Origins of Europe's North-South Divide: Population changes, real wages and the 'Little Divergence' in Early Modern Europe

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Abstract

In this paper I investigate the "little divergence" in late medieval and early modern Europe, focusing on the long run response of real wages to demographic changes. Through a quantitative analysis of the 14th-18th centuries series of real wages and population shocks in fourteen European cities, I find that in the northwestern regions the urban real wages were detached from population before the Industrial Revolution, while, in the central and southern regions wages had a moderate or negative response to population changes. In addition, I show that this different response dates back to the 14th-16th centuries. Finally, I claim, that these two results support three possibly non alternative interpretations of the "little divergence", either based on changes of fertility regimes, rural and urban labor organizations, or on the onset, in early modern northwestern Europe, of non strictly Malthusian growth mechanisms.

1 Introduction

One of the most relevant issues in the economic history of the early modern Europe is the emergence of a striking and persistent divide in real wages between northwestern regions and the central and southern ones at least 150 years before the Industrial Revolution. The study of such a divide, also known as the "little divergence" and different from the "great

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divergence" between European regions and the other areas of the world (Epstein (2000), Pomeranz (2000), Broadberry (2013)), is important for at least two reasons. First, because according to several economic historians (Habbakkuk (1962), Allen (2009, 2015)), the high real wages in the northwestern European regions, and particularly in Britain, were instrumental for the labor saving inventions that initiated the Industrial Revolution (e.g. the spinning jenny.) Second, because regional differences in Europe still persist nowadays, and the analysis of their origins and path dependence might help to understand contemporary challenges to a convergence that would create a unified social and economic European area. (Carlin (2010), Boltho (2010).)

In this paper, I investigate the late medieval and early modern European divide focusing on the long run response of real wages to changes in population across regions. Since the famous *Essay on the Principle of Population* by Thomas Malthus (Malthus (1798)), several economists and historians have focused on the relationships between the changes in population and the living standards in pre industrial societies. The basic Malthusian principle of a negative relationship between per capita wages and demographic trends has been often suggested as a fundamental mechanism for the determination of the living standards in pre industrial Europe (e.g. Postan (1973) for the late medieval England.) The main argument is the following. In the late middle ages the European societies relied mainly on agricultural production, where innovations were negligible and returns to production were diminishing. In this context, under a general tendency of population to increase, demographic shocks were negatively related with per capita wages. Many works have focused on the social and economic effects of the high mortality shocks in late medieval Europe, initiated with the mid 14th plague commonly known as the 'Black Death'. (Ziegler (1969), Biraben (1975), Herlihy (1997), Benedictow (2004), Kelly (2005)) Several contributions have analyzed the demographic and epidemiological features of this and the subsequent shocks, (Cohn (2002), Cohn and Alfani (2002), Campbell (2010)) the causes behind their persistence, (Carmichael (2014)) and their role in shaping the societies of European regions. (Alfani (2013a), Campbell (2013).) Other recent works have suggested that the Malthusian mechanism, associated with the high mortality regimes in late medieval Europe, might explain the early economic rise of the northwestern regions and their divergence from the other areas of the world. (Clark (2007a), Sharp et al. (2012), Voigtländer and Voth (2013a).)

However, a comparative analysis of the role of the population changes on wages in the pre industrial Europe is missing. In this paper, I fill the gap and, through the analysis of the Robert Allen's dataset of real wages in the building sector of fourteen European cities (Allen (2001)) and a series of urban and regional population covering the 14th-18th centuries, I find two main results. First, that the northwestern European regions differed from the central and southern ones not only in the pre industrial wage levels but also in the long run response of real wages to population. While central and southern regions experienced the expected Malthusian negative response of wages to demographic schocks, in the northwestern regions the two variables were detached already before the Industrial

Revolution. This finding partially contrasts with the previous results (Lee (1973), Lee and Anderson (2002) Sharp et al. (2012)) and is more in line with other works that show that in the pre industrial northwestern Europe the living standards were detached from demographic trends (van Zanden (2009), Møller and Sharp (2014), Pleijt and van Zanden (2015).) Second, restricting the empirical analysis to an earlier period of time, I show that the different response of the northwestern societies emerged already in the 14th-16th centuries. This result is new in the literature of the divide and suggests the need for further investigations on the subject. In particular, focusing on these two main empirical findings, I will claim that, among the range of explanations of the divide provided in the economic history literature, those emphasizing the pre 17th century difference between northwestern regions and the rest of Europe should be preferred.

These findings are based on two methodological choices. First, I focus on the real wages as an indicator of the living standards rather than using the series of pre industrial GDP. In fact, even if there exists a wide set of estimates of GDP per capita for early modern Europe (Broadberry et al. (2015) for England, Alvarez-Nogal and Prados de la Escosura (2013) for Spain, Malanima (2011) for central and northern Italy, van Zanden and van Leuween (2012) for Holland), not all of them seem to be equally reliable.[1] In addition, the series of real wages fit better with the aim of this paper for at least two other reasons. First, because they are more directly related with demographic changes than a composite index of prices and wages (Williamson (1995).) Second, because real wages might have been instrumental to the emergence of the Industrial Revolution and, therefore, the analysis of their relationship with demographic shocks might add a piece of knowledge to the explanation of such a fundamental event in the modern economies.

As a second methodological choice, I focus only on the real wages of the unskilled workers. The reason is that the trends of real wages of skilled workers show a less clear divergence across European regions (Pamuk (2007), Malanima (2013)), thus implying a more complex relationship with population trends, institutions and the relative prices of factors (Chor (2005), van Zanden (2009).)

In this paper I will firstly present a brief review of the main works on the "little divergence" showing why a comparative analysis of the relationship between the wages and population represents a contribution to the subject (section 2.) Then, I will show the theoretical framework for the study of the effects of population on real wages as well as the data used, the identification strategy, the econometric method, and the results of the investigation. (Section 3.) Finally, I will analyze the implications of the two empirical findings for the investigation of the causes of the "little divergence." (Section 4.)

[1] See for example Bolt and van Zanden (2014) for a discussion of the problems of the Italian GDP estimates.

2 The European "little divergence" in economic history

An important contribution for the understanding of the early modern economic divergence between the northwestern European regions and the rest of the continent is the work by Robert Allen, who collected a large series of real wages of skilled and unskilled workers in the building sector of nineteen European cities, and highlighted a divide between the northwestern regions and the central and southern ones dating back to the 17th century (Allen (2001).) Following this comparative analysis of the European real wages, in 2007 Şevket Pamuk contributed to the debate linking the divergence to the mid 14th century demographic shocks initiated in Europe with the 1347-48 Black Death (Pamuk (2007).) He argued that the decreased labor force subsequent to the plague caused a sharp rise in real wages while, on the other hand, the increased land to labor ratio caused a decline in the relative price between agricultural and manufacturing goods. Per capita incomes and wages increased throughout all European regions in the following decades, remaining higher than the pre plague levels until the recovery of population, when the divergence appeared. Recently, several works have also analyzed the extent of such divergence, with living standards measured through series of pre industrial GDP (Broadberry (2013), Pleijt and van Zanden (2015), Foquet and Broadberry (2015)) In Broadberry (2013) the European "little divergence", has been confirmed also when using GDP per capita, with an interesting comparison to a similar internal divide among eastern Asian regions.

Many contributions have provided explanations of the divergence of real wages and, more generally, of living standards and economic development in early modern Europe. Some authors, for example, have focused on the demographic regimes that might have caused the striking rise of northwestern real wages. These works have theoretically and empirically stressed how the long run high per capita incomes might have been caused by persistently high death rates (Clark (2007b), Voigtländer and Voth (2013a)) or by the concurrence of high mortality and technological improvements (Sharp et al. (2012).) Other contributions have emphasized the importance of the emergence of new fertility regimes, as for example the European marriage pattern in the northwestern regions (De Moor and van Zanden (2010)), Voigtländer and Voth (2013b) and Dennison and Ogilvie (2013) and Carmichael et al. (2015) for a recent debate on the issue.) A second group of interpretations has highlighted, instead, the role of different institutional paths. What made some regions have persistently higher living standards, was the adoption of particular societal or economic organizations that fostered economic growth. Some works have focused on the emergence of political institutions securing property rights in northwestern regions (North and Weingast (1989)), while others have stressed the importance of the combination between geographical exposure to the Atlantic trade and the pre existing growth enhancing institutions (Acemoglu et al. (2005), Palma (2016).) Pamuk (2007) has provided an interesting survey of the heterogeneous institutions emerged in the post Black Death Europe and also Broadberry (2013) has presented a wide analysis of the possible causes of the divergence. Finally, some contributions have tried to check the relative importance of each different explanation. Among them, in Allen (2003) it is shown that the increase in agricultural productivity, more than the institutional or demographic changes, was a key factor for the sustained high real wages. Recently, Pleijt and van Zanden (2015) have challenged such results and, although using GDP per capita rather than real wages, they have suggested that the representative parliaments and the higher accumulation of human capital in the northwestern regions accounted for the largest share of the divide.

Summarizing, there are still two main puzzles about the European "little divergence." First, it is still unclear what was the long run relationship of wages and population across regions. As already mentioned, several works in economic history have underlined the role of demographic factors in the changes of incomes both in early modern Europe (Lee (1973), Pamuk (2007), Sharp et al. (2012), Voigtländer and Voth (2013a)) and in other regions of the world (Pamuk and Shatzmiller (2014).) What is commonly known is that population changes affected labor supply, the ratio of land and capital to population and, hence, the relative cost of production factors. Thus, periods of population decline were followed by shortage of labor and a subsequent increase of real wages, while demographic upward trends were associated with an higher population pressure on the existing limited resources (capital and land) and, hence, a decrease in the cost of labor (wage) relative to the costs of other production factors (interest rate and rent.)

Indeed, since the mid 14th century, all the European regions experienced a long period of high mortality. The main historical studies on the Black Death (e.g. Ziegler (1969), Herlihy (1997), Benedictow (2004), Kelly (2005)) agree on the fact that since 1347, when the plague firstly reached the Mediterranean regions, the disease spread all over Europe and the death rates ranged from 35% to 60%. High mortality also hit the regions of Holland and Belgium, for which less archival evidence is available (Blockmans (1980).) In the following decades, the European population did not restore immediately, and several subsequent epidemics kept the pace of the demographic recovery low at least until the first half of the 15th century. (Biraben (1975), Carmichael (2014).) The Low Countries and Belgium were hit by plagues several times by the end of the 14th century and the following fifty years (Blockmans (1980)), and also the Kingdom of Valencia experienced a similar high mortality with at least six dramatic episodes of pestilences between the 1420s and 1460s (Pérez Puchal (1972).) The population in northern and central Italy suffered from a prolonged demographic decline in the decades following the Black Death (Del Panta (1980), Caferro (2008), Cohn and Alfani (2002), Alfani (2013a)) and also in England similar high rates of mortality persisted in the 14th-15th centuries (Wrigley and Schofield (1981).) However, since the mid 16th centuries, when population begun to recover, living standards differed dramatically across regions, a divergent outcome that motivates further investigation on the long run pre industrial response of wages to demographic changes.

A second puzzle is related with the timing of the divergence. Both the works that have analyzed the real wages or the living standards, (Allen (2001), Broadberry (2013), Malanima (2013), Pleijt and van Zanden (2015)) as well as those that have focused on the important institutional and political changes that occurred in early modern northwestern regions, (North and Weingast (1989), Acemoglu et al. (2005), Chor (2005)) they all date the beginning of the European divide in the 17th centuries or later. Only few works, instead, have claimed that the divergence was related with the late medieval demographic changes and emerged at least one century before. (Clark (2007b), De Moor and van Zanden (2010) and Pamuk (2007), although here the author frames the distinctive northwestern pattern in a broader divide with southern European and middle Eastern regions.) There is no doubt that the divide in the level of living standards did not took place earlier than the 17th century. However, a focus on the response of living standards to population changes, could not only allow to clarify how the relationship between these two variables eventually differed across regions but it could also suggest new insights about the timing and the causes of the divide.

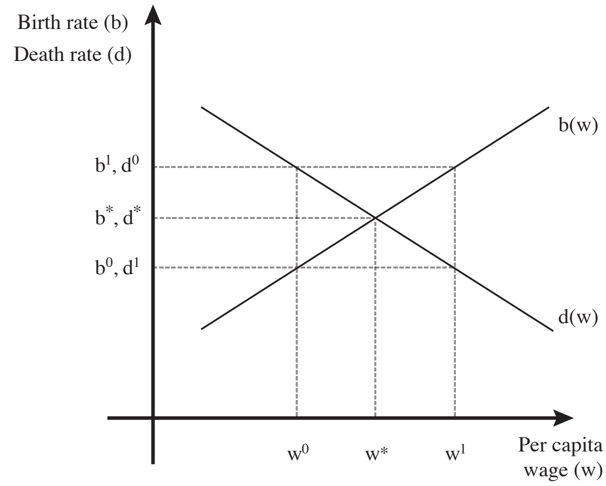
3 Assessing the early modern relationship between real wages and population

3.1 Theoretical framework

The Thomas Malthus' principle of "Iron law of population" applied to the pre modern European societies claims that, since in these economies the improvements in agricultural productivity were absent or negligible, diminishing returns to land coupled with a natural tendency of population to grow would have ended up in a negative response of real wages to demographic shocks. In addition, the changes of the birth and fertility rates associated with the fluctuations of the living standards would have functioned as the adjusting mechanisms bringing back the system to the equilibrium levels of population and real wages.

The causalities implied by the approach can be shown through the famous diagram for the Malthusian determination of per capita wages and population (figure 1.) The decreasing returns to land are indirectly shown in the lower quadrant, where the negative relationship between wages and population reflects the fact that the higher is the number of people living out of the existing resources, the lower is the marginal per capita return from the use of such resources. In the upper quadrant, instead, the birth and death rates have respectively, a positive and a negative reaction to the changes of the per capita wages. The equilibrium levels of the wages and population are determined from the intersection of the two rates, and they function as the mechanisms through which the society returns to the equilibrium after any deviation due to the changes of population size. If the population increases (for example, from N^* to N^0), the per capita wage decreases (from w^* to w^0) and the correspondent death rate is higher than the birth rate. ($d^0 > b^0$) Mortality is higher than fertility, population decreases and, hence, the capita wage increases until all the variables return to the equilibrium (w^*, N^*, b^* and d^*.) The opposite movements occur when the population decreases below the equilibrium level.

Indeed, since a long run past historiographical tradition, it has always been thought that



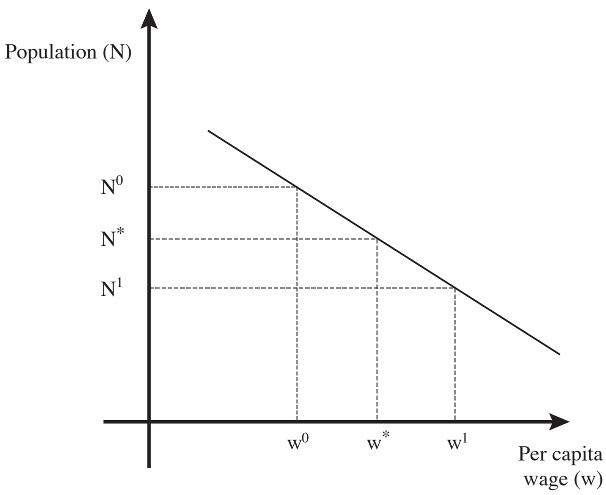


Figure 1: **The Malthusian equilibrium of wages and population.** The lower quadrant shows the negative relationship between the per capita wage and population while the upper quadrant show the birth and death rates associated with changes of wage due to demographic changes. Source: Sharp et al. (2012), Voigtländer and Voth (2013a).

the late medieval and early modern European economies were largely based on extensive agricultural activity, characterized by slow technological innovation and low returns to production. (van Bath (1966), Postan (1973).) In addition, as previously mentioned, these economies often experienced dramatic fluctuations of population size, which, at least in the short run, were followed by a negative response of living standards. However, as already mentioned, some regions had long lasting higher living standards, persisting even in periods of demographic recovery. This fact suggests that either they escaped from the Malthusian traps, or they experienced different processes of growth. In particular, with a clear depart from the traditional perspectives, recent historical findings have shown the non negligible technological innovations in early modern European agriculture. (Overton (1996).) This might suggest that those regions that had long lasting higher living standards, might have gone through early processes of endogenous technological changes, as for example, the ones driven by population density and described in Boserup (1965, 1981), and whose importance for the facts observed here will be described in the following sections.

In order to check if and when some regions diverted from a common Malthusian pattern, I set up here a time series analysis of real wages and population across several European regions in early modern times, (14th-18th centuries) with the objective to test whether all of them experienced the negative relationship between wages and population implied by the Malthusian equilibrium and, in case some of them diverted from it, when it did happen. For doing so, I will use the real wages of European cities as the proxies for living standards in those areas. Demographic conditions, instead, will be proxied through population levels, the most extensively available demographic information for early modern European regions. This last choice is, of course, a limitation. A proper test of the Malthusian mechanisms would require a continuous series of vital rates (birth and death rates) as variables for demographic changes. For instance, several works have used them for testing the Malthusian mechanisms in England. (Lee (1973), Bailey and Chambers (1993), Lee and Anderson (2002), Nicolini (2007) and Møller and Sharp (2014).) Other works have handled the problem of proxying demographic changes in a single region through the population level over time. (Chiarini (2010).) The present work has a comparative goal and, since for many of the regions in the dataset the vital rates are not available, I will use the population level as the demographic variable for testing the Malthusian predictions.

