des prix en France do 1500 a 1800*. Paris: Slatkine Reprints. Data accessed via the A-U database.

Douai: 1329-1789

Mestayer, M., 1963. Les prix du blé et de l'avoine de 1329-1793. *Revue du Nord*, 45, 157-176. Data accessed via the A-U database.

Draguignan: 1681-1790

Baehrel, R., 1961. *Une croissance: La Basse Provence rurale de la fin du VIe siecle a 1789*. Paris: SEVPEN. Data accessed via the A-U database.

Grenoble: 1501-1780

Hauser, H., 1985. *Recherches et documents sur l'histoire des prix en France do 1500 a 1800*. Paris: Slatkine Reprints. Data accessed via the A-U database.

Montelimar: 1501-1625

Hauser, H., 1985. *Recherches et documents sur l'histoire des prix en France do 1500 a 1800*. Paris: Slatkine Reprints. Data accessed via the A-U database.

Paris: 1431-1788

Labrousse, E., et, al., 1970. *Le prix du froment en France*. Paris.

Labrousse, E. and Baulant, M., 1968. Les prix des grains? Paris de 1431-178, Annales: E. S. E., 23, pp. 520-540. Data accessed via the GPIH database with the link: https://gpih.ucdavis.edu/files/Paris_1380-1870.xls.

Rennes:1615-1786

Hauser, H., 1985. *Recherches et documents sur l'histoire des prix en France do 1500 a 1800*. Paris: Slatkine Reprints. Data accessed via the A-U database.

Strasburg:1342-1875

Hanauer, A., 1878. *Etudes économiques sur l' Alsace, ancienne et moderne*. Strasbourg. Data accessed via the GPIH database with the link: https://gpih.ucdavis.edu/files/Allen_Strasbourg_1313-1875.xlsx

Toulouse: 1486-1792

Frêche, G. and Frêche, G., 1967. *Les prix des grains des vins et des legumes a Toulouse, 1486-1868*. Paris: Presses Universitaires de France. Data accessed via the A-U database.

Tours: 1431-1788

Baulant, M., 1968. Le prix des grains à Paris de 1431 à 1788. In *Annales. Histoire, Sciences Sociales*, 23(3), pp. 520-540. Cambridge University Press. Data accessed via the A-U database.

Valence: 1501-1753

Hauser, H., 1985. *Recherches et documents sur l'histoire des prix en France do 1500 a*

1800. Paris: Slatkine Reprints. Data accessed via the A-U database.

Vienne: 1501-1638
Hauser, H., 1985. *Recherches et documents sur l'histoire des prix en France do 1500 a 1800*. Paris: Slatkine Reprints. Data accessed via the A-U database.

Voiron: 1501-1638
Hauser, H., 1985. *Recherches et documents sur l'histoire des prix en France do 1500 a 1800*. Paris: Slatkine Reprints. Data accessed via the A-U database.

Spain
Andalusia: 1554-1650
Hamilton, E., 1936. *Money, Prices, and Wages in Valencia, Aragon, and Navarre, 1351-1500*. Cambridge: Harvard University Press, Appendices III, IV & V. Data accessed via the GPIH database with the link: https:// gpih.ucdavis.edu/files/Spain_1351-1800.xls

Aragon: 1382-1497
Hamilton, E., 1936. *Money, Prices, and Wages in Valencia, Aragon, and Navarre, 1351-1500*. Cambridge: Harvard University Press, Appendices III, IV & V. Data accessed via the GPIH database with the link: https:// gpih.ucdavis.edu/files/Spain_1351-1800.xls

Barcelona: 1494-1808
Feliu, G., 1991. *Precios y salarios en la Cataluna moderna, I: Alimentos*. Madrid: Banco de Espana. Data accessed via the GPIH database with the link: https://gpih.ucdavis.edu/files/Cataluna_1494-1808.xls

Leon: 1506-1650
Hamilton, E., 1965. *American Treasure and the Price Revolution in Spain, 1501-1650*. New York: Octagon Books, Appendices I-VI. Data accessed via the GPIH database with the link: https://gpih.ucdavis.edu/files/Spain_1351-1800.xls

Madrid:1501-1799
Data accessed via the A-U database.

Valencia: 1413-1789
1413-1500: Hamilton, E., 1936. *Money, Prices, and Wages in Valencia, Aragon, and Navarre, 1351-1500*. Cambridge: Harvard University Press, Appendices III, IV & V.
1501-1650: Hamilton, E., 1965. *American Treasure and the Price Revolution in Spain, 1501-1650*. New York: Octagon Books, Appendices I-VI.
1651-1789: Hamilton, E., 1969. *War and Prices in Spain, 1651-1800*. New York: Russell & Russell. Appendix I.

Data accessed via the GPIH database with the link: https://gpih.ucdavis.edu/files/Spain_1351-1800.xls

Valladolid: 1499-1600
Bennassar, B., 1967. *Valladolid au Siecle d'or: une ville de Castile et sa campagne au XVIe siecle.* Paris: Mouton and Co. Data accessed via the GPIH database with the link: https://gpih.ucdavis.edu/files/Valladolid_1499-1600.xls

Gerona:1569-1776
Feliu, G., 1991. textitPrecios y Salarios en la Cataluna Moderna. Madrid: Banco de Espana. Data accessed via the GPIH database with the link: https://gpih.ucdavis.edu/files/Cataluna_1494-1808.xls

Portugal
Data accessed via the Prices, Wages and Rents in Portugal 1300-1910 database with the link: http://pwr-portugal.ics.ul.pt/

