150 Years of Worldwide Regional Income Differences

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Abstract

We explore the extent to which contemporary GDP per capita at the sub-national level is correlated to economic development in 1850. Drawing on historical city data, we construct measures of urban population density in 1850 for a sample of 2,058 sub-national regions covering 135 countries. We find strong evidence of persistence in regional development. Our findings are robust to a large range of geographic and spatial controls. We also find that this persistence is remarkably robust even for various sub-samples of nations - grouped by continent, colonization history, current income levels, and also using alternative measures of modern development such as current urbanization, population density, and night-time light density. We also find that past urbanization is associated with contemporary human capital and infrastructure differences across regions.

1 Introduction

Research on long run growth has shifted its emphasis from understanding the forces of convergence in the past few decades, to exploring the sources of persistent differences in living standards over centuries, if not millennia. At the sub-national level, one would expect such persistence to be less important. The movement of goods and people is inherently easier between regions because of lower transport costs, similar national institutions, and fewer political barriers. Despite this, it is often observed that the distribution of economic activity across regions can persist over decades or even hundreds of years. Economically developed regions also show remarkable resilience to large scale natural disasters. Davis and Weinstein (2002), for example, document that the cities of Hiroshima and Nagasaki in Japan returned to prewar trends of population growth in about 20 years after being substantially damaged by nuclear bombings. San Francisco experienced a devastating earthquake in 1906, in which about 200,000 inhabitants were left homeless but this had little effect on long run population growth (Vigdor, 2008). Similarly, historically capital cities, such as Nanjing in China, and Berlin in Germany, continue to retain their status as an important center of commerce despite

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repeated mass destruction.[1] On the other hand, there are examples of regions like Louisiana in the US, and the state of West Bengal in India, which, while having some of the highest levels of economic development in the past have experienced relative declines within the past century.[2] Given the variety of experiences, in this paper we empirically explore the extent to which regional inequalities persist globally; whether they are driven by geographical differences, whether they vary by continent, and various other such groupings. While there are numerous studies on persistence at the regional level, to the best of our knowledge we are the first to explore the same employing a global sample while simultaneously encompassing a period of one hundred and fifty years.

More specifically, we examine the relationship between contemporary and 1850 measures of regional economic development using a sample that covers 2,058 sub-national regions from 135 countries. For the year 1850, we construct a measure of urban population density - urban population relative to total land area, based on various sources of estimates of historical settlements such as Chandler (1987), Bairoch (1988), and Eggimann (1994). We supplement this measure with indicators to capture the existence of urban areas within a region, as well as its neighboring regions, urban population densities in neighboring regions, as well as quadratic versions of the density variables to capture non-linearities. Our results overwhelmingly support worldwide "persistence of fortunes" at the sub-national level during the past 150 years. The existence of sufficiently large urban populations 150 years ago is significantly associated with regional income per capita in 2005 as well as other proxies of contemporary economic development such as urbanization rates and night-time light density. We control for country fixed effects and a large range of geographic factors commonly used in the literature. The results are also robust across different samples of countries grouped by continent, by their colonization history, and also semi-contemporary controls. We also briefly look for mechanisms through which urbanization 150 years ago affects current economic performance at the sub-national level. While not conclusive, we find that both human capital and physical capital, as measured by infrastructure, are more strongly associated with historical urban density than cultural or institutional factors. We also find that regions in the US and Canada are exceptions to such persistence.

Our choice of using 1850 as the initial year is dictated largely by data considerations - mainly concerns of accuracy and reasonably exhaustive sample size. As one goes further back in time, measurement error gets worse for at least three reasons - 1) the number of cities covered by any source or even a combination of sources is likely to get more and more unreliable, 2) even if a city is recorded, population estimates are

[1] The national capital of China has alternated between Beijing and Nanjing over the past 600 years.

[2] Easterlin (1960, pp97) estimates Louisiana's per capita income to have been the second highest in 1840 after Rhode Island. West Bengal which was one of the first states to industrialize under British Rule has by all accounts experienced deindustrialization since India's independence in 1947.

likely to be increasingly inaccurate as we go further back in time. Indeed if we go back to 1750 or even 1800, the historical compilations are missing population estimates for what were obviously well settled regions (e.g. a number of states in the US North East, the state of Kerala and Orissa in India, Tehran in Iran, to name a few.) It is also likely that more developed regions kept longer and more complete historical statistics records. In that case our estimation strategy fails, and any evidence of persistence is really one of persistence of records availability. Finally, while all these reasons are essentially limitations to not going back further, we feel 1850 remains instructive as a starting point since most countries had only just begun industrializing and integrating into the rest of the world. This would mean that regions with higher levels of development in a country then either capture a much longer civilization history or some initial advantages related to industrialization and/or colonization.