3.2 Dataset description

The series of real wages used here are the urban daily wages of the unskilled workers in the building sector provided in Allen (2001). In particular, I focus on the fourteen cities with the longest series of real wages and which are most geographically representative of different European areas. The cities, with the beginning and final dates of the series in parentheses, are: Amsterdam (1344-1800), Antwerp (1399-1800), Augsburg (1502-1766), Barcelona (1508-1797), Florence (1326-1800), Krakow (1409-1795), London (1301-1800), Madrid (1551-1800), Naples (1548-1800), Oxford (1301-1800), Paris (1431-1786), Strasbourg (1395-1800), Valencia (1413-1785) and Vienna (1440-1800). The real wages are obtained through a deflation procedures that used the consumer price indexes provided in Allen (2001).[2] I check the response of wages to population changes focusing only on the wages earned by the unskilled workers. Their employment conditions were usually not regulated by guilds and other labor organizations and, thus, their wages were more likely to depend on the fluctuations of the size of the labor force. (Epstein (1991).)

A potential concern about the use of the real wages as a measure of the response of living standards to population changes, might arise from the fact that in certain European regions, especially in the southern ones, a part of the wages of the urban workers was sometimes paid in kind, usually food provision. (e.g. the cases mentioned for the late medieval Florence in Goldthwaite (1982)) Therefore, if this part was substantial and fixed over time, a possible consequence would have been that the variation of the monetary part due to the population shocks would have been, in these regions, higher than where the payments were mostly in monetary terms. However, for this concern to represent a problem for the present analysis, two conditions should verify. First, that the in kind part was a relevant portion of the wage in the southern regions, and second, that the employers committed to pay in that form a constant fraction of the wage and, hence, that fraction was likely to not respond to the Malthusian mechanisms.

A brief summary of the historical sources show that neither of the two conditions were frequently observed in the southern regions included in the present dataset. For example, a recent research on the real wages in the Iberian peninsula has shown that the workers in early modern Madrid, "only received money wages", and the sources used for the creation of the wage series, which is compatible and complementary with the Robert Allen's one, (Appendix A.1.1), "did not mention the existence of payments in kind among these categories of workers." In addition, this characteristic seems to have been common to other cities in the peninsula, as for example Barcelona. (All these information and quotes are from Ucendo and Lanza Garcia (2014, p.610).) Also, the most relevant historical works on the wage formation in the post Black Death Florence, might clarify the second condition required for the in kind payments to not substantially affect the analysis of their Malthusian response. In particular, it seems evident from the sources that the non monetary part of the payment, especially for the unskilled workers, "was rare". (Goldthwaite (1982, p.291)) In addition, it seems that when there was an in kind payment, as in the attested 15th century cases, this "not infrequently exceeded his [author is referring to the worker] needs for ordinary consumption purposes". (Goldthwaite (1982, p.292)) Overall, it seems that at least for the southern regions used in the present analysis, the in kind payment did not frequently constitute a relevant part of the wage, and when it did, it might have been higher than subsistence, probably revealing that it was not fixed and it was likely to vary not differently

[2] Extensions and modifications of the original series and the details of the deflation procedure are in appendix A.1.

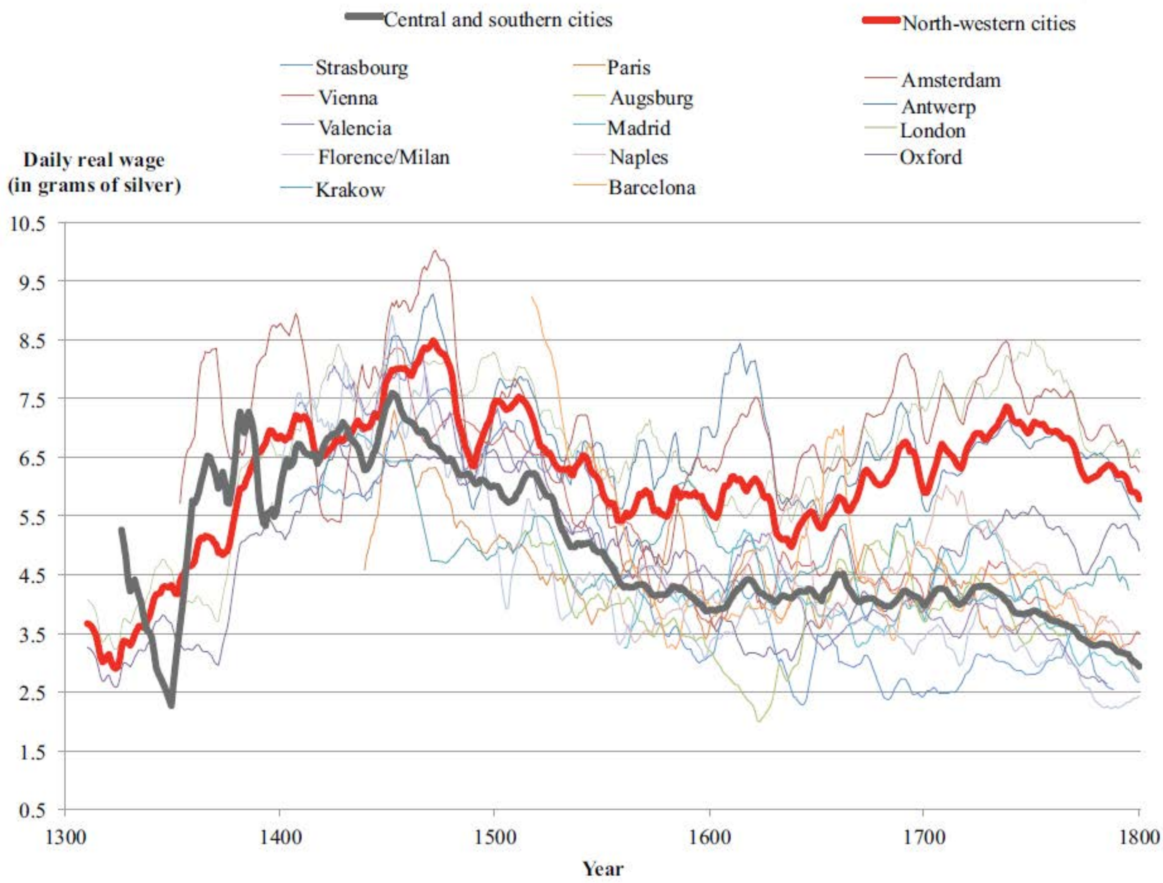


Figure 2: **The long run European divergence of real wages (unskilled workers.)** The lines show the trends of real wages in fourteen European cities. Data have been smoothed by 15 years moving average. Source: text and appendix A.1.

than the monetary wage component.

From a first look at the long run trend of European real wages, some stylized facts might be observed (figure 2.) During the period of high mortality shocks in the 14th -15th centuries, the real wages sharply increased in all areas where data are available. Then, since the beginning of the 16th century a divide emerged. Some regions had higher real wages, (London, Amsterdam and Antwerp) while in the others the real wages tended to either stagnate (e.g. Oxford, Krakow) or they widely oscillated with a long run tendency to decline. (E.g. Florence and Valencia.)

As a proxy for the demographic changes in the fourteen cities used in the analysis, I collect two series of population: urban and regional. The urban series includes the population living in the walled city, while the regional series includes the people living in a larger surrounding region. I have identified the region for each city as the most historically representative area around each urban center. Hence, for example, the population of Holland is considered the regional population for Amsterdam. For the other cities I have used the following historical concepts of region (in parenthesis the urban city to which the region refers): Brabant (Antwerp), Bavaria (Augsburg), Catalonia (Barcelona), Tuscany (Florence), Lesser Poland (Krakow), Middlesex (London), New Castile (Madrid), Campania (Naples), Oxfordshire (Oxford), Île-de France (Paris), Alsace (Strasbourg), Kingdom of

Valencia (Valencia) and Lower Austria (Vienna). I use the urban series as the main variable capturing the demographic changes, while the regional population is used as a robustness check, testing whether the trends are confirmed when a larger geographical unit is taken into account.

The available data for population are more fragmentary than the wage data and I have collected them from several different sources. Urban series are obtained from three main well known sources, Chandler and Fox (1974), Vries (1984a) and Bairoch et al. (1988), and are integrated with the data provided by specific works for each city. Regional data are obtained either from the rare works on them (e.g. the work by van Zanden and van Leuween (2012) for Holland and Malanima and Breschi (2002) for Tuscany) or from the aggregation of multiple indirect sources. The general method for the construction of both urban and regional series has implied the comparison, aggregation and integration of the data provided by different sources. Finally, I have used the linear interpolation method to fill the gaps between data.[3]

3.3 Econometric method and identification strategy

I implement a time series analysis of the long run relationship between the real wages and population. (I use the natural logarithms of the two variables). Since all the population and wage series are non stationary, they have a unit root and a single cointegration relationship, (Appendix D) the ordinary least squares (OLS) estimation of an autoregressive distributed lag model (ARDL) would, in theory, provide a consistent estimate of the short run relationship between the two variables and a super consistent one of the long run relationship, with a valid inference from standard distribution. (Pesaran and Shin (1999).) The ARDL model takes the following form

$$ln(w_{i,t}) = \alpha_0 + \sum_{j=1}^{n} \alpha_j ln(w_{i,t-j}) + \sum_{k=1}^{m} \beta_k ln(pop_{i,t-k}) + e_t \quad (1)$$

where the natural logarithm of $w_{i,t}$, the urban real wage in the city i in the year t, is regressed on n lags of itself and m lags of the natural logarithm of the population size, urban or regional depending on the series used in the estimation, of the city i, pop_i. The population level at time t is excluded from the regressors as it is likely that it took at least one period for a change of the population level to affect the wage level. Following the Schwarz Bayesian Information Criterion, the total number of lags for both the real wages and the population level is set equal to 2 for all the cities. (This number of lags also guarantees no serial correlation in the error terms, as shown in tables in the Appendix E.) Finally, e_t is the error term and α_0, $\alpha_1, ..., \alpha_n$ and $\beta_1, ..., \beta_n$ are the coefficients to be estimated and that are used to compute the long run response of wages to population. With n and m number of lags

[3]See appendix B for a detailed explanation of sources used for the construction of urban and regional population for each city, the number of data available and the description of the geographical unit used for the regional population.

equal to 2, the long run response takes the following form

$$\eta = \frac{\beta_1 + \beta_2}{1 - \alpha_1 - \alpha_2} \tag{2}$$

and, since all the variables are expressed in logarithms, the coefficient η can be interpreted as the elasticity of urban wages with respect to the change of population.

This estimation method, however, is affected by endogeneity, caused by the fact that the population level was likely to be correlated with the level of real wages and, possibly, with the other unobserved characteristics captured here through the error term. For example, a higher level of real wages might have stimulated a substantial population migration from the rural to the urban areas. Also, a general improvement of the economic conditions of a region, unobserved in the present model, might have raised, at the same time, both the real wages and the population. In both cases, these endogenous forces could have resulted in a positive relationship between the real wages and population, which could have been working even if, at the same time, the Malthusian forces were driving down the real wages because of the increase of the population level. As a consequence, while a proper estimation of the Malthusian model would show a negative long run relationship between the real wages and the exogenous population changes, the OLS estimation of the model described above would not disentangle the endogenous and exogenous changes of population, hence resulting in an incorrect estimation of the long run elasticity.

Therefore, in order to isolate the exogenous variation of the population level, and to show how much it actually accounted for the long run elasticity of the real wages, I estimate the model shown in eq.(1) through a two stages least square (TSLS) estimation and using, as an instrument for the exogenous variation of population, a variable that would capture the demographic changes due to the recurrent plague outbreaks in the late medieval and early modern European cities.[4]

I build the instrument collecting the available information on the plague outbreaks in pre modern Europe from Biraben (1975), the most widely used source on the subject, and I integrate it with additional specific sources for each region. [5] However, these data have a main limitation, consisting in the bounded information that they can provide. In fact, they usually inform on whether a plague occurred or not in a certain year and they only rarely attempt in the complicate objective of reconstructing the actual mortality caused by an outbreak in a region. (This task is, for example, convincingly accomplished in Alfani (2013a) for England and north central Italy in the 17th century.)

Here, I try to cope with this limitation and, instead of exploiting only the binary information about whether a plague occurred or not in a certain year, I use two characteristics

[4] I am deeply thankful to one of the two anonimous referees for helping me in discerning the endogeneity problem and for suggesting the recurrent plague outbreaks in Europe as a possible method to cope with that.

[5] I have collected information on plague outbreaks that hit both the city analyzed and the communities in their regions. See Appendix C.1 for details on the sources used.

that are related to plagues occurrence and that might have significantly and differently affected the exogenous mortality in each year. First, I observe that while certain plagues were isolated episodes, which lasted for a year only, other plagues lasted for more than a year, and reasonably implied a larger degree of mortality. (Biraben (1975), Benedictow (2004), Carmichael (2014).) Second, I also consider that in a year of no plague, the mortality might have been different if a plague had occurred or not in a previous time interval, and whether the plague that had occurred was a single year episode or a longer one. With this distinction, I aim at capturing the persistence of the plague effects on the mortality in the years subsequent to its occurrence. In other words, using the simple information about whether there was a plague or not in a year, I construct, for each city in the dataset, an index of exogenous mortality due to plague outbreaks, according to which each year has a certain exogenous mortality degree depending on the combinations of the two distinctions mentioned above. First, if the plague outbreaks lasted a single year or more, and second, if a year without a plague was anticipated or not by one or more plague outbreaks in a certain time interval.

In practice, the index is built as follows. I choose as a time range for the persistence of plague mortality, the following ten years without a plague. This choice is arbitrary and it represents a balance between the need to account for a time persistence of the plague and the evidence of the development of a resilience of the surviving population to the disease. (Benedictow (2004), Livi Bacci (2007, p.41-42).) Then I distinguish five combinations of the two above mentioned criteria, which represent the five cases in which each year can be possibly categorized. Namely, they are

1. If a year had no plague and there was no plague in the previous ten years;
2. If a year had no plague but there was at least one plague lasting one year in the previous ten years;
3. If a year had no plague but there was at least one prolonged shock (a plague lasting more than one year) in the previous ten years;
4. If a year had a plague lasting only one year;
5. If a year had a plague and it was part of an outbreak lasting more than one year.

I assign to each of these five combination an increasing integer number from 1 to 5, meaning, for example, that the fifth case in the list above characterizes a year with an higher exogenous mortality due to plague outbreaks than the fourth case, and so on. Since the index has no cardinal but only ordinal interpretation, I normalize it and the five cases assume then values going from 0 to 1. Finally, in order to make the index more suitable for capturing the exogenous variation of a continuous series, I smooth it using a standard local polynomial smoothing technique, (with a ten years bandwidth) equal for all the cities, and take the natural logarithm to make it comparable with population and wage series. (Simonoff and Tutz (2000).)

In order for the instrument to be a good one, it has to be valid, exogenous and it has to show some variation across space and time, so that it can be a consistent identification strategy for the dependent variable.

The validity of the instrument is straightforward. As previously mentioned, the plague outbreaks were not limited to the great waves of bubonic plague following the 1348 Black Death, but they recurrently hit the European regions also in the following centuries. They consistently reduced the rural and urban population without directly affecting the real wages. For this reason, as it will be also confirmed by the F-test of the first stages of the TSLS estimation, they represent a valid and strong instrument for the population variable.

The exogenous nature of the instrumental variable cannot be quantitatively proven and, in this case, several concerns might be raised by the fact that the occurrence and spread of the plague outbreaks in the pre modern societies might have been positively correlated with trade expansion, urbanization, other unobserved economic growth related conditions or certain particular characteristics of the regions. (Voigtländer and Voth (2013a), Alfani (2013a).) However, a descriptive analysis of the the data collected shows two main evidence supporting the exogenous nature of the instrumental variable. First, when considering the number of plagues occurred over the period here analyzed, it is evident that they did not substantially differ across regions. The cities experienced a similar fraction of years with a plague, on average the 10.5 percent of the years covered by the dataset with a variance equal to 0.01 percent. (Table 1.)

Table 1: **Average ratio of plagues to years included in the dataset.** Shown is, for each city in the dataset, column (1), the number of years covered by both the real wages and population, column (2), and the fraction of years in which a plague outbreak is observed to the total number of years in the dataset, column (3). Source: appendix C.1.