Lisbon: 1500-1853
pwr-portugal.ics.ul.pt/wp-content/uploads/Grain-barley-bran-flour-maize-rice-rye-wheat.xls

Coimbra: 1504-1853
pwr-portugal.ics.ul.pt/wp-content/uploads/cbr_Grain-barley-flour-maize-rice-rye-wheat.xls

Evora: 1506-1850
pwr-portugal.ics.ul.pt/wp-content/uploads/E_Grain.xls

Porto: 1543-1850
pwr-portugal.ics.ul.pt/wp-content/uploads/P_Grain.xls

Appendix 3: Other Control Variables

Temperature Data:
Using a diverse multiproxy network comprising more than a thousand tree ring, ice core, coral, sediment, and other assorted proxy records, Mann et al. (2009) reconstructed global patterns of surface temperature changes over the past 1500 years. Temperature is expressed in the form of temperature anomaly, the difference relative to the 1961-1990 mean temperature. The temperature by Mann et al. (2009) is available at 5-degree latitude/longitude grid level. Using the country shapefiles, we map each grid point to a country, and calculate the mean temperature by taking average of the temperature across grid points within a country.

Mann, M.E., Zhang, Z., Rutherford, S., Bradley, R.S., Hughes, M.K., Shindell, D., Ammann, C., Faluvegi, G. and Ni, F., 2009. Global signatures and dynamical origins of the Little Ice Age and Medieval Climate Anomaly. *Science*, 326(5957), pp.1256-1260.

Proximity to Roman Roads

DARMC Roman Road Network (version 2008) (viewable at darmc.harvard.edu) provides shapefiles which are used to calculate the distance to the nearest Roman road via ArcGIS. We then construct a dummy variable taking value of one if the distance of both wheat markets i and j to the Roman roads are below the median value in the sample.

Proximity to Main Rivers

European Environment Agency provides shapefiles on large rivers in the Europe: https://www.eea.europa.eu/data-and-maps/data/wise-large-rivers-and-large-lakes. The large rivers refer to those with a catchment area larger than 50,000 km^2. We first calculate the distance of each wheat market to the nearest river using ArcGIS and then construct a dummy variable taking value of one if the distance of both wheat markets i and j to the Roman roads are below the median value in the sample.

Proximity to Coast

European Environment Agency provides shapefiles on coastline in the Europe: https://www.eea.europa.eu/data-and-maps/data/eea-coastline-for-analysis-1/gis-data/europe-coastline-shapefile. We first calculate the distance of each wheat market to the nearest coast using ArcGIS and then construct a dummy variable taking value of one if the distance of both wheat markets i and j to the Roman roads are below the median value in the sample.

Population Data

The United Kingdom

1210-1270: Clark, G., 2007. The long march of history: Farm wages, population, and economic growth, England 1209-1869. *The Economic History Review*, 60(1), pp. 97-135. *1460-1820*: Broadberry, S., Campbell, B. M. S., Klein, A., Overton, M. and van Leeuwen, B., 2015. *British Economic Growth 1270-1870*, Cambridge University Press. Data for England is scaled up before 1700.

Italy

1300-1819: Malanima, P., 2003. Measuring the Italian economy. 1300-1861. *Rivista di storia economica*, 19(3), pp. 265-296. *1820-1870*: Maddison, A., 2003. *The World Economy:Historical statistics.* OECD publishing.

France

1300-1680: Malanima, P., 2009. *Pre-modern European economy: one thousand years*

(10^{th}-19^{th} centuries), Vol. 5. Brill. *1690-1770*: Henry, L., and Yves B., 1975. La population de la France de 1740 a 186. *Population*, 30(1), pp. 71-122 (p.95. Table 12).

Germany

1-1500, Geometric interpolation of the series: 1, 200, 400, 600, 800, 1000, 1100, 1200, 1300: McEvedy, C. and Richard J., 1978. *Atlas of world population history.* Penguin Books Ltd, Harmondsworth, Middlesex, England. *1500-1618* and *1650-1815*: Pfister, U., and Georg F., 2010. The population history of Germany: research strategy and preliminary results. Max Planck Institute for Demographic Research (MPIDR) working paper WP 2010-35. *1618-1650*: The thirty years' war (1618-1648) reduced population of Germany from an estimated 21 million to 13.5 million. Lee, S. J., 2005. European population growth 1500-1800, in Lee, S. J. (ed.). *Aspects of European history 1494-1789*, Routledge.

Spain

1-1300, Geometric interpolation of the series: 1, 200, 400, 600, 800, 1000, 1100, 1200, 1300: McEvedy, C., and Richard J., 1978. *Atlas of world population history*, Penguin Books Ltd, Harmondsworth, Middlesex, England. *1357-1360*: Álvarez-Nogal, C., and Leandro P. D. L. E., 2013. The rise and fall of Spain (1270-1850). *The Economic History Review*, 66(1), pp. 1-37. Population is assumed to decline by 30% during the period 1348-1360 since Spain was not affected as much by the Black Death as other European Countries. *1618, 1700, 1723, 1777*: de Jonnès, Alexandre M., 1834. *Statistique de l'Espagne.* Cosson.

Portugal

1250-1800: Valério, N., 2010. Portuguese economic performance 1250-2000, in Andreu, Juan Hernandez, Ruiz, José Luis Garcia, Critz, José Morilla and Ortiz-Villajos, José Manuel (eds), *Homenaje a Gabriel Tortella . Las Claves del Desarrollo Economico y Social*, Madrid: Universidad de Alcalá, pp. 431-444. *1300-1347*: Assumed to grow at the rate as the previous century.