Theories that explain regional disparities in economic development emphasize the role of physical geography and the economics of agglomeration, both of which have implications on the long run persistence of economic activities. There are several channels through which physical geography can lead to the persistence. First, permanent characteristics of specific locations, such as temperatures, distance to the coast, and ruggedness of terrain, that determined economic prosperity hundreds or thousands of years ago may still play important roles in contemporary economic development. As indicated earlier, Davis and Weinstein (2002) find that the relative population densities of regions in Japan were only temporarily (though substantially) affected by the Allied bombings during World War II, and emphasize the long run importance of physical geography. Second, geographic characteristics may account for differences in culture and social norms, and local institutional development which persist over time. For instance, it is sometimes considered that historical differences between the arable areas which favored permanent settlement and the pastoral areas led to nomadic culture partly contribute to China's cultural differences (Breinlich et al., 2013).

The economics of agglomeration postulates that there are advantages to agglomerations derived from technological externalities which refer to spillovers of knowledge, ideas, and information, and pecuniary externalities which include bigger labor-market pooling and richer availability of intermediates (Breinlich et al., 2013). These externalities attract mobile factors from other regions which in turn generate higher agglomeration effects until the advantages are offset by higher commuting costs, higher land rents, and other congestion costs. While physical geography might often be a primary determinant, such agglomeration effects might help explain why certain regions sustain their advantages. Bleakley and Lin (2012)study the evolution of economic activity across portage sites built before 1900 to avoid navigational obstacles. They find evidence that there is persistence of relatively high population densities at those sites even though their direct relevance to transport costs has long been obsolete.

1.1 Related Literature

Our research is inspired by two recent advances in the economic growth literature. First, an increasing availability of sub-national data, beyond industrialized countries, has drawn economists to investigate sources determining within-country differences. Acemoglu and Dell (2010), For example, observe that cross-municipality labor income differences within a country is twice as large as cross-country differences in Latin America. With use of access to paved roads as a proxy of local institutions' efficiency in providing public goods, they show that such huge between-municipality differences are potentially attributed to various quality of municipal institutions. Tabellini (2010), on the other hand, suggests that variation in institutions may be important to explain cross-country inequality but not within-country inequality. Gennaioli et al. (2013) use a database of 1,569 regions from 110 countries to look for determinants of regional development. They find a sizable return of education to regional GDP per capita (25 - 35 percent) but little effect of institutions. Their work represents a significant advance in this literature since it is the first paper to examine regional differences with such a comprehensive sample of countries. Based on a similar coverage of regions, Mitton (2013) finds no evidence of a positive effect of institutions on development. Acemoglu et al. (2014), on the other hand, argue that Gennaioli et al.'s (2013) findings on effects of education and institutions on regional economy are not reasonable and largely result from "bad control" documented by Angrist and Pischke (2008). By instrumenting for the current average years of schooling with the share of protestant missionaries per 10,000 people in the early 20th century, they claim that the effect of human capital on income per capita returns to the reasonable range of 6 - 10 percent in regions within former colonial countries.

A separate strand of research on long run development has increasingly found that countries which benefitted from more advantageous conditions hundreds, or even thousands of years ago, tend to be richer today. Such conditions include the importance of geographic factors (Hibbs and Olsson, 2004; Olsson and Hibbs, 2005; Ashraf and Galor, 2013) as well as early development in technology (Comin et al., 2010), state capacity (Bockstette et al., 2002), and agriculture (Galor and Moav, 2007). Acemoglu et al. (2002), on the other hand, is a notable exception and find no such persistence among former European colonies over the past 500 years. We revisit the same question in the regional context, albeit for a much shorter time period. The only other paper that examines the relationship between historical economic development on modern regional outcomes is Maloney and Valencia Caicedo (2014). They examine regions of 18 countries within the

Americas, and find that regions with higher pre-colonial population densities 500 hundred years ago tend to have higher population densities and higher income per capita today. They show evidence that geographic factors as well as increasing return of population agglomeration are plausible mechanisms of persistence. While similar in nature, our work encompasses more countries though the time scale is shorter.

The remainder of the paper is organized as follows. In Section 2 we describe our regional measure of development in 1850, measures of contemporary development around 2000-2005, and the empirical framework. In Section 3 we present our results. In Section 4 we look at potential mechanisms for persistence. In Section 5, we briefly investigate persistence over 500 years. Section 6 concludes.

2 Subnational Data and Empirical Strategy

2.1 Measuring Development at the Regional level in 1850

Following Gennaioli et al. (2013), we define sub-national regions as first-level administrative divisions. Their geographic boundaries are procured from the Database of Global Administrative Areas Map version 2 (GADMv2).[3] In Figure 1, we display boundaries of all subdivisions across the world. Excluding regions from countries that have no settlements recorded in our data - there are a total of 2,058 regions from 135 countries covered in this study.[4] Of these, there are 1,395 regions from 92 countries for which 2005 GDP per capita numbers are available. Most of our analysis is based on these regions which are marked in red and are not hatched.