City **(1)**	**Series length (in years)** **(2)**	**Fraction of years with a plague** **(3)**
Amsterdam	457	0.107
Antwerp	402	0.101
Augsburg	265	0.117
Barcelona	290	0.110
Florence	474	0.126
Krakow	387	0.101
London	500	0.126
Madrid	250	0.120
Naples	252	0.109
Oxford	500	0.126
Paris	356	0.112
Strasbourg	394	0.109
Valencia	374	0.112
Vienna	361	0.133

Also the mortality index, built from the information of plague occurrence as described above, shows some distributional characteristics that support its exogenous nature.[6] In fact,

[6]As the smoothing technique of the index is the same across cities, it does not affect the exogenous characteristics of the instrument.

some concerns might rise if the combinations of the index capturing the occurrence or persistence of longer plague episodes would largely differ across cities, namely the combinations 3, 4 and 5 listed in the description above. This would imply that regionally specific characteristics did affect the occurrence of plague outbreaks or the persistence of the stronger ones over time. However, the frequency distribution of the five combinations of the index across the cities in the dataset shows that this was not the case. (Table 2.) Even if there was a non negligible degree of heterogeneity of the first two combinations, (the years without a plague in the previous ten years or with only one year of plague in the previous 10 years), the cities had a similar frequency of occurrence of the other three combinations. This implies that they had a similar frequency of plagues that lasted one year only, as well as of those that lasted more. In addition, they also experienced a similar frequency of years without a plague but with at least a major plague outbreaks in the previous ten years.

Table 2: **Frequency distribution of the mortality index values across cities.** Shown is for each city in the dataset, the number of year for which we have both real wages and population data, and the frequency distribution of each of the 5 values of the mortality index, built as described in the text, across the years covered by the dataset. The last two rows show the average frequency across all the cities and the standard deviation for each value of the index. Source: text and appendix C.1.

City	**Series length (in years)**	**Distribution of the index values across years**				
		1	**2**	**3**	**4**	**5**
Amsterdam	457	46%	20%	23%	3%	8%
Antwerp	402	50%	25%	15%	4%	6%
Augsburg	265	44%	19%	25%	3%	9%
Barcelona	290	59%	2%	27%	1%	11%
Florence	474	54%	5%	28%	2%	11%
Krakow	387	42%	25%	23%	3%	7%
London	500	41%	23%	24%	4%	8%
Madrid	250	62%	4%	22%	0%	12%
Naples	252	74%	0%	17%	0%	10%
Oxford	500	43%	23%	22%	5%	7%
Paris	356	41%	29%	19%	6%	5%
Strasbourg	394	42%	21%	25%	4%	8%
Valencia	374	68%	8%	13%	1%	10%
Vienna	361	36%	30%	21%	4%	9%
	Average frequency	50%	16%	22%	3%	9%
	Std. Deviation	11%	10%	4%	2%	2%

Finally, the data also show that the cities were only rarely hit at the same time, thus suggesting that the instrumental variable exploits some variation across time and space.

I first show this for the occurrence of plague outbreaks, for which I compute the fraction of cities that were contemporaneously hit by a plague to the total number of cities in the dataset. The evidence shows that the 40 percent of the plague outbreaks occurred contemporaneously only in the 10 percent of the cities in the dataset, the 89 percent of the plagues occurred at the same time only in the 30 percent or less of the cities, and only the 9 percent of plagues hit, at the same time, the 40 percent or more of the city included in the dataset. (Figure 3.)

Similarly, I show that also the information implied by the exogenous mortality index

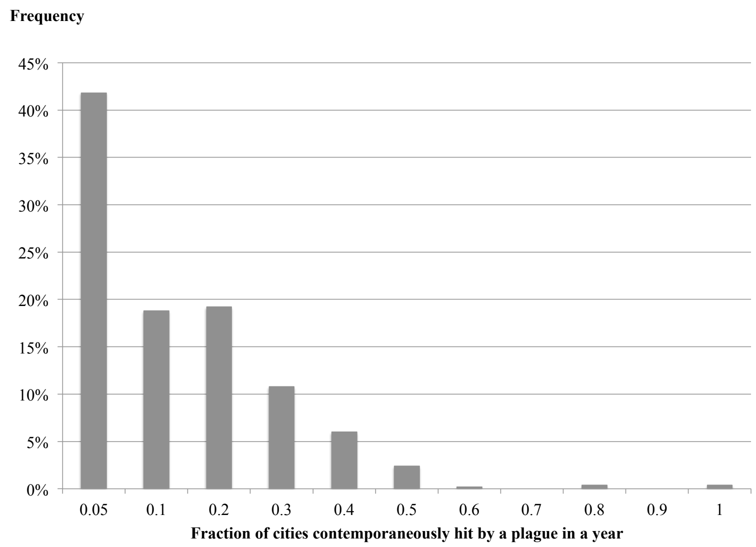


Figure 3: **Frequency of distribution of the fraction of cities contemporaneously hit by a plague.** Shown is the frequency, y-axis, of the fractions of cities contemporaneously hit by a plague in a certain year, x-axis, in the whole period under analysis (14th-18th centuries). Note that the single year in which all the cities where it by a plague is a year, 1361, in which the total number of cities in the dataset is only 4 (London, Oxford, Florence and Amsterdam.) Source: see Appendix C.1.

exploits a substantial degree of time variation across cities. Focusing on the four last combinations of the index, those implying the occurrence or the persistence of any type of plague outbreak, it is shown that all of them occurred contemporaneously in a limited fraction of cities of the dataset. (Figure 4.) For example, the plague outbreaks longer than one year occurred in more than 70% of the case, in only 30% or less cities of the dataset contemporaneously. These two results combined suggest that the plague outbreaks, and the instrumental variable derived from them, might represent a good solution to the identification problem.

For all the fourteen cities included in the dataset, I implemented the TSLS estimation of econometric model across the whole period for which data are available in each city of the dataset.

In addition, in order to check when any eventual difference across the regions emerged, I have restricted the above analysis to two different sub periods: before and after the year 1600. The sub period analysis has been possible only for ten cities that have a sufficiently large number of observation before that date: Amsterdam, Antwerp, Florence, Krakow, London, Oxford, Paris, Strasbourg, Valencia and Vienna. Each pair of variables maintain, in the sub periods, the time series characteristics that they show in the long run. (Appendices D.) Also, the plague outbreaks and the derived index are, in the sub periods, a valid and exogenous instrument for identification. (Appendix C.2.) The choice of the 1600 as the boundary for the sub periods is motivated by the need to test, in two sufficiently large periods, whether the changes of the demographic patterns in certain regions occurred in the immediate decades following the dramatic demographic shocks in the 14th-16th centuries,

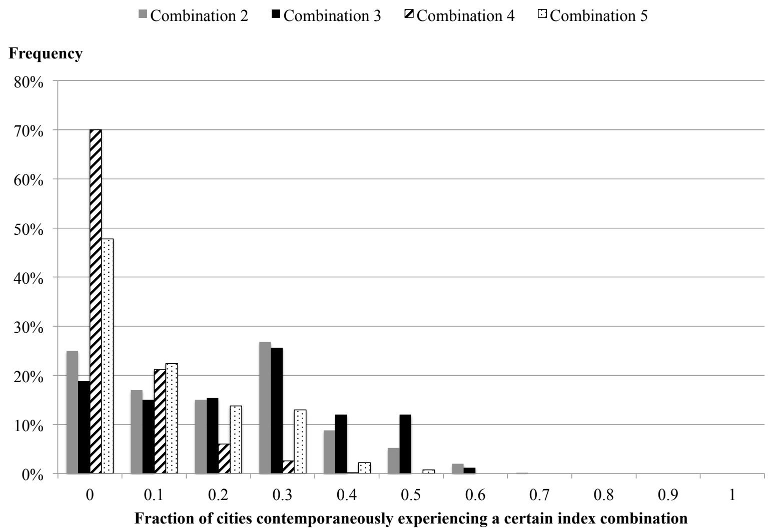


Figure 4: **Frequency of distribution of fraction of cities contemporaneously experiencing the same plague mortality index value.** Shown is the frequency, y-axis, of the fractions of cities, x-axis, contemporaneously experiencing one of the four last index values in the whole period analyzed. (14th-18th centuries.) Source: text and appendix C.1.

and they eventually anticipated the important institutional and technological changes that might have accounted for the distinguished path of the northwestern regions. In addition the analysis of the post 1600 provides insights about how the living standards and demographic factors behaved in different regions in the two centuries before the Industrial Revolution.

Finally, the choice of restricting the analysis to the pre 1600 years might also represent an additional way to cope with the limited information about the possible heterogenous mortality induced by the plague outbreaks. In particular, recent findings have underlined how, starting from the 17th century, the disease outbreaks might have differently affected the mortality across Europe. Regionally specific economic characteristics might have influenced the impact of plagues on mortality in each region, thus making the outbreaks not an equally exogenous demographic shocks across Europe. (Alfani (2013a).) Limiting the analysis to the 14th-16th centuries, when plague outbreaks were likely to be a more homogenous shock on mortality across regions, might provide an interesting robustness check on the result found for the whole 14th-18th centuries period.

3.4 Results

The long run elasticities of the real wages to the population changes are computed from the single coefficients estimated for each city in each period analyzed. (Appendix E.) A caveat with the results is that in some case the short run coefficients have large standard error, which might weaken their statistical significance. [7] However, as shown in Wooldridge (2012, p.353) and, more generally, in Johnston and DiNardo (1997), even in this case the derived long run coefficients are consistent.

The elasticities for the 14th-18th centuries period show a large degree of variation, across the European cities, of the response of the real wages to the exogenous population shocks. (Figure 5).[8]

Four northwestern urban centers (Amsterdam, Antwerp, London and Oxford) shared a common long run path, characterized by a negligible negative check of mortality shocks on real wages. (The mean coefficient across the four cities is -0.046, when using urban population.) This results suggests that, in these regions, the living standards were, in the long run, delinked from the main exogenous demographic changes, and the pattern was likely to not be limited only to the cities with a capacity to mobilize a large amount of economic and demographic resources in their areas. Indeed, most of the cities in the northwestern sample were important centers in their respective regions (as in the cases of London, Amsterdam and Antwerp), but a northwestern region that was surely less relevant to the development of the whole area, Oxford as representative of Southern England, experienced a similar long run delink, thus suggesting that the phenomenon was probably a general tendency of the northwestern economies, not only limited to the main urban centers. Overall, a clear common path characterized the northwestern Europe, it consisted in a long run escape from the Malthusian forces regulating the living standards, and it clearly distinguished those regions from the rest of the continent. (The Welch t-statistics of the significancy of the difference in mean coefficients between the four cities and the other ten in the dataset is 4.060, Welch (1947).)

Among the other European cities, two patterns emerged and, even if with some marked exception, they show a geographic localization. A group of central European cities (Paris, Augsburg, Krakow and Vienna) had a moderate negative elasticity, a behavior that reflects their long run stagnation of living standards, when compared to northwestern regions, (Allen (2001), Pleijt and van Zanden (2015)), paired with a demographic pressure on available resources relatively lower than in the southern European areas. (Pfister and Fertig (2010).) Four southern cities (Barcelona, Valencia, Naples and Florence) had a clearly different path, and all of them shared the expected negative Malthusian check of exogenous population shocks on real wages. (The mean coefficients in the two groups are statistically different,

[7] The problem might be due to a small degree of multicollinearity caused by the fact of using lags in both the first and second stages of the regression, or by the use of a small sample in some cases. (Wooldridge (2012).)

[8] The standard errors are computed through a bootstrap procedure where the TSLS regression is iterated 1000 times and each time the residuals are saved and rescaled. Then for each iteration the coefficients are saved and the elasticities computed. From these computation, the standard error is derived. (Vinod (1993).) The single coefficients of the TSLS estimations, the main diagnostics of the regressions and the details of the computed elasticities are, for the whole period and sub periods analyses, and when using either urban or regional population series, in the tables in appendix E. There I also report the results of the estimation of the econometric model for all the cities and periods using the OLS method.

Welch t-statistics = -3.652.)

Two exceptions emerge in each of the two groups: Madrid, where the long run elasticity was not only different from the average southern elasticity, but also an exception among the Iberian peninsula cases, and Strasbourg, which exhibited a response of the real wages to population changes more similar to the southern Europe than to the closer central European cities. The result of Madrid is not entirely surprising, as recent literature on pre modern Spain has already marked the heterogenous Malthusian patterns in the region. In Alvarez-Nogal and Prados de la Escosura (2013) it has been observed that a positive link might have existed in certain Spanish regions between per capita output and population expansion, (Alvarez-Nogal and Prados de la Escosura (2013, p.24), while in Chaney and Hornbeck (2015) a clear Malthusian pattern has been shown for the 17th century Kingdom of Valencia. On the other side, the Strasbourg evidence is new and calls for more detailed research on the region, which is out of the scope of the present research.

Overall three main results emerge. First, the northwestern Europe had a clear delink of real wages to the exogenous changes of population. This pattern was not confined to the main urban centers and, instead, it was shared with the other minor centers in the area. Second, a different path characterized the central and southern European regions, with the former experiencing a moderate negative check of demographic shocks on real wages, while the check was markedly more negative in the south. Finally, even if with a different magnitude and some relative change in the order among cities, these differences are mostly confirmed when using regional rather than urban population.

Among the fourteen series analyzed in the long run, ten of them go sufficiently back in time to allow for a sub period analysis of the long run response of the real wages to the exogenous population changes. As already mentioned, this further investigation serves two main purposes. First, to check when a different pattern between northwestern regions and the rest of Europe emerged, with the choice of the 1600 break point motivated by the occurrence, mainly in the 17th century, of the great trade and institutional changes in the northwestern Europe. Second, it might also be taken as a robustness check of the long run results. If the difference observed in the longer time span would be confirmed in the first two centuries after the Black Death, this would mean that the divergent pattern across the Europe occurred also when exogenous shocks were likely to be more qualitatively similar across regions.

The negative magnitudes of the elasticities in all European regions in the pre 1600 period are obviously different than those observed from the 14th-18th centuries coefficients (in the aftermath of the Black Death the real wages increased also in northwestern regions) but, however, they surprisingly define a similar divide across European regions prior to the 17th centuries. (Figure 6.) The northwestern cities had a significant different path with respect to the other European urban centers. (The two groups average coefficients are statistically different with a Welch t-statistics equal to 3.883.) Among them, the central European cities (with the exception of Krakow) seem to have had a lower negative response than the other southern regions, which, in turns, had a strong negative response, that resembles their long run pattern. These results are confirmed (with the exception of Paris), when the regional population series is used.

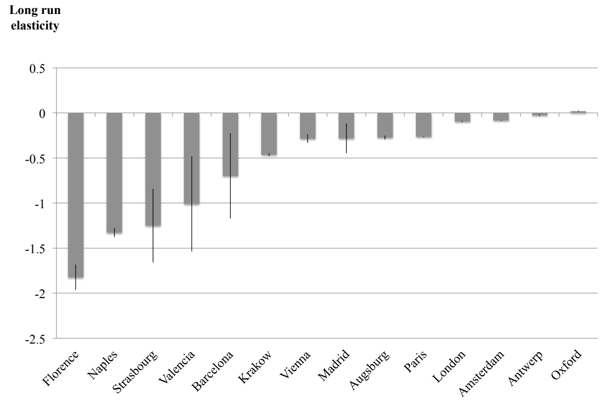
Finally, it is also interesting to observe how the same ten cities analyzed in the pre 1600 period behaved when the response of real wages to the exogenous population changes is studied in the two centuries before the year 1800. (Figure 6.)

As for the whole period and for the 1600 results, the northwestern cities maintained, in the 17th-18th centuries, a path distinguished from other European regions. (The unexpected substantial negative response observed for Antwerp is somehow puzzling and weakens any comparison of mean averages between northwestern regions and the other groups.) The central regions too experienced a pattern resembling the one observed over the long period, even more similar than it was observed in the pre 1600 analysis. The average long run elasticities of Vienna, Paris and Krakow was relatively lower than in their pre 1600 period (Welch t-test of the difference, 2.613), but not significantly different than their elasticity in the whole period analysis, (Welch t-statistics, 1.836, p-value 0.174) Finally, also the southern regions strongly confirm their long run tendency. The post 1600 analysis suggests that those areas went through a process of Malthusian stagnation which was more marked than in the central regions and was maybe due also to a different qualitative incidence of the plague outbreaks in the 17th-18th centuries. (Alfani (2013b).)

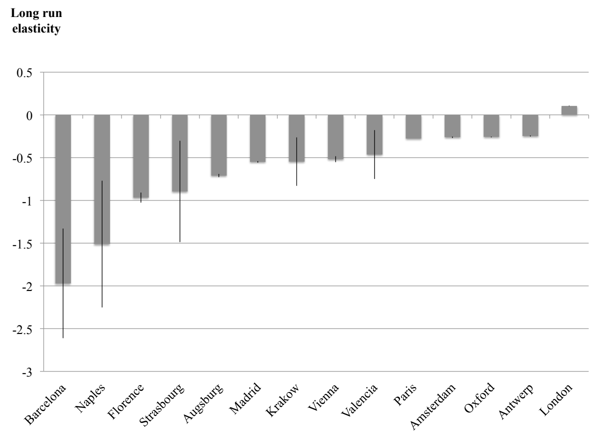
4 The European different response to population changes and the implications for the "little divergence"

The results presented in the previous section have two important implications for the study of the "little divergence". As shown from the long run and sub period analyses, it appears that the northwestern regions experienced an evident escape from the Malthusian positive checks on living standards before the Industrial Revolution, and that this long run pattern was not experienced by the other central and southern European regions. Thus the "little divergence" between the northwestern Europe and the rest of the continent consisted not only in a divide in the wage level, or in other economic, social and political factors, but also involved the pre modern fundamental relation between the living standards and the population level.

In addition, the results have also shown that the northwestern regions escaped from the Malthusian positive check far before the Industrial Revolution and, surprisingly, even before the substantial economic and political changes that occurred in the 17th-18th centuries, as, for example, the great development of the Atlantic trade, and the consequent economic gains for northern countries, or the new political institutions that emerged in England during the 17th century. This finding, in particular, bears consequences on the causes of the divide, and it suggests that among all the explanations provided, those focusing on the differential patterns emerged in the 14th-16th centuries should be preferred. Therefore, although it is

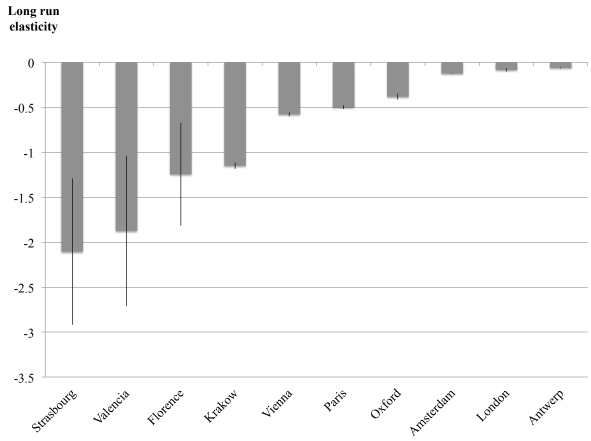


(a) TSLS - Urban population

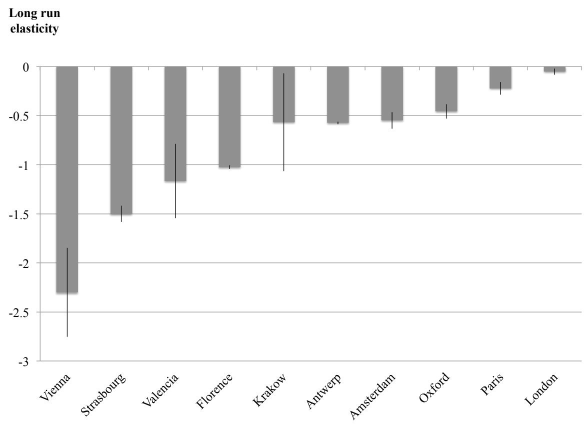


(b) TSLS - Regional population

Figure 5: **Long run elasticities of wages to population. (14th-18th centuries.)**. Shown in figures (a-b) are the elasticities of real wages to population changes, computed using the TSLS estimation of eq.(1) in the 14 European cities in the dataset when, respectively, urban and regional population series are used. The standard errors are computed from 1000 bootstrap iteration following the procedure described in section 3.3. Source: tables E.1 and E.2 in appendix E.

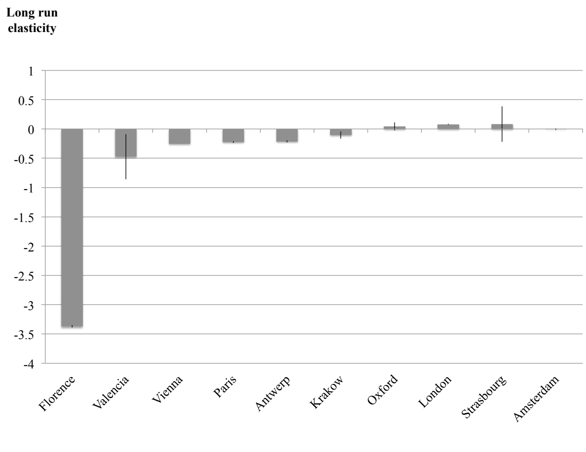


(a) TSLS - urban population

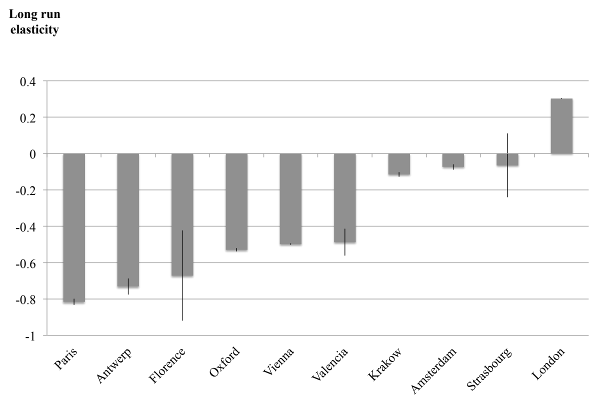


(b) TSLS - regional population

Figure 6: **Long run elasticities of wages to population. (Pre 1600)**. Shown in figures (a-b) are the elasticities of real wages to population changes, computed using the TSLS estimation of eq.(1) in the 10 European cities in the dataset for which the pre 1600 analysis has been implemented and when, respectively, urban and regional population series are used. The standard errors are computed from 1000 bootstrap iteration following the procedure described in section 3.3. Source: tables E.3 and E.4 in appendix E.



(a) TSLS - urban population



(b) TSLS - regional population

Figure 7: **Long run elasticities of wages to population. (Post 1600)**. Shown in figures (a-b) are the elasticities of real wages to population changes, computed using the TSLS estimation of eq.(1) in the 10 European cities in the dataset for which the post 1600 analysis has been implemented and when, respectively, urban and regional population series are used. The standard errors are computed from 1000 bootstrap iteration following the procedure described in section 3.3. Source: tables E.5 and E.6 in appendix E.

out of the scope of the present work to provide any quantitative account of the reasons of the divergence, I will here briefly summarize three explanations, provided more or less recently in the economic history literature with the objective to show how they could fit with the results provided above and what they, eventually, have in common.

A first possible suitable explanation of the observed differential pattern of the northwestern regions is represented by those analyses that have emphasized the changes in the demographic regimes that occurred in the northwestern Europe in the 14th-16th centuries, and that probably did not conteporaneously occur in the southern European regions. This explanation focuses on the role played by the European Marriage Pattern, (EMP) and it emphasizes how the implied institutional innovations, in the northern Europe, in marriage, fertility choices and female labor participation might have favored a change in the preventive check implied by the Malthusian framework. (Hajnal (1965), De Moor and van Zanden (2010),Voigtländer and Voth (2009), Voigtländer and Voth (2013b).) In particular, the institutions that mattered for such distinct path were the late age at marriage, the marriage decision based on the sole consensus of the wife and husband, (opposite to the combined marriages where the original families took the marriage decision) and the changes of labor markets organizations that favored female employment. All of these institutional changes fostered a reduction of birth rates, either because women worked more when younger than they used to do before, or because they introduced women concern in fertility choices. Recently, the response to a scholar debate on the subject, and on the issues related with the quantitative account of the role of the EMP, has convincingly clarified that it was not simply the age at marriage (a decision, in fact, endogenous to the short run population and real wages trend) that affected the fertility choices but, more generally, all those "girlfriendly" institutions that likely increased the role of women in the households and, more broadly, in the economic system and were instrumental to a change in fertility regimes in the northwestern Europe. (Dennison and Ogilvie (2013), Carmichael et al. (2015).)

A second possible explanation, is represented by the different labor institutions and mechanisms regulating the determination of workers' wage across the late medieval and European regions. This idea, which is relatively less developed in the recent economic history debate, finds its origins in the Robert Brenner's contribution to the analysis of the influence of social institutions on the income distribution effects of the late medieval demographic exogenous shocks. (Brenner (1976) and Aston and Philpin (1985).) In that contribution, the main hypothesis was that a similar demographic exogenous shock, such as the 1348 Black Death, might have differently impacted on the subsequent income distribution of the European regions, conditional on the eventual different pre shock social structures regulating the distribution of power and gains from agricultural labor.

The hypothesis, which focused on rural income distribution, suggests that in those regions where institutions favored a large landlords' extraction of revenues from land cultivation, the returns to agriculture were unavoidably diminishing and the changes in population were negatively linked with the changes in incomes. This was the case, for example of

Italy, where the urban based landlords exerted a large control on rural production before the 14th-15th centuries exogenous shocks, and where such power helped them to limit the rural incomes afterwards. (Cortonesi (2006), Piccinni (2006).) Or, similar mechanism took place in those regions where a strict pre demographic shock control by landlord on rural revenue, translated in a progressively increasing extractive power of the king in the following centuries, as it happened in France (Forquin (1962, 1976), Jacquart (1974)) or Spain (Garcia-Oliver (1991), Furió (1995, 1997).) Instead, if the set of rural labor institutions, customs and rules, would have favored the peasants conditions, as in the case of Low Countries, (van Bavel (2002, p.15), van Bavel and van Zanden (2004)), or, to some extent also of England, (Campbell (2000), Campbell (2005, p.6)), a negative population shock could have, for example, generated some additional extra income for investments in productivity, which could have supported high incomes also when population recovered.

This perspective has two main shortcomings. First, as the mentioned different institutions mainly were rural, evidence should be found of a similar divide across regions in urban labor institutions. However, the most recent research on the issue, and the urban wage regulation in the late medieval Europe, show a larger variety of institutional outcomes and economic effects than the regularities observed for the rural sector. This suggests a more complex analysis of the interaction between the late medevial changes of urban labor markets and the Malthusian forces in Europe. (Cohn (2007)) In addition, in order for the hypothesis to identify a viable path of economic growth, some evidence of the increase of labor productivity should be observed in the regions with more favorable labor institutions. Several works have suggested that the improvements of labor productivity in pre modern Europe were negligible, (Clark (2007b) and Voigtländer and Voth (2013a)) while others have claimed that the 14th-15th centuries transformation of the economies in northwestern regions were instrumental to rural production diversification and increase in labor productivity. (van Bavel and van Zanden (2004).) Overall, additional historical research on the labor institutions and productivity is needed, in order to support an early modern Brenner's type mechanism of escape from a Malthusian trap.

So far, I have presented interpretations of the northwestern early escape from the Malthusian trap either based on mechanisms intrinsic to the Malthusian model itself, as the new fertility regimes implied by the EMP, or based on some endogenous factors, as the rural or urban labor institutions, that might have determined a different realization of the Malthusian predictions. A third additional group of interpretations is represented by those contributions that have suggested that an additional growth model might supplement the Malthusian one for the explanation of the changes of population and living standard in the pre modern economies. These works are based on the Ester Boserup's model of economic growth, (Boserup (1965, 1981)) and, in particular, on the idea that such model is not alternative but, rather, "complementary" to the Malthusian one. (Lee (1986), Alfani (2013a), Møller and Sharp (2014))

The main structure of these syntheses is that the two models, which share the concept of diminishing returns to labor given a certain technological level, might be merged to explain how population density might have induced technological change that, in turns, provided the conditions for a society to overcome the constraints to a sustained population growth. It is not in the scope of the present research to go through the dynamics describing how these processes might have actually occurred. (Lee (1986)) However, it is interesting to observe that both England and the Low Countries, when their population levels start to recover in the 16th century, went through significant agricultural technological changes, which might have created the conditions to increase the output and support further population development. It is probably the case, for example, of the many agricultural changes in the 16th century England, as for example the innovations to the crop rotation system, Overton (1996) or the already mentioned development of non agricultural rural productions in Holland. (van Bavel and van Zanden (2004).) Still, it remains to be further developed under what conditions, in this Boserupian - Malthusian framework, population density might have induced technological change. In the original synthesis of the two models, what accounted for the change were mainly large exogenous demographic shocks. (Lee (1986).) Recently, it has been suggested that also a certain set of institutions might have been instrumental for the change. For example, in certain early modern North Italian regions, (Emilia, Veneto and part of Lombardy) the early modern combination of high population density and a small land ownership structure might have determined a change of crops cultivation, accompanied by a new organizational techniques, which might have been instrumental to the overcome, even if it was a late one, of the long run limits to population growth. (Alfani (2012).)

Summarizing, these three theories are not necessarily alternative to each other, and they might capture parallel changes in the northwestern regions that concurred to the overcome of past boundaries to the growth of population and living standards. Indeed, all of them, at least in their most recent interpretations, seem to point to a common factor that characterized the early northwestern exceptionality: the pre existence or the arise of more favorable institutions, (labor markets, marriage or structure of land ownership) that helped those regions to escape from the Malthusian trap a moment before that the new resources would have been available from the Atlantic trade.

5 Conclusion

Through the analysis of the long run relationship between the real wages and the exogenous population changes across fourteen European cities, I have shown two new results about the nature and the timing of the "little divergence".

First, I have shown that while southern and central European areas experienced, in the long run, (14th-18th centuries) the predicted Malthusian negative response of living standards to population, the northwestern regions escaped from that trap, and had their real wages detached from demographic changes already before the Industrial Revolution. Second, I have restricted the analysis to the 14th-16th centuries and I have found that the distinctive long run pattern of the northwestern economies originated in these early centuries.

As a consequence of these results, I have suggested that among the wide range of explanations provided for the "little divergence" in Europe, those that concentrates of differential factors arising in the first two centuries after the 1348 Black Death should be preferred. Among these, I have briefly presented the three that I consider to be more suitable for interpreting the result of this paper: the change in fertility regimes in northwestern Europe, the pre existence and development of labor institutions more favorable for rural and urban workers and the arise of a different growth model, namely the synthesis of the Boserupian and Malthusian ones. I have claimed that further investigations on the possible combined effects of the three factors and, in particular, a focus on the underlying institutions favoring their occurrence, might enhance the understanding of the European early modern economic divide.

Appendices

A Sources for historical series of real wages and population

I describe here the main sources used for assembling information on the historical series of real wages and urban and regional population used for the econometric analysis in the text. The number of single point available for each series are shown in table B.1. I can provide the whole set of series used in the analysis upon request.

A.1 Wage data

The series of nominal wages of the unskilled workers and consumer price indexes for 13 of the 14 cities included in the analysis are those compiled by Robert Allen in 2001 (see Allen (2001), series can be found at: www.nuffield.ox.ac.uk/People/sites/Allen/SitePages/Biography.aspx.) These are: Amsterdam, Antwerp, Augsburg, Florence, Krakow, London, Madrid, Naples, Oxford Paris, Strasbourg, Valencia, Vienna. Here, I explain the modifications and integration I have made to some of those series to make them the most possible continuous and complete. The nominal wages and consumer price indexes for Barcelona are obtained from different sources that are shown below.

For all the 14 series, the deflation procedure consisted in deflating nominal wages expressed in silver grams by a Laspeyres consumer price index (CPI), which, following Allen (2001), for each city has been made relative to the 1744-45 CPI for Strasbourg, in order to compare them at purchasing parity power. Differently from the Allen's deflation procedure, where real wages are computed using the concept of welfare ratios, here the nominal wages in silver grams for each year have been simply divided by the corresponding CPI in silver grams at purchasing parity power.

A.1.1 Some notes on the construction of wages and prices series

<u>Amsterdam</u>
In the Allen's dataset the series covers the period 1500-1800. I have anticipated it to the year 1344 using the real wages for the urban unskilled laborers in the Holland region provided in van Zanden and van Leuween (2012). The series covers the 1344-1500 period and is comparable to the Allen's data. (The series can be downloaded at www.cgeh.nl/reconstruction-national-accounts-holland-1500-1800-0.)
<u>Florence</u>
The series is realized combining the wages of urban workers in the Tuscan city for the period 1326-1600 with the wage for laborers in Milan in the following two centuries. In Malanima (2013) it has been shown that, for the period in which both the two series are available, the wages almost overlap. In addition, the aggregation of the two wage series is also supported by the almost similar demographic and economic conditions of the two cities in early modern

times. Taking this into account, the series is arbitrarily labeled as "Florence" in the paper, although I acknowledge that it should be considered as representative of northern - central Italy. In addition, Malanima (2013) has suggested several corrections to the wage series of florentine skilled workers based on edited sources. Here, I have conducted a similar analysis on the original sources used for the construction of the wage series of florentine unskilled workers (de La Roncière (1982), Goldthwaite (1982) and De Maddalena (1949, 1974)) and I found no substantial difference with respect to the series built by Allen.