To examine the long run evolution of regional inequality, one needs reliable measures of regional development. This is particularly problematic as one goes back in time. GDP per capita, which is usually the preferred variable of choice, does not exist at the national level for most countries in the nineteenth century, let alone at regional levels. In fact, it is only recently that Gennaioli et al. (2013, 2014) compiled regional GDP per capita for the late 20th century and early 21st century. However, GDP per capita is not the only measure of development. The degree of urbanization, i.e. the fraction of the population living in urban areas, is also a strong correlate of development. In addition to urbanization, population densities can also serve as a viable indicator. In fact, as argued by Rappaport and Sachs (2003), population density is preferable to incomes when studying variations across regions within a country.[5] In similar vein, in the urban economics

[3]Sources: www.gadm.org. A detailed explanation of regions is provided in Appendix B.

[4]The areas with hatch marks are ones for which we have no information on settlements. If a country had no settlement in any of our sources, it was completely dropped.

[5]The cross-country literature, on the other hand, uses population density as a proxy for development mainly for the pre-industrial era when Malthusian forces were dominant.

literature, population trends in urban regions are routinely used to compare relative prosperity. However, in 1850, even population estimates for regions are hard to come by making the construction of both measures, population density and urbanization, difficult. At the same time, urban historians, such as Chandler (1987), Bairoch (1988), and Eggiman (1994) have compiled population estimates of urban settlements going back centuries. We draw on these sources to construct our primary indicator of development - the 1850 total urban population in a contemporary region divided by the total contemporary land area of the region - or what we call *urban population density*. Urban population density is, by definition, a product of the degree of urbanization and population density since, $\frac{UrbanPopulation}{LandArea} = \frac{UrbanPopulation}{Population} \times \frac{Population}{LandArea}$. Hence, while not as precise as the two underlying measures, increases in either or both of them would be reflected in increases in urban population density.

2.1.1 Defining an urban area

In order to create a measure of urban population density we need to first define what constitutes an urban location. Even today, the definition of an urban area can vary from country to country and might depend on the size of the population inhabiting an area or its population density. For our work, we include any location that has a recorded population of 5,000 or more in 1850 from our sources.[6] We follow Acemoglu et al. (2014), Acemoglu et al. (2011), and Cantoni (2010) in this regard. At the same time we recognize that there is nothing sacrosanct about this number. Indeed, there are historical studies that use other thresholds. For example, when studying cities for the period 800-1800, Bosker et al. (2013) only consider those that had at least 10,000 inhabitants. Nunn (2011) constructs national urbanization numbers for the period 1000-1900 using a much higher threshold of 40,000. In a later section of the paper, we show that our main results are robust to using higher thresholds. When all of our data sources taken together, we have 2,803 settlements spanning 141 contemporary countries in the year 1850 with populations estimates of at least 5,000.[7] Among 2,058 regions covered in this study, 766 regions had settlements with population higher than 5,000 in 1850. For these 766 regions, the average urban population density is 33.6 persons per square kilometer with a standard error of 178.5 persons per square kilometer implying a high variance. However, not all of these regions have GDP per capita data in 2005. Of the 1,395 regions where regional GDP per capita is available, 668 regions had cities in 1850 with an average urban population density of 23 persons per square kilometer and a standard deviation of 112 persons per square kilometer. In Figure 3, we depict the distribution of

[6]We are grateful to Omer Ozak and David Weil for sharing the data from Bairoch (1988) and Eggiman (1994).

[7]The listing of these cities with estimated population are displayed in an online appendix of this paper which can be downloaded at http://www.dachaoruan.com/#!research/clvf.

urban population in 1850 across the world, aggregated to the regional level. The darker regions are more densely populated. Asia and Europe had many more cities in 1850 as well as higher population per city than other places. This pattern does not alter dramatically when we use a higher minimum population threshold. We report summary statistics of urban population density in Table 1. We summarize the distribution of cities across countries and continents according to different minimum population thresholds in Appendix Table A.1.

To what extent is urban population density actually correlated with urbanization and population density? Since we do not have regional measures for the latter two variables in 1850, as a starting point, we evaluate the extent to which the former captures these measures by examining correlations using country level data. Figures 2(a) and 2(b) are scatterplots of the two variables against the logarithm of urban population density.[8] Both plots indicate that log urban population density is strongly associated with log population density and urbanization. For the 86 countries for which we could gather data, the simple correlations are 0.86 and 0.45, respectively.