Madrid

There are two main shortcomings in the series for Madrid provided in Allen (2001): the series of nominal wages of the unskilled workers has a gap in the 1600-1730 years and the prices used for the CPI in the 1550-1700 period (coming from Hamilton (1934, 1947)) are not the most recent (and accurate) ones (see the discussion in Ucendo and Lanza Garcia (2014).) I fill the gap in the nominal wages combining the series of wage rates in silver grams for unskilled workers in Madrid for the 1600-1700 years provided in Ucendo and Lanza Garcia (2014), with the one for the 1701-1730 period provided in Llopis Angelàn and Garcia Montero (2009, 2011). Both the two series are comparable with the one provided by Allen for the other years of the series. For the deflation of the 1600-1730 nominal wages I have used the CPI given in Ucendo and Lanza Garcia (2014), which solves the shortcomings of the prices series of Hamilton, it almost overlaps with the Allen's CPI for the period in which both are available and it has a similar trend. As the new CPI provided in Llopis Angelàn and Garcia Montero (2009) is built on prices collected from pious institutions, a completely different source than the one investigated by both Hamilton (1934, 1947) and Ucendo and Lanza Garcia (2014), I have decided to deflate the 1700-30 nominal wages with the CPI provided by Allen (based on Hamilton's data and for a period not covered by the new CPI given in Ucendo and Lanza Garcia (2014).)

Naples

The CPI provided in Allen (2001) has one gap for the 1641-1747 period. I filled the gap using price data provided in Moziani et al. (1966) and Sartorelli et al. (1967) and building a CPI coherent to the one built by Allen. The new CPI can be provided upon request.

Barcelona

The series of nominal wages of unskilled workers in the building sector is based on the data provided in Feliu (1991). (Data can be downloaded at: www.iisg.nl) Nominal wages starts in 1508 and end in 1800 with several gaps that I have filled using interpolation. The CPI has been built with the same quantities and goods used in Allen (2001) for the construction of the CPI of Valencia. In the years with missing information prices have been derived using the technique suggested in López Losa and Piquero Zarauz (2016).

B Population data

For the construction of series of urban population for the cities included in the dataset I integrated the information provided in Chandler and Fox (1974), Vries (1984a) and Bairoch et al. (1988). Then, I have revised or integrated those information with those coming from secondary sources dealing specifically with each of the city in the dataset. I describe the criteria and information used to construct the urban population series for each city below. I have assembled the series for regional population using specific sources for each region. I described them below.

Amsterdam

Urban population. The data from Bairoch et al. (1988) starts in the year 1200 and, with a 100 years time interval, cover the whole period until the year 1800. I have merged this series with the data for the 16th and 17th centuries given in Chandler and Fox (1974) and Vries (1984a). These data have been integrated with: the data point information in 1470 given in Russel (1958), three data for the 16th-17th centuriestaken from Hinskens and Muysken (2007) who report data shown in Kuypers (2005) for the years 1585, 1625 and 1632. The 1622 population figure is given in Vries and van der Woude (1997).

Regional population. The interpolated series for Holland population is taken from the estimation of Holland national accounts produced by Jan Luiten Van Zanden and Bas van Leuween available online at http://www.cgeh.nl/ and used for van Zanden and van Leuween (2012). The series spans since the 1344 to the end of the 18th century and is mainly based on the work of Vries (1984b) and Vries and van der Woude (1997). Authors also inform that the continuous series is obtained taking into account of the following demographic changes not captured by the series: the population decline in the 1572-1576 period, the increase in demographic growth after the 1580 and the reduction in population due to the epidemics occurred in the 1630-70 years.

Antwerp

Urban population. Bairoch et al. (1988) provide population numbers for the period ranging the 1200-1800 years and data are given for every 100 years. Data for the 15th, 16th and 17th also come from Chandler and Fox (1974) and Vries (1984a). These information have been integrated with 2 data points from Klep (1976) about the population in 1374 and 1474. In particular, in Klep (1976), the following information are given: extension of the Antwerp area (urban and rural) in square kilometers across centuries, population density per square kilometer and urbanization rate. The figures used in the present analysis have been obtained multiplying the extension of the urban area times population density and extracting from this the percentage of those living in the city (the urbanization rate). The resulting number are coherent to the ones shown in Bairoch et al. (1988) and Chandler and Fox (1974).

Regional population. Information of the historical population of the Brabant region comes from Klep (1976) multiplying the extension of the region in square kilometres times the population density (urban and rural) per square kilometer. Data points range from 1374 to

1806 and are integrated with 4 observations from Russel (1958).

Augsburg

Urban population. Data from Bairoch et al. (1988), cover the 1200-1850 period with a 100 years interval. These have been merged with the observations for the 14th-18th centuries provided in Chandler and Fox (1974) and those in the 16th-18th centuries given in Vries (1984a).

Regional population. To my knowledge, there is no extant information on the population of Bavaria in the 16th century. For this reason I have extrapolated it, using information of the population of Bavarian cities for the 16th-18th centuries (Bairoch et al. (1988)) and comparing them with the Bavarian population data in the 17th-18th centuries and provided in Lee (1977), Schlögl (1988), Albrecht (1998) and Pfister (1994).

Barcelona.

*Urban population.*Bairoch et al. (1988) provide 7 figures for urban population of Barcelona between 1300 and 1800. These have been integrated with figures for 1550 and 1650 from Vries (1984a). From Chandler and Fox (1974) I have taken the observations to complete the series in the mid-14th century (2 data points), the beginning of the 16th and 18th century and the second half of the 18th century (4 observations in the years between 1750 and 1800.) Sources: Chandler and Fox (1974), Vries (1984a), Bairoch et al. (1988).

Regional population. The main structure of the regional population is built on the figures provided by Russel (1958) for the 14th-15th centuries and Nadal (1983) for the 16th-18th centuries. These figures have been integrated with 1 observations provide in Nadal and Giralt (1960) (year 1600), 7 observations from Ojeda Nieto (2004) for the first half of the 17th century and 2 observations from Livi Bacci (1968) for the end of the 18th century.

Florence

Urban population. The sources for Florentine population in 14th-17th centuries are taken from table I in Goldthwaite (1982), who, to my knowledge, has provided the most recent accurate discussion of late medieval and renaissance Florentine urban population. In particular, I have taken as the population figures for the years between 1300 and 1349, the average between the numbers reported in Fiumi (1958), de La Roncière (1976) and Herlihy and Klapisch-Zuber (1978). Data points between 1349 and 1379 are from de La Roncière (1976) while those between 1380 and 1480 are from Herlihy and Klapisch-Zuber (1978). Finally, data between 1520 and 1632 come from Beloch (1994), whose numbers are similar to those provided in Chandler and Fox (1974), Vries (1984a) and Bairoch et al. (1988) for the same period. Since 1629 up to the end of the 18th century, I have merged the information provided in Chandler and Fox (1974), Vries (1984a) and Bairoch et al. (1988).

Regional population. The population series for Tuscany is from Malanima and Breschi (2002). Data cover the 1300-1900, with a 10 years interval.

Krakow

Urban population. The series is built integrating the 7 observations for the 1200-1800 period given in Bairoch et al. (1988) with one observation for the mid-16th century given in

Pelus Kaplan (2015), one for the mid-17th century provided in Miller (2008) and the figures for the 18th century given in Chandler and Fox (1974) and Vries (1984a).
Regional population. The main sources for the population of Lesser Poland is Główny Urzad Statystyczny (1994), where observations are provided for the 14th-18th centuries. I have integrated the series with figures provided in Bogucka and Samsonowicz (1986), Gieysztorowa (1976).

<u>London</u>

Urban population. The series is built using the 7 observations given in Bairoch et al. (1988) for the 14th-19th centuries. These are integrated with figures for the second half of the 14th centuries, and the beginning of the 15th, 16th and 17th centuries, provided in Chandler and Fox (1974), observations for the years 1520 and 1670 in Wrigley (1985) and those for the 1550 and 1650 given in Vries (1984a).
Regional population. The population data for the Middlesex county come from Wrigley (2009) where the information are provided for the years 1086, 1290, 1377, 1600, 1700, 1750, 1800. In addition, from Wrigley (2007) I have taken the 10 years range data for Middlesex county population for the 1761-1801 period. Broadberry et al. (2015) show that for the 1377-1600 period it is possible to know only the population for the whole England territory, while estimates of population by county are not available. I have filled the gap with the following method. I took the available county shares of English population in 1290, 1377 and 1600 (Broadberry et al. (2015, Table 1.07, p.23)) and I have used them to extract from the data point of English population in the 15th-16th centuries, also given in Broadberry et al. (2015), the estimates of counties' population. For each year when total England population is available, I have used, as a share of the total population, either the closest counties' shares or the average between the most recent ones. This procedure gives proxies for counties' population in the following years (in parentheses are the years from which I have taken the counties' shares to extract counties' population): 1250 (1290), 1325 (1290), 1351 (1377), 1400 (1377), 1430 (the average share between 1377 and 1600), 1450 (the average share between 1377 and 1600), 1522 (the average share between 1377 and 1600), 1541 (1600).

<u>Madrid</u>

Urban population. Bairoch et al. (1988) provide 6 observations with 100 years interval range for the 1300-1800 period. I have integrated their series with 5 observations from Chandler and Fox (1974) (16th and 17th centuries, and second half of the 18th century), two observations from Vries (1984a) (1550 and 1650), 3 observations from Ringrose (1973) (first half of the 16th centuries, first and second half of the 17th centuries) and the observation in 1631 provided in Piquero et al. (1991).
Regional population. From Nadal (1983) I have taken 4 data points for the 16th and 18th centuries. From Castillo (1965) I have built population figure for the 1540 and 1591 summing up the population level of the main provinces of the New Castile. For the beginning of the 17th century I estimate the population figure for the New Castile in the following way. In Piquero et al. (1991) the authors provide the population number for the whole Castile in

the in the year 1631. In the same article, at p. 86, the authors provide the ratio of the population of each province in Castile in 1631 to their population level in 1591. Hence, I take population figures from Castillo (1965) for the provinces in New Castile in 1591, multiply them by the ratio provided in Piquero et al. (1991) and I obtain their population estimate in 1631. Finally, I sum up those estimates to get the total population of New Castile in 1631. Data for the end of the 17th century are taken from Lanza Garcia (2005) while those for the first half and the end of the 18th century are from, respectively, 75 (1977) and Bardet (1997, vol.II; ch 18).

<ins>Naples</ins>

Urban population. In Bairoch et al. (1988) 7 observations, at 100 years intervals, are given for the 1300-1800 period. I merge them with the observations provided in Chandler and Fox (1974) for the 14th-18th centuries period, the observation for the year 1450 from Del Panta et al. (1996), those in 1550 and 1650 given in Vries (1984a) and those for the second half of the 18th century provided in Beloch (1994).

Regional population. The main source used for the construction of this series is Beloch (1994, p.113-181), where the author provides the population level for the provinces in the Kingdom of Naples in the 16th-18th centuries period (earlier data are not needed as the real wages series for the city of Naples starts in the year 1548. (Appendix A.1.) In order to reconstruct the population of the Campania region at the contemporary boundaries I select the following provinces from the Kingdom of Naples:

- *Terra di Lavoro*: the contemporary province of Caserta (excluding Pontecorvo, which was part of the Papal state), the contemporary province of Naples, excluding the city of Naples, part of the contemporary province of Avellino
- *Principato Ultra*: including the contemporary province of Salerno
- *Principato Citra*: Benevento and part of the contemporary province of Avellino

For these provinces, population figures are available for the following years: 1505, 1532, 1545, 1561, 1595, 1648, 1669. Data come from the tax censuses and reports the number of *fochi* (taxable hearths.) Following the information given by Beloch (1994), I multiplied the number of *fochi* by 5.5. (This is the average between the average number of inhabitants per censed *foco* and the number of inhabitants per taxed *foco* in the Kingdom of Naples in the 16th century.) As a proof of the validity of the 5.5 multiplier, note that my total population estimate is the same as the one estimated by Beloch for the year 1595. (The only year in which he tries to proxy population from *fochi*.) For the same provinces, the actual population level is provided in the 18th century (Beloch (1994, p.176).) I obtain the population for the Campania region (at contemporary boundaries) in the 16th-18th centuries summing up the population of each province described above and adding the population of the city of Naples described above.

Oxford

Urban population. The series is obtained merging the information given in Bairoch et al. (1988) for the 1500-1800 period with those provided in Vries (1984a) for the 1650 year.

Regional population. Population for the Oxfordshire county has been built using the same sources and method described for the creation of the Middlesex population.

Paris

Urban population. The information on Paris population provided in Bairoch et al. (1988) cover the 1300-1800 period providing 7 observations with a 100 years interval. These data have been integrated for the 14th-16th centuries with the numbers in Chandler and Fox (1974), and with data from Jacquart (1980) providing information for the second half of the 16th and first half of the 17th centuries. Data for the second half of the 17th century come from Vries (1984a) and Dupaquier (1969).

Regional population. I have identified as the historical population for the city of Paris the *Generalité de Paris* as established in 1542 (Mollat (1971).) Population figures for the period before the constitution of such administrative region are scarce and the only approximate information come from Forquin (1956). I have included this information in the series. Population estimates for the 16th-18th centuries are more detailed and come from Morineau (1977) for the years 1680, 1780, 1787, Jacquart (1980) (I have taken number of *feux*, hearths, in the *Generalité de Paris* in the years 1565, 1709 and 1720 and multiplied by 4.5), Dupaquier and Lepetit (1988) for the year 1700 and Rivals (1984) for the end of the 18th century. Note, in particular, that in Rivals (1984), the author provides with the number of windmills in the *Generalité de Paris* at the beginning of the 19th century and the estimated number of individuals per windmill. Population level is obtained multiplying the two number and adding the population of the city of Paris.

Strasbourg

Urban population. The series from Bairoch et al. (1988) for the 1300-1800 period has been combined with one observation for the mid15th century from Kintz (1968), the observations from Chandler and Fox (1974) (first half of the 16th-18th centuries), the observation in 1550 from Vries (1984a) and the observations from Dreyer Roos (1969) for the end of the 17th century and the first and second half of the 18th centuries.

*Regional population.*The main sources for the reconstruction of the population of Alsace is Spisser (1964). There estimates of population for communities, villages and towns in Alsace are provided since the end of the Middle Age up to the 1723. I summed up population estimates across those administrative entities and I obtained 11 estimates from the end of the 14th century up to the first half of the 18th century. I have integrated the series with observations for the 17th-18th centuries provided in Morineau (1977), Dupaquier and Lepetit (1988) and Rivals (1984) .(Here I followed the method described for the population of the *Generalité de Paris.*

Valencia

Urban population. Bairoch et al. (1988) provide 8 observations in the 1300-1800 period. I integrate them with figures from Chandler and Fox (1974) (mid-14th century, beginning of the 17th century, first and second half of the 18th century) and from Vries (1984a) for the years 1550 and 1650.

Regional population. As regional dimension for the city of Valencia I have used the territory of the Kingdom of Valencia (1238-1707). Population for the 15th-18th century period is from Pérez Puchal (1972) and those data are consistent with the reconstruction of population for the *País Valenciano* from Ardit (1991). In addition, I have integrated the series with the observation in year 1300 from Cruselles Gómez (2003), and 4 observations from Nadal (1984) (2 in the 16th century and 2 at the end of the 18th century.)

Vienna

Urban population. I combine the 7 observations given by Bairoch et al. (1988) for the 1300-1800 period, with the observations from Chandler and Fox (1974) (mid-15th, beginning and end of the 17th and first half of the 18th century), the observation for the year 1650 provided in Vries (1984a) and the data for the years 1590 and 1660 given in Klein (2015).

Regional population. The series for the population of Lower Austria (the territories on the east of the Enns river) is provided by Klein (2015) for the 15th-18th centuries period. Earlier data are not needed as the series for real wages in Vienna starts in 1440.

C Plague outbreaks and exogenous mortality in early modern Europe

C.1 Sources

Shown in table C.1 are all the main sources used, additionally to Biraben (1975), for the identification of the years with plague outbreaks.

Table C.1: **Sources for plague outbreaks in late medieval and early modern Europe.** Shown are for each city and correspondent historical region, column (1), the edited sources, additional to Biraben (1975) used for the identification of years with plague outbreaks in pre modern Europe.

City - Region **(1)**	**Sources for plague outbreaks** **(2)**
Amsterdam - Holland	Helin and van der Woude (1997)
Antwerp - Brabant	-
Augsburg - Bavaria	Bulst and Pfister (1997), Marschalk and Dupaqueir (1997)
Barcelona - Catalonia	Nadal (1984)
Florence - Tuscany	Del Panta (1980)
Krakow - Little Poland	Bérélowitch and Gieysztorowa (1997)
London - Middlesex	Broadberry et al. (2015)
Madrid - New Castile	Perez Moreda (1980), Nadal (1984), Carbajo (1985)
Naples - Campania	Del Panta (1980)
Oxford - Oxfordshire	Broadberry et al. (2015)
Paris - Île-de-France	Forquin (1962), Jacquart (1974)
Strasbourg - Alsace	Dreyer Roos (1969)
Valencia - Kingdom of Valencia	Nadal (1984)
Vienna - Lower Austria	Head-König and Andorka (1997), Andorka et al. (1997)

C.2 Exogeneity and variability of the plague outbreaks and the derived index in the sub periods

This section collects the evidence about the exogenous nature and the variability across time of the plague outbreaks and the derived plague mortality index in the two sub periods in which the TSLS analysis is implemented. (Pre and post 1600.) I show the evidence only for the 10 cities used in the sub periods analysis.

First, I show in tables C.2, C.3 and C.4 that both the number of plagues and the derived index were likely to be exogenous to regionally specific characteristics both before and after the year 1600. The tables report the same data and they have the same interpretation as the corresponding tables in the text.

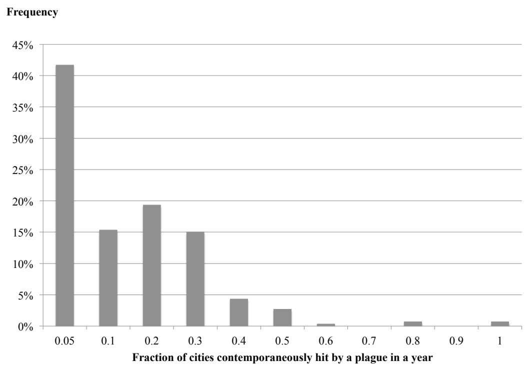
Then, I show in the figures C.1 and C.2, that both the number of plagues and the derived index exhibit a substantial degree of time variation across cities in the two subperiods. Also in this case, the figures show the same type of information and they have the same interpretation as the corresponding figures in the text.

D Unit roots and cointegration tests

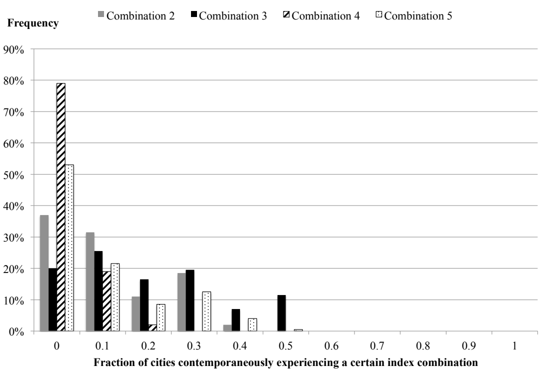
I have used two tests to check if the natural logarithm of real wages and population in the 14th-18th centuries have unit roots: the augmented Dickey Fueller (ADF) test and the Kwiatkowski - Phillips - Schmidt - Shin (KPSS) test. The former tests the null hypothesis of unit root in the series, while the latter tests the null hypothesis of stationarity of the series. The tests are implemented on the whole period of observation and in the two sub periods used in the analysis (beginning of the series-1600 and 1601-end of the series.) The results are in tables D.1, D.2 and D.3, and they show that all the series in the dataset are non stationary both over the entire period and in the two sub periods (before and after 1600.)

In order to check for the existence of a cointegrating relationship among each pair of natural logarithm of real wages and population level, I have used a simple two-step procedure. First, I have regressed the natural logarithm of the real wages at time t on the natural logarithm of population size at time t. Then, I have run and ADF test without constant on the residuals. Here the null hypothesis is that residuals have a unit root. If not rejected, then the series are not cointegrated. Instead, if rejected, residuals are stationary and the series are cointegrated. Results show that the null hypothesis is rejected in each case at at 95% confidence interval (for Valencia the null hypothesis in urban and regional cases is rejected at 90% confidence interval) (table D.4.)

E Single coefficients of ARDL model

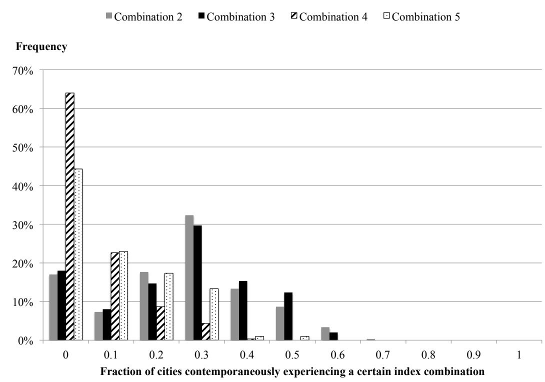


(a) Pre 1600

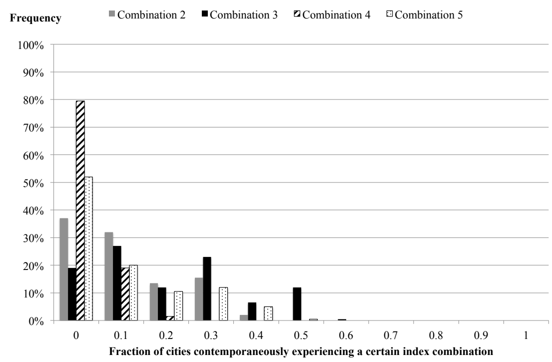


(b) Post 1600

Figure C.1: **Frequency of distribution of the fraction of cities contemporaneously hit by a plague in the two subperiods.** Figures (a) and (b) show the frequency of fractions of cities contemporaneously hit by a plague in a certain year in, respectively, the sub period before the year 1600 and the sub period after the year 1600. Note that the single year in which the all the cities where it by a plague is a year, 1361, in which the total number of cities in the dataset is only 4 (London, Oxford, Florence and Amsterdam.) Source: Appendix C.1.



(a) Pre 1600



(b) Post 1600

Figure C.2: **Frequency of distribution of fraction of cities contemporaneously experiencing the same plague mortality index value.** Figure (a) and (b) show the frequency of fractions of cities contemporaneously experiencing one of the last four combinations of the plague mortality index in a certain year in, respectively, the sub periods before and after the year 1600. Source: appendix C.1.

Table B.1: **Main details of the variables**. Shown in the tables are the number of single observations available for each city (and region), column (1), of the series used in the econometric analysis in the whole period, column (4) and the two sub periods, columns (5-6), only for the cities for which this analysis has been performed. The numbers shown for the population data are the single points derived from the sources described in appendix B. For those series the regression uses the linear interpolated data, following the most used method for the approximation of population series. (van Zanden and van Leuween (2012).)

City	**Series**	**Start -end date**	**Number of single observations**		
			Whole period	**Pre-1600**	**Post-1600**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Amsterdam	Real Wages	1344-1800	457	257	200
	Urban population		18	9	9
	Regional population		454	254	200
Antwerp	Real Wages	1399-1800	402	202	200
	Urban population		16	9	16
	Regional population		14	9	5
Augsburg	Real Wages	1502-1766	265	-	-
	Urban population		17	-	-
	Regional population		8	-	-
Barcelona	Real Wages	1508-1797	96	-	-
	Urban population		20	-	-
	Regional population		20	-	-
Florence	Real Wages	1326-1800	475	275	200
	Urban population		30	21	9
	Regional population		49	29	20
Krakow	Real Wages	1409-1795	387	192	145
	Urban population		9	5	4
	Regional population		10	4	6
London	Real Wages	1301-1800	500	300	200
	Urban population		15	9	6
	Regional population		14	7	7
Madrid	Real Wages	1551-1800	250	-	-
	Urban population		21	-	-
	Regional population		11	-	-
Naples	Real Wages	1548-1800	253	-	-
	Urban population		21	-	-
	Regional population		28	-	-
Oxford	Real Wages	1301-1800	500	300	200
	Urban population		15	9	6
	Regional population		15	9	6
Paris	Real Wages	1431-1786	356	170	186
	Urban population		15	9	6
	Regional population		14	8	6
Strasbourg	Real Wages	1395-1788	314	206	188
	Urban population		14	6	8
	Regional population		16	7	9
Valencia	Real Wages	1413-1785	373	188	185
	Urban population		13	6	7
	Regional population		13	6	7
Vienna	Real Wages	1440-1800	361	161	200
	Urban population		16	6	10
	Regional population		16	6	10

Table C.2: **Average ratio of plagues to the years included in the dataset.** For the 10 cities for which the analysis has been implemented also in sub periods (see text), shown is the fractions of the years with a plague outbreaks over the total number of years for the pre 1600 period, column (2), and the post 1600 period, column (3). Source: appendix C.1.

City	**Fraction of years with a plague to years in the series**	
	1300-1600	**1601-1800**
(1)	**(2)**	**(3)**
Amsterdam	0.101	0.115
Antwerp	0.163	0.040
Florence	0.167	0.070
Krakow	0.083	0.118
London	0.153	0.085
Oxford	0.153	0.085
Paris	0.176	0.053
Strasbourg	0.136	0.079
Valencia	0.122	0.102
Vienna	0.136	0.088

Table C.3: **Frequency distribution of the plague mortality index values across cities before the year 1600.** Shown is, for each city in the dataset, the number of year for which we have both real wages and population data, and the frequency distribution of each of the 5 values of the plague mortality index across the years covered by the dataset. The last two rows show the average frequency across all the cities and the standard deviation for each value of the index. Source: Text and Appendix C.1.

City	**Series length (in years)**	**Distribution of the index values across years**				
		1	**2**	**3**	**4**	**5**
Amsterdam	257	37%	28%	24%	4%	7%
Antwerp	202	22%	42%	19%	8%	9%
Florence	275	35%	8%	41%	3%	13%
Krakow	192	41%	32%	19%	4%	4%
London	300	26%	30%	29%	6%	9%
Oxford	300	26%	30%	29%	6%	9%
Paris	170	10%	38%	34%	10%	8%
Strasbourg	206	29%	30%	28%	5%	8%
Valencia	188	59%	16%	13%	2%	10%
Vienna	161	45%	44%	6%	4%	1%
	Average frequency	33%	30%	24%	5%	8%
	Std. Deviation	13%	11%	10%	2%	3%

Table C.4: **Frequency distribution of the plague mortality index values across cities after the year 1600.** Shown is for each city in the dataset, the number of year for which we have both real wages and population data, and the frequency distribution of each of the 5 values of the mortality index across the years covered by the dataset. The last two rows show the average frequency across all the cities and the standard deviation for each value of the index. Source: Text and Appendix C.1.

City	**Series length (in years)**	**Distribution of the index values across years**				
		1	**2**	**3**	**4**	**5**
Amsterdam	200	58%	10%	20%	2%	10%
Antwerp	200	78%	8%	10%	1%	3%
Florence	200	82%	0%	11%	0%	7%
Krakow	387	44%	17%	27%	3%	9%
London	200	64%	11%	16%	3%	6%
Oxford	200	69%	12%	10%	3%	6%
Paris	186	69%	20%	6%	3%	2%
Strasbourg	178	57%	12%	22%	2%	7%
Valencia	185	77%	0%	13%	0%	10%
Vienna	200	29%	18%	33%	5%	15%
	Average frequency	63%	11%	17%	2%	7%
	Std. Deviation	17%	6%	9%	1%	4%

Table D.1: **Unit root tests. (Whole period.)** For each city, column (1), are reported the p-values for the ADF and KPSS tests (implemented assuming level, l and trend t stationarity. The null hypothesis of the ADF test is that the series has a unit root, while the null of the KPSS test is that the series is stationary. Columns (2-4) show the results of the test for the series of real wages (in natural logarithm), columns (5-7) show the result for the series of urban population (in natural logarithm) and columns (8-10) show the results for the series of regional population (in natural logarithm.)

City	**Natural log of real wages**			**Natural log of urban population**			**Natural log of regional population**		
	ADF	**KPSS**		**ADF**	**KPSS**		**ADF**	**KPSS**	
		l	t		l	t		l	t
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Amsterdam	0.44	0.04	0.01	0.99	0.01	0.01	0.99	0.01	0.01
Antwerp	0.38	0.01	0.06	0.97	0.01	0.01	0.96	0.01	0.01
Augsburg	0.32	0.02	0.01	0.58	0.01	0.01	0.64	0.01	0.01
Barcelona	0.39	0.08	0.10	0.91	0.01	0.01	0.99	0.01	0.01
Florence	0.13	0.01	0.10	0.53	0.01	0.01	0.66	0.01	0.01
Krakow	0.37	0.01	0.03	0.83	0.01	0.01	0.84	0.01	0.05
London	0.45	0.01	0.01	0.96	0.01	0.01	0.98	0.01	0.01
Madrid	0.38	0.01	0.02	0.94	0.01	0.01	0.64	0.01	0.01
Naples	0.30	0.04	0.01	0.94	0.01	0.01	0.81	0.01	0.01
Oxford	0.37	0.01	0.01	0.86	0.01	0.01	0.85	0.01	0.01
Paris	0.34	0.01	0.04	0.94	0.01	0.01	0.95	0.01	0.01
Strasbourg	0.28	0.01	0.01	0.91	0.01	0.01	0.73	0.01	0.01
Valencia	0.25	0.01	0.01	0.91	0.01	0.01	0.77	0.01	0.01
Vienna	0.23	0.01	0.01	0.98	0.01	0.01	0.96	0.01	0.01

Table D.2: **Unit root tests. (Before the 1600)** For each city, column (1), are reported the p-values for the ADF and KPSS tests (implemented assuming level, l and trend t stationarity. The null hypothesis of the ADF test is that the series has a unit root, while the null of the KPSS test is that the series is stationary. Columns (2-4) show the results of the test for the series of real wages (in natural logarithm), columns (5-7) show the result for the series of urban population (in natural logarithm) and columns (8-10) show the results for the series of regional population (in natural logarithm.)

City	Natural log of real wages			Natural log of urban population			Natural log of regional population		
	ADF	KPSS		ADF	KPSS		ADF	KPSS	
		l	t		l	t		l	t
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Amsterdam	0.49	0.01	0.01	0.99	0.01	0.01	0.99	0.01	0.01
Antwerp	0.45	0.01	0.02	0.94	0.01	0.01	0.75	0.01	0.01
Florence	0.24	0.01	0.01	0.51	0.01	0.01	0.55	0.01	0.01
Krakow	0.44	0.01	0.01	0.90	0.01	0.01	0.99	0.01	0.01
London	0.49	0.01	0.01	0.91	0.01	0.01	0.94	0.01	0.01
Oxford	0.43	0.01	0.01	0.83	0.01	0.01	0.58	0.01	0.01
Paris	0.42	0.01	0.03	0.84	0.01	0.01	0.95	0.01	0.01
Strasbourg	0.39	0.01	0.01	0.80	0.01	0.01	0.49	0.01	0.01
Valencia	0.37	0.01	0.01	0.63	0.01	0.01	0.61	0.01	0.01
Vienna	0.15	0.01	0.01	0.22	0.01	0.01	0.92	0.01	0.01

Table D.3: **Unit root tests. (After 1600.)** For each city, column (1), are reported the p-values for the ADF and KPSS tests (implemented assuming level, l and trend t stationarity. The null hypothesis of the ADF test is that the series has a unit root, while the null of the KPSS test is that the series is stationary. Columns (2-4) show the results of the test for the series of real wages (in natural logarithm), columns (5-7) show the result for the series of urban population (in natural logarithm) and columns (8-10) show the results for the series of regional population (in natural logarithm.)

City	Natural log of real wages			Natural log of urban population			Natural log of regional population		
	ADF	KPSS		ADF	KPSS		ADF	KPSS	
		l	t		l	t		l	t
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Amsterdam	0.45	0.01	0.01	0.99	0.01	0.01	0.92	0.01	0.01
Antwerp	0.37	0.01	0.01	0.99	0.01	0.01	0.97	0.01	0.01
Florence	0.28	0.01	0.01	0.80	0.01	0.01	0.95	0.01	0.01
Krakow	0.42	0.06	0.01	0.62	0.01	0.01	0.67	0.01	0.01
London	0.48	0.01	0.01	0.99	0.01	0.01	0.99	0.01	0.01
Oxford	0.43	0.01	0.01	0.83	0.01	0.01	0.95	0.01	0.01
Paris	0.41	0.01	0.07	0.59	0.01	0.01	0.80	0.01	0.01
Strasbourg	0.29	0.01	0.01	0.81	0.01	0.01	0.76	0.01	0.01
Valencia	0.31	0.01	0.01	0.93	0.01	0.01	0.87	0.01	0.01
Vienna	0.43	0.01	0.01	0.99	0.01	0.01	0.91	0.01	0.01

Table D.4: **ADF tests for unit root of the residuals** For each city are shown the p-values for the null hypothesis of unit root in the residuals of the regression of real wages on urban and regional population.

City	**14th-18th centuries**		**pre-1600**		**post-1600**	
	Urban	**Regional**	**Urban**	**Regional**	**Urban**	**Regional**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Amsterdam	0.01	0.01	0.01	0.01	0.01	0.01
Antwerp	0.01	0.01	0.01	0.01	0.01	0.01
Augsburg	0.01	0.01	-	-	-	-
Barcelona	0.01	0.01	-	-	-	-
Florence	0.01	0.01	0.01	0.01	0.32	0.33
Krakow	0.01	0.01	0.02	0.01	0.01	0.01
London	0.1	0.01	0.01	0.01	0.01	0.01
Madrid	0.01	0.01	-	-	-	-
Naples	0.01	0.01	-	-	-	-
Oxford	0.01	0.01	0.01	0.01	0.01	0.01
Paris	0.01	0.01	0.01	0.01	0.01	0.01
Strasbourg	0.04	0.04	0.10	0.12	0.01	0.01
Valencia	0.07	0.08	0.04	0.02	0.11	0.12
Vienna	0.05	0.02	0.42	0.41	0.01	0.01

Table E.1: **Coefficients of the ADL - Whole period - Urban population** Shown in the figure are the coefficients of the OLS and TSLS estimations of the econometric model in eq.(1), when the whole period is analyzed and urban population is used. The table also shows the F-statistics of the two first stage regressions. (One for each endogenous population lag.) The long run elasticities are computed according to the method described in the text. The standard errors are in parenthesis. ***Significant at 99% **Significant at 95% *Significant at 90%.