2.2 Measuring Outcomes

We use log GDP per capita - the most commonly used measure of economic development - as the main proxy of contemporary regional prosperity. The regional income data cover regions from 92 countries. However, relying on GDP per capita means that we have fewer regions with contemporary income than we have with 1850 urban population data. Moreover, it is known that GDP is not accurately measured, especially in developing countries (Chen and Nordhaus, 2011; Henderson et al., 2012). One would expect this problem to be more severe at the sub-national level. Within a country GDP in richer regions may be more accurately reported than in poorer regions. To make sure our conclusions are not driven by the drawbacks of regional income, we use three alternative measures of development. These are log average nighttime light intensity using satellite data, the fraction of population living in cities (i.e. urbanization), and log population density. We have already discussed the merits of the last two. Nighttime luminosity using satellite data has become increasingly popular as a way to circumvent some of the problems related to measurement error in GDP. Henderson et al. (2012) and Hodler and Raschky (2014) have documented a positive correlation between GDP and nighttime luminosity at the country level and regional level, respectively. An increasing number of studies focusing on research questions at the sub-national level also rely on satellite data.[9]

[8]Data for total population in 1850 at the country level is taken McEvedy and Jones (1978). We calculate urbanization in 1850 as the ratio of urban population to the total population.

[9]For example, Storeygard (2013) and Alesina et al. (2012) use nighttime luminosity to study urbanization and ethnic divisions in Sub-Saharan Africa.

Table 1 lists summary statistics for these four outcomes. Among them, 1,395 regions for which we have GDP per capita data, the mean in 2005 (PPP) is 12,652 US dollars with a standard deviation of 13,387 dollars. The mean value of luminosity is 0.257 and standard deviation of it is 2.494. Urbanization in 2000 has a mean of 0.432 and a stand deviation of 0.288. Population density in 2000 has a mean of 286 persons per square kilometer and a standard deviation of 1,026 persons per square kilometer. We provide description and the sources of those variables in Appendix Table A.2.

2.3 Empirical Strategy

We estimate the effect of urban population density in 1850 on per capita income in 2005. However, part of the sample had no cities in 1850 and urban population density for those regions is 0. In addition to using urban population density in 1850, we create a dummy that equals one if one or more cities existed in a region in 1850, hereafter year 1850 city dummy. If we regress income per capita in 2005 on urban population density in 1850 and year 1850 city dummy, positive (negative) signs of both urban population density and city dummy indicate persistence (reversal) of regional economic prosperity.

Economic prosperity in one region may be closely related to development and characteristics of adjoining regions. In this study, we deal with potential spatial correlation by assuming that spatial correlation arises from spillover effect of cities in adjoining areas on other regions. We add a dummy identifying whether one or more cities existed within 25 miles geodesic distance from the regions, hereafter year 1850 neighboring city dummy.[10] We use 25 miles as a range of neighboring areas since there are no theoretical reasons to favor other distances. We also use 50 miles, 75 miles, and 100 miles as alternative ranges of neighboring areas for robustness checks. Based on those surrounding cities, we generate population density that equals the ratio of aggregated population in neighboring cities to land area of regions, hereafter year 1850 neighboring urban population density. A positive (negative) spillover from neighboring cities suggests positive (negative) signs for both the year 1850 neighboring city dummy and neighboring urban population density in 1850.

Settlements with population slightly lower than the minimum population threshold are not cities. Our urbanization variables fail to capture potential variation of development in 1850 for these regions. Caution is therefore required in interpreting those variables, especially for the year 1850 city dummy and the year 1850 neighboring city dummy - the signs of their coefficients are economically more meaningful than the magnitudes. Nonetheless, using urbanization variables based on different minimum population thresholds do not dramatically change our conclusions. We show this in results.

[10]Geodesic distance refers to the shortest line between two places on the Earth's surface, and it does not necessarily mean the shortest path in reality.

In the main model specification, we regress measures of contemporary development during 2000 to 2005 on urbanization in 1850 with the following equation:

$$\begin{aligned} \mathrm{Y}_{i,2005} = \alpha + \beta_1 \mathrm{CityDummy}_{i,1850} + \beta_2 \mathrm{UrbPopDensity}_{i,1850} + \beta_3 \mathrm{UrbPopDensity}^2_{i,1850} \\ + \beta_4 \mathrm{NeibCityDummy}_{i,1850} + \beta_5 \mathrm{NeibUrbPopDensity}_{i,1850} \\ + \beta_6 \mathrm{NeibUrbPopDensity}^2_{i,1850} + X_i \delta + \mu_c + \varepsilon_i \end{aligned} \tag{1}$$

where $\mathrm{Y}_{i,2005}$ mainly represents log income per capita for region i in year 2005. We also use log average nighttime light intensity during 2001-2005, the urbanization rate in 2000, and the log population density in 2000 as alternative outcome variables. $\mathrm{CityDummy}_{i,1850}$ is the year 1850 urban dummy of the i^{th} region. $\mathrm