	Amsterdam		**Antwerp**		**Augsburg**		**Barcelona**		**Florence**		**Krakow**		**London**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Main regression														
Intercept	0.406***	0.540***	0.692***	0.547	0.808***	0.742	0.604**	0.564	3.746***	5.305	0.668***	0.891	0.124**	0.329**
	(0.068)	(0.201)	(0.098)	(0.345)	(0.284)	(0.412)	(0.244)	(0.909)	(0.520)	(8.322)	(0.257)	(1.502)	(0.051)	(0.149)
W_{t-1}	0.805***	0.796***	0.924***	0.939***	0.898***	0.900***	0.676***	0.677***	0.889***	0.957***	0.694***	0.703***	0.957***	0.939***
	(0.046)	(0.049)	(0.049)	(0.060)	(0.061)	(0.062)	(0.059)	(0.065)	(0.045)	(0.229)	(0.051)	(0.073)	(0.045)	(0.063)
W_{t-2}	0.015	0.016	-0.205***	-0.188***	-0.077	-0.073	0.257***	0.258***	-0.138***	-0.203	0.149***	0.153***	-0.047	-0.027
	(0.046)	(0.047)	(0.049)	(0.062)	(0.062)	(0.065)	(0.059)	(0.059)	(0.043)	(0.151)	(0.050)	(0.056)	(0.045)	(0.063)
Pop_{t-1}	-0.895**	-1.246	-1.066	0.805	0.591	0.046	0.096	0.527	-0.993	-7.252***	1.128*	-0.459	-0.438	-9.730**
	(0.441)	(2.029)	(0.742)	(4.237)	(0.611)	(1.601)	(0.635)	(3.494)	(0.206)	(3.050	(0.713)	(9.374)	(0.453)	(3.870)
Pop_{t-2}	0.890**	1.231	1.054	-0.811	-0.646	-0.509	-0.955	-0.572	0.687***	6.804**	-1.170*	0.392	0.442	9.721**
	(0.440)	(2.017)	(0.743)	(4.244)	(0.614)	(1.589)	(0.646)	(3.574)	(0.210)	(2.901)	(0.712)	(9.228)	(0.454)	(3.861)
R^2	0.680	0.673	0.652	0.645	0.757	0.757	0.905	0.905	0.832	0.499	0.738	0.734	0.848	0.707
F-test	239.8	233.6	185.2	109.7	201.7	200.8	675.5	674	582.7	190.3	268.5	263.2	688.7	359.8
DW-test	0.385	0.385	0.121	0.121	0.392		0.326		0.286		0.455	0.455	0.287	0.287
1st stages F-statistics														
Pop_{t-1}	-	19.18	-	186.1	-	74.22	-	827.8	-	139.6	-	30.98	-	215.1
Pop_{t-2}	-	19.34	-	188.8	-	79.07	-	773.7	-	153.8	-	32.61	-	219.1
LR Elasticity	-0.026	-0.084	-0.043	-0.026	-0.306	-0.274	-0.737	-0.699	-1.231	-1.822	-0.271	-0.464	0.042	-0.096
	(0.006)	(0.002)	(0.001)	(0.009)	(0.004)	(0.021)	(0.027)	(0.472)	(0.003)	(0.141)	(0.005)	(0.015)	(0.001)	(0.007)

	Madrid		**Naples**		**Oxford**		**Paris**		**Strasbourg**		**Valencia**		**Vienna**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Main regression														
Intercept	0.348**	-0.030	1.090**	2.693***	0.250**	0.158***	1.560***	1.411*	0.595**	1.333	1.601***	0.730	0.813***	0.788
	(0.161)	(1.008)	(0.472)	(0.798)	(0.126)	(0.181)	(0.293)	(0.759)	(0.286)	(0.991)	(0.491)	(1.220)	(0.181)	(0.633)
W_{t-1}	0.882***	0.898***	0.737***	0.723***	-0.986***	0.970*	0.676***	0.685***	0.689***	0.670***	0.702***	0.724***	0.542***	0.545***
	(0.064)	(0.301)	(0.063)	(0.080)	(0.045)	(0.047)	(0.053)	(0.065)	(0.049)	(0.056)	(0.051)	(0.056)	(0.051)	(0.068)
W_{t-2}	-0.030	0.127	0.071	0.125	-0.076*	-0.080*	-0.001	0.021	0.253***	0.235***	0.201	0.216***	0.286***	0.287***
	(0.064)	(0.357)	(0.063)	(0.084)	(0.045)	(0.046)	(0.053)	(0.080)	(0.049)	(0.055)	(0.051)	(0.056)	(0.050)	(0.077)
Pop_{t-1}	-0.056	-1.3318	0.523	7.410***	-1.222*	-4.247**	0.005	2.965	-0.034	-3.595	-0.666	-0.263	-0.092	0.074
	(0.187)	(1.606)	(0.569)	(2.655)	(0.634)	(1.924)	(0.640)	(5.688)	(0.805)	(5.323)	(0.524)	(1.607)	(0.349)	(1.670)
Pop_{t-2}	0.043	1.332	-0.588	-7.610***	1.209*	4.249**	-0.090	-3.043	-0.016	3.478	0.531	0.204	0.043	-0.122
	(0.186)	(1.608)	(0.574)	(2.685)	(0.634)	(1.916)	(0.638)	(5.651)	(0.808)	(5.264)	(0.528)	(1.643)	(0.352)	(1.704)
R^2	0.730	0.490	0.648	0.430	0.863	0.856	0.616	0.593	0.911	0.905	0.920	0.919	0.870	0.869
F-test	164.8	7.685	113.4	72.47	779.8	744	140.3	130.4	1001	932.1	1054	1040	592.4	588.1
DW-test	0.428	0.428	0.404	0.404	0.239	0.239	0.305	0.305	0.553	0.553	0.708	0.708	0.348	0.348
1st stages F-statistics														
Pop_{t-1}	-	140.7	-	148.9	-	324	-	152.2	-	86.82	-	228.3	-	252.7
Pop_{t-2}	-	133.9	-	145.7	-	332	-	152.6	-	87.76	-	226.9	-	255.4
LR Elasticity	-0.087	-0.283	-0.342	-1.327	-0.139	0.020	-0.262	-0.265	-0.895	-1.250	-1.402	-1.010	-0.290	-0.286
	(0.003)	(0.164)	(0.006)	(0.050)	(0.005)	(0.005)	(0.001)	(0.005)	(0.084)	(0.407)	(0.009)	(0.527)	(0.001)	(0.046)

Table E.2: **Coefficients of the ADL -Whole period - Regional population.** Shown in the figure are the coefficients of the OLS and TSLS estimations of the econometric model in eq.(1), when the whole period is analyzed and regional population is used. The table also shows the F-statistics of the two first stage regressions. (One for each endogenous population lag.) The long run elasticities are computed according to the method described in the text. The standard errors are in parenthesis. ***Significant at 99% **Significant at 95% *Significant at 90%.

	Amsterdam		**Antwerp**		**Augsburg**		**Barcelona**		**Florence**		**Krakow**		**London**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Intercept	0.422***	1.008	1.735***	1.423**	1.192***	2.445	0.470*	0.584	5.356***	5.626***	0.800**	1.582	0.115*	0.067
	(0.143)	(0.664)	(0.413)	(0.682)	(0.427)	(1.868)	(0.271)	(0.383)	(0.579)	(0.990)	(0.331)	(1.776)	(0.069)	(0.102)
W_{t-1}	0.811***	0.797***	0.912***	0.921***	0.884***	0.869***	0.674***	0.724***	0.827***	0.811**	0.702***	0.692***	0.958***	0.947***
	(0.047)	(0.055)	(.049)	(0.052)	(0.061)	(0.071)	(0.059)	(0.079)	(0.045)	(0.049)	(0.051)	(0.056)	(0.045)	(0.047)
W_{t-2}	0.008	0.015	-0.203***	-0.199***	-0.091	-0.091	0.248***	0.239***	-0.202***	-0.198***	0.150***	0.134*	-0.045	-0.027
	(0.047)	(0.530)	(0.49)	(0.050)	(0.061)	(0.066)	(0.059)	(0.070)	(0.045)	(0.050)	(0.051)	(0.063)	(0.045)	(0.048)
Pop_{t-1}	-0.670	-4.840	-1.820*	-0.968	2.401***	1.764	-1.820**	6.071	-0.661	-2.716**	0.125	-0.755	-0.338	-3.982***
	(0.536)	(7.884)	(0.995)	(4.397)	(0.917)	(1.496)	(0.810)	(6.463)	(0.821)	(1.418)	(0.417)	(3.360)	(0.486)	(1.240)
Pop_{t-2}	0.664	4.791	1.729*	0.899	-2.469***	-1.922	1.793**	-6.114	0.305	2.342*	-0.166	0.661	0.342	3.991***
	(0.536)	(7.847)	(1.003)	(4.415)	(0.925)***	(1.550)	(0.807)	(6.479)	(0.826)	(1.437)	(0.415)	(3.267)	(0.487)	(1.236)
R^2	0.674	0.617	0.658	0.656	0.761	0.751	0.905	0.872	0.836	0.834	0.737	0.730	0.848	0.830
F-test	231.8	196.9	190.2	185.8	206.2	195.8	678.5	499.9	598	579.6	266.2	259.3	687.5	621.7
DW-test	0.506	0.506	0.119	0.119	0.405	0.405	0.371	0.371	0.344	0.344	0.496	0.496	0.290	0.290
1st stages F-statistics														
Pop_{t-1}	-	15.66	-	235.3	-	19.82	-	369.2	-	292.7	-	33.21	-	177.9
Pop_{t-2}	-	15.73	-	229.5	-	19.9	-	351.1	-	294.2	-	34.14	-	181.5
LR Elasticity	-0.030	-0.262	-0.312	-0.248	-0.326	-0.710	-0.353	-1.197	0.951	0.967	-0.280	-0.547	0.045	0.105
	(0.001)	(0.008)	(0.002)	(0.005)	(0.004)	(0.019)	(0.012)	(0.641)	(0.001)	(0.059)	(0.004)	(0.283)	(0.002)	(0.003)

	Madrid		**Naples**		**Oxford**		**Paris**		**Strasbourg**		**Valencia**		**Vienna**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Intercept	1.278*	2.045*	0.980*	4.773**	0.729***	0.565*	2.109***	2.183***	0.279	0.418	2.133***	0.370	2.581***	1.254***
	(0.666)	(1.077)	(0.514)	(2.387)	(0.201)	(0.311)	(0.318)	(0.646)	(0.235)	(0.842)	(0.477)	(1.761)	(0.508)	(0.827)
W_{t-1}	0.869***	0.833***	0.738***	0.847***	0.973***	0.963***	0.639***	0.632	0.697***	0.696***	0.677***	0.730***	0.518***	0.550***
	(0.064)	(0.069)	(0.063)	(0.179)	(0.045)	(0.047)	(0.053)	(0.066)	(0.049)	(0.052)	(0.051)	(0.070)	(0.051)	(0.058)
W_{t-2}	-0.044	-0.062	0.071	-0.064	-0.086*	-0.092**	-0.035	-0.039	0.259***	0.270***	0.173***	0.219***	0.256	0.299***
	(0.064)	(0.069)	(0.063)	(0.179)	(0.044)	(0.046)	(0.053)	(0.059)	(0.049)	(0.056)	(0.051)	(0.067)	(0.056)	(0.056)
Pop_{t-1}	-2.306	-11.739***	-0.148	9.636	2.197**	6.094**	-0.562	-1.508	-0.089	1.848	0.127	-0.363	0.084	-4.765
	(1.575)	(4.400)	(0.304)	(7.854)	(0.910)	(2.418)	(0.458)	(4.290)	(0.419)	(2.132)	(0.933)	(2.661)	(1.294)	(6.747)
Pop_{t-2}	2.230	11.614***	0.096	-9.964	-2.247**	-6.127**	0.452	1.394	0.071	-1.878	-0.276	0.340	-0.258	4.687
	(1.573)	(4.425)	(0.307)	(7.985)	(0.915)	(2.434)	(0.457)	(4.267)	(0.419)	(2.103)	(0.943)	(2.765)	(1.303)	(6.765)
R^2	0.734	0.694	0.646	-0.982	0.865	0.858	0.631	0.625	0.911	0.906	0.921	0.918	0.872	0.866
F-test	168	148.7	112.4	21.64	729.7	754.8	149.2	142.4	993.4	940.6	1079	1034	605	571.3
DW-test	0.409	0.409	0.409	0.409	0.223	0.223	0.283	0.283	0.559	0.559	0.656	0.656	0.318	0.318
1st stages F-statistics														
Pop_{t-1}	-	71.7	-	87.74	-	347.3	-	188.4	-	42.32	-	391.4	-	516.7
Pop_{t-2}	-	69.57	-	85.4	-	348	-	188.8	-	41.91	-	389.1	-	522.7
LR Elasticity	-0.432	-0.549	-0.278	-1.512	-0.447	-0.258	-0.275	-0.278	-0.409	-0.897	-0.998	-0.464	-0.774	-0.519
	(0.008)	(0.010)	(0.006)	(0.740)	(0.004)	(0.005)	(0.001)	(0.001)	(0.027)	(0.592)	(0.003)	(0.286)	(0.002)	(0.034)

Table E.3: **Coefficients of the ADL -Pre 1600 - Urban population.** Shown in the figure are the coefficients of the OLS and TSLS estimations of the econometric model in eq.(1), when the pre 1600 period is analyzed and urban population is used. The table also shows the F-statistics of the two first stage regressions. (One for each endogenous population lag.) The long run elasticities are computed according to the method described in the text. The standard errors are in parenthesis. ***Significant at 99% **Significant at 95% *Significant at 90%.

	Amsterdam		**Antwerp**		**Florence**		**Krakow**		**London**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Intercept	0.604***	0.666**	0.880***	0.995	3.890***	3.752	1.001**	2.837	0.207	0.226
	(0.141)	(0.284)	(0.302)	(0.752)	(0.670)	(4.415)	(0.494)	(1.940)	(0.187)	(0.391)
W_{t-1}	0.725***	0.724***	0.880***	0.868***	0.859	0.926***	0.569***	0.534***	0.980***	0.968***
	(0.062)	(0.066)	(0.069)	(0.072)	(0.059)	(0.187)	(0.070)	(0.080)	(0.058)	(0.064)
W_{t-2}	0.073	0.055	-0.227***	-0.239***	-0.169***	-0.173*	0.270***	0.247***	-0.054	-0.040
	(0.061)	(0.070)	(0.070)	(0.072)	(0.057)	(0.088)	(0.069)	(0.075)	(0.058)	(0.064)
Pop_{t-1}	-0.985	0.848	-2.053	-2.900	-0.891***	-3.427	3.584*	2.795	-0.269	-4.207***
	(0.672)	(3.057)	(1.363)	(3.239)	(0.251)	(2.484)	(2.036)	(4.179)	(0.550)	(1.371)
Pop_{t-2}	0.963	-0.876	2.036	2.877	0.582**	3.120	-3.659*	-3.045	0.263	4.201**
	(0.674)	(3.072)	(1.380)	(3.293)	(0.257)	(2.751)	(2.040)	(4.087)	(0.557)	(1.359)
R^2	0.686	0.676	0.607	0.605	0.751	0.656	0.760	0.741	0.868	0.841
F-test	136.7	131.2	75.44	74.21	202.3	140.8	146.5	135.6	483.3	404.4
DW-test	0.398	0.398	0.156	0.156	0.314	0.314	0.670	0.670	0.322	0.322
1st stages F-statistics										
Pop_{t-1}	-	52.93	-	23.18	-	55.57	-	14.48	-	25.85
Pop_{t-2}	-	52.8	-	22.81	-	62.53	-	15.24	-	27.31
LR Elasticity	-0.111	-0.126	-0.049	-0.062	-0.998	-1.244	-0.472	-1.150	-0.085	-0.085
	(0.001)	(0.003)	(0.002)	(0.005)	(0.004)	(0.572)	(0.010)	(0.036)	(0.008)	(0.019)

	Oxford		**Paris**		**Strasbourg**		**Valencia**		**Vienna**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Intercept	1.553***	0.493	3.983***	2.406	2.984***	2.461	1.348	1.012	1.416***	-1.534
	(0.536)	(0.766)	(1.148)	(1.862)	(1.081)	(2.560)	(0.841)	(1.428)	(0.398)	(5.464)
W_{t-1}	0.964***	0.971***	0.683***	0.711***	0.543***	0.548***	0.699***	0.728***	0.622***	0.784**
	(0.058)	(0.059)	(0.078)	(0.083)	(0.066)	(0.074)	(0.073)	(0.076)	(0.078)	(0.315)
W_{t-2}	-0.090*	-0.072	-0.058	-0.023	0.340***	0.342***	0.183**	0.224	0.180**	0.413
	(0.058)	(0.059)	(0.079)	(0.088)	(0.066)	(0.070)	(0.073)	(0.077)	(0.079)	(0.438)
Pop_{t-1}	-1.239*	-3.056***	-0.124	0.558	-4.076	6.756	-0.437	4.660*	0.639*	-3.268
	(0.774)	(0.979)	(0.760)	(2.780)	(4.000)	(20.829)	(1.933)	(0.295)	(0.442)	(7.091)
Pop_{t-2}	1.081	3.018***	-0.152	-0.715	3.797	-6.986	0.330	-4.749*	-0.742*	3.383
	(0.076)	(0.969)	(0.759)	(2.788)	(3.796)	(20.654)	(1.966)	(3.018)	(0.452)	(7.488)
R^2	0.863	0.857	0.579	0.572	0.853	0.847	0.815	0.806	0.928	0.881
F-test	463.8	445.1	56.11	53.15	288.7	277.2	199.9	190.3	497.5	299.1
DW-test	0.268	0.268	0.221	0.221	0.434	0.434	0.605	0.605	0.465	0.465
1st stages F-statistics										
Pop_{t-1}		149.3	-	60.53	-	88.02	-	28.31	-	223.7
Pop_{t-2}		142	-	57.85	-	87.2	-	27.43	-	230.8
LR Elasticity	-1.257	-0.383	-0.737	-0.499	-2.385	-2.105	-0.912	-1.874	-0.527	-0.578
	(0.012)	(0.034)	(0.006)	(0.020)	(0.026)	(0.812)	(0.159)	(0.837)	(0.002)	(0.022)

Table E.4: **Coefficients of the ADL - Pre 1600 - Regional population.** Shown in the figure are the coefficients of the OLS and TSLS estimations of the econometric model in eq.(1), when the pre 1600 period is analyzed and regional population is used. The table also shows the F-statistics of the two first stage regressions. (One for each endogenous population lag.) The long run elasticities are computed according to the method described in the text. The standard errors are in parenthesis. ***Significant at 99% **Significant at 95% *Significant at 90%.

	Amsterdam		**Antwerp**		**Florence**		**Krakow**		**London**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Intercept	1.773***	1.978	3.423***	3.237	6.187***	9.649**	0.964*	2.104	0.230	0.157
	(0.574)	(1.798)	(0.974)	(2.044)	(0.858)	(4.759)	(0.510)	(9.051)	(0.178)	(0.363)
W_{t-1}	0.726***	0.720***	0.867***	0.865	0.801***	0.741***	0.586***	0.563***	0.980***	0.970***
	(0.063)	(0.070)	(0.069)	(0.072)	(0.059)	(0.110)	(0.070)	(0.208)	(0.058)	(0.062)
W_{t-2}	0.052	0.054	-0.221***	-0.212	-0.232***	-0.372**	0.268***	0.208***	-0.053	-0.027
	(0.063)	(0.084)	(0.069)	(0.077)	(0.059)	(0.183)	(0.070)	(0.094)	(0.058)	(0.062)
Pop_{t-1}	-0.018	-1.539	-2.041	-3.344	-0.197	8.547	3.366	15.354	-0.110	-3.519***
	(0.739)	(8.090)	(1.293)	(3.829)	(1.064)	(10.085)	(2.627)	(38.840)	(0.563)	(1.101)
Pop_{t-2}	-0.089	1.415	1.828	3.144	-0.214	-9.194	-3.420	-15.484	0.102	3.516***
	(0.751)	(8.209)	(1.296)	(3.890)	(1.068)	(10.378)	(2.630)	(38.261)	(0.566)	(1.092)
R^2	0.680	0.673	0.615	0.613	0.755	0.681	0.758	0.726	0.868	0.851
F-test	131.3	128.6	77.98	75.74	206.8	151.6	144.9	127.8	482.9	431
DW-test	0.460	0.460	0.145	0.145	0.403	0.403	0.680	0.680	0.323	0.323
1st stages F-statistics										
Pop_{t-1}	-	94.6	-	34.83	-	139.9	-	14.03	-	27.05
Pop_{t-2}	-	97.1	-	34.19	-	139.8	-	14.26	-	28.08
LR Elasticity	-0.485	-0.549	-0.603	-0.575	-0.955	-1.025	-0.368	-0.567	-0.111	-0.053
	(0.005)	(0.084)	(0.006)	(0.012)	(0.002)	(0.019)	(0.007)	(0.498)	(0.013)	(0.032)

	Oxford		**Paris**		**Strasbourg**		**Valencia**		**Vienna**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Intercept	2.846***	1.246	2.354***	1.707	1.894**	2.983	6.383***	-3.886	4.977***	-4.334
	(0.550)	(3.860)	(0.497)	(1.444)	(0.773)	(1.908)	(1.689)	(6.331)	(1.221)	(22.364)
W_{t-1}	0.909***	0.925***	0.648***	0.683***	0.548***	0.527***	0.612***	0.873***	0.587***	0.768*
	(0.057)	(0.063)	(0.078)	(0.109)	(0.066)	(0.074)	(0.074)	(0.156)	(0.079)	(0.445)
W_{t-2}	-0.129**	-0.114*	-0.085	-0.054	0.342***	0.326***	0.101*	0.358**	0.158	0.373
	(0.056)	(0.064)	(0.078)	(0.102)	(0.066)	(0.072)	(0.074)	(0.155)	(0.079)	(0.524)
Pop_{t-1}	1.726*	6.990	-0.591	0.389	-0.344	-0.527	-3.368	3.312	1.609	-1.640
	(1.043)	(17.757)	(0.529)	(3.995)	(0.776)	(1.410)	(4.465)	(2.089)	(2.235)	(4.434)
Pop_{t-2}	-1.956*	-7.076	0.468	-0.472	0.207	0.307	2.901	-3.328*	-1.970	1.673
	(1.042)	(17.412)	(0.528)	(3.954)	(0.783)	(1.457)	(4.502)	(2.078)	(2.265)	(4.597)
R^2	0.878	0.857	0.594	0.583	0.852	0.850	0.828	0.698	0.930	0.887
F-test	498.1	442.7	59.83	54.47	286.6	282.9	218.5	122.7	511.5	314.5
DW-test	0.234	0.234	0.214	0.214	0.431	0.431	0.480	0.480	0.437	0.437
1st stages F-statistics										
Pop_{t-1}	-	253.1	-	41.87	-	64.37	-	133.6	-	323.8
Pop_{t-2}	-	270.7	-	41.49	-	64.4	-	132.7	-	324.2
LR Elasticity	-1.043	-0.457	-0.281	-0.223	-1.260	-1.501	-1.635	-1.166	-1.419	-2.301
	(0.004)	(0.073)	(0.001)	(0.064)	(0.182)	(0.082)	(0.010)	(0.378)	(0.005)	(0.458)

Table E.5: **Coefficients of the ADL -Post 1600 - Urban population.** Shown in the figure are the coefficients of the OLS and TSLS estimations of the econometric model in eq.(1), when the post 1600 period is analyzed and urban population is used. The table also shows the F-statistics of the two first stage regressions. (One for each endogenous population lag.) The long run elasticities are computed according to the method described in the text. The standard errors are in parenthesis. ***Significant at 99% **Significant at 95% *Significant at 90%.

	Amsterdam		**Antwerp**		**Florence**		**Krakow**		**London**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Intercept	-0.278	0.531	0.780**	1.098	5.122***	10.754***	0.166	0.595	0.308	0.320
	(0.459)	(1.312)	(0.351)	(1.667)	(1.663)	(2.578)	(0.330)	(0.655)	(0.492)	(1.094)
W_{t-1}	1.098***	1.106***	0.974**	0.972***	0.906***	0.858***	0.719***	0.766***	0.836***	0.810***
	(0.067)	(0.070)	(0.069)	(0.070)	(0.071)	(0.074)	(0.073)	(0.096)	(0.073)	(0.074)
W_{t-2}	-0.343***	-0.365***	-0.199***	-0.204***	-0.097	-0.134	-0.028	-0.001	-0.094	-0.123*
	(0.067)	(0.070)	(0.069)	(0.072)	(0.070)	(0.074)	(0.073)	(0.083)	(0.073)	(0.074)
Pop_{t-1}	1.355	-1.614	-0.259	-1.892	-2.166	-1.181	0.824	-2.819	-3.393	-5.795
	(1.115)	(3.148)	(2.157)	(12.307)	(2.095)	(5.227)	(0.791)	(4.701)	(3.547)	(8.328)
Pop_{t-2}	-1.293	1.613	0.232	1.843	1.729	0.250	-0.795	2.794	3.409	5.820
	(1.080)	(3.042)	(2.138)	(12.190)	(2.099)	(5.307)	(0.795)	(4.661)	(3.515)	(8.253)
R^2	0.724	0.709	0.690	0.689	0.812	0.801	0.517	0.458	0.714	0.709
F-test	128.2	121.6	108.8	108.4	211.2	201.8	50.95	45.13	122.3	121.9
DW-test	0.066	0.066	0.157	0.157	0.298	0.298	0.294	0.294	0.255	0.255
1st stages F-statistics										
Pop_{t-1}	-	28.38	-	124.3	-	119.8	-	25.61	-	269.8
Pop_{t-2}	-	28.54	-	124.8	-	113.6	-	25.95	-	270
LR Elasticity	0.253	-0.005	-0.120	-0.213	-2.288	-3.369	0.094	-0.104	0.062	0.079
	(0.004)	(0.014)	(0.003)	(0.016)	(0.020)	(0.018)	(0.003)	(0.062)	(0.004)	(0.008)

	Oxford		**Paris**		**Strasbourg**		**Valencia**		**Vienna**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Intercept	-0.157	1.069	1.972*	1.711	0.230	-0.014	1.994***	0.698	0.998***	2.455***
	(0.576)	(2.164)	(1.213)	(2.614)	(0.742)	(1.514)	(0.621)	(1.063)	(0.452)	(0.933)
W_{t-1}	0.941***	0.596***	0.606***	0.583***	0.742***	0.765***	0.641***	0.683***	0.452***	0.329***
	(0.073)	(0.214)	(0.074)	(0.076)	(0.073)	(0.129)	(0.073)	(0.081)	(0.070)	(0.111)
W_{t-2}	-0.138*	-0.410**	0.027	0.015	0.085	0.109	0.179**	0.208***	0.242***	0.098
	(0.072)	(0.187)	(0.074)	(0.075)	(0.073)	(0.131)	(0.072)	(0.077)	(0.070)	(0.121)
Pop_{t-1}	-4.591*	-4.654*	0.813	6.629	-0.205	1.079	-1.260***	-1.107	-0.166	3.704*
	(2.978)	(2.371)	(4.088)	(12.158)	(0.856)	(3.854)	(0.473)	(1.231)	(0.495)	(2.607)
Pop_{t-2}	4.642*	4.658**	-0.925	-6.719	0.201	-1.078	1.098**	1.055	0.117	-3.849*
	(2.928)	(2.359)	(4.014)	(11.972)	(0.860)	(3.844)	(0.475)	(1.251)	(0.498)	(2.658)
R^2	0.854	0.484	0.482	0.468	0.661	0.346	0.840	0.837	0.535	0.340
F-test	287.1	81.46	42.14	42.04	89.15	46.31	237.6	228.3	56.21	39.4
DW-test	0.225	0.225	0.429	0.429	0.437	0.437	0.551	0.551	0.265	0.265
1st stages F-statistics										
Pop_{t-1}	-	84.83	-	139.7	-	53.51	-	114.1	-	43.94
Pop_{t-2}	-	84.53	-	137.2	-	55.37	-	108.4	-	43.7
LR Elasticity	0.258	0.043	-0.305	-0.223	-0.025	0.084	-0.902	-0.474	-0.160	-0.253
	(0.010)	(0.069)	(0.007)	(0.015)	(0.006)	(0.302)	(0.007)	(0.384)	(0.001)	(0.001)

Table E.6: **Coefficients of the ADL -post 1600 - regional population.** Shown in the figure are the coefficients of the OLS and TSLS estimations of the econometric model in eq.(1), when the post 1600 period is analyzed and regional population is used. The table also shows the F-statistics of the two first stage regressions. (One for each endogenous population lag.) The long run elasticities are computed according to the method described in the text. The standard errors are in parenthesis. ***Significant at 99% **Significant at 95% *Significant at 90%.

	Amsterdam		**Antwerp**		**Florence**		**Krakow**		**London**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Intercept	0.634	0.668	1.102	2.807	5.237***	2.140	-0.389	0.953	-0.556*	-0.985**
	(0.672)	(1.850)	(0.733)	(3.963)	(1.399)	(2.459)	(0.513)	(1.776)	(0.304)	(0.406)
W_{t-1}	0.090***	1.075***	0.966***	0.961***	0.879***	0.895***	0.721***	0.737***	0.780***	0.687***
	(0.066)	(0.070)	(0.069)	(0.072)	(0.071)	(0.078)	(0.073)	(0.078)	(0.072)	(0.084)
W_{t-2}	-0.342***	-0.349***	-0.202***	-0.206***	-0.129	-0.099	-0.034	-0.044	-0.133*	-0.210**
	(0.066)	(0.068)	(0.069)	(0.071)	(0.071)	(0.078)	(0.073)	(0.086)	(0.071)	(0.081)
Pop_{t-1}	-2.002**	-3.608	-1.864	1.375	-2.108	6.562**	-0.399	-1.824	-6.884***	-15.89***
	(0.963)	(2.951)	(2.067)	(13.225)	(1.830)	(3.294)	(0.448)	(3.126)	(1.678)	(3.300)
Pop_{t-2}	1.992**	3.599	1.814	-1.555	1.750	6.425**	0.460	1.788	6.981***	16.055***
	(0.934)	(2.840)	(2.102)	(13.522)	(1.841)	(3.288)	(0.451)	(3.038)	(1.687)	(3.324)
LR Elasticity	-0.040	-0.033	-0.213	-0.731	-1.431	-0.671	0.195	-0.115	0.275	0.303
	(0.006)	(0.015)	(0.007)	(0.044)	(0.009)	(0.248)	(0.003)	(0.013)	(0.001)	(0.001)
R^2	0.728	0.722	0.692	0.684	0.817	0.808	0.521	0.477	0.733	0.693
F-test	130.9	127.5	109.9	106.6	218.1	204.8	51.75	46.74	134.1	118.1
DW-test	0.061	0.061	0.156	0.156	0.287	0.287	0.248	0.248	0.340	0.340
1st stages F-statistics										
Pop_{t-1}	-	21.12	-	25.4	-	614.1	-	13.04	-	267.3
Pop_{t-2}	-	21.71	-	24.95	-	596.7	-	14.43	-	266.8

	Oxford		**Paris**		**Strasbourg**		**Valencia**		**Vienna**	
	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS	OLS	TSLS
Intercept	-0.121	2.342**	2.091**	5.000*	0.061	0.169	1.589***	0.687	3.113***	2.651***
	(0.664)	(1.041)	(0.859)	(2.698)	(0.253)	(0.511)	(0.544)	(0.879)	(0.716)	(0.838)
W_{t-1}	0.936***	0.887***	0.619***	0.588***	0.730***	0.769***	0.676***	0.705***	0.397***	0.442***
	(0.072)	(0.080)	(0.074)	(0.078)	(0.073)	(0.095)	(0.073)	(0.077)	(0.070)	(0.078)
W_{t-2}	-0.170**	-0.227***	0.040	0.029	0.064	0.138	0.179**	0.199***	0.185***	0.221***
	(0.073)	(0.082)	(0.074)	(0.078)	(0.075)	(0.141)	(0.073)	(0.075)	(0.070)	(0.075)
Pop_{t-1}	2.561***	7.193***	-1.637	-8.121	-0.777*	1.831	0.184	-0.584	-1.252	2.740
	(0.821)	(1.817)	(3.196)	(11.639)	(0.550)	(4.126)	(0.838)	(1.256)	(1.790)	(3.286)
Pop_{t-2}	-2.558***	-7.211	1.524	7.809	0.790*	-1.837	-0.292	0.541	1.059	-2.907
	(0.824)	(1.824)	(3.163)	(11.463)	(0.552)	(4.117)	(0.855)	(1.287)	(1.808)	(3.286)
R^2	0.856	0.832	0.476	0.442	0.664	0.623	0.834	0.832	0.555	0.540
F-test	290.8	250.4	41.15	40.09	90.74	80.32	227.2	221.8	60.94	56.6
DW-test	0.230	0.230	0.422	0.422	0.407	0.407	0.530	0.530	0.259	0.259
1st stages F-statistics										
Pop_{t-1}	-	2570	-	92.58	-	39.37	-	94.92	-	222.6
Pop_{t-2}	-	2513	-	95.11	-	40.56	-	96.17	-	233.7
LR Elasticity	0.149	-0.529	-0.332	-0.816	0.062	-0.065	-0.748	-0.458	-0.463	-0.498
	(0.008)	(0.009)	(0.005)	(0.017)	(0.095)	(0.175)	(0.008)	(0.074)	(0.003)	(0.004)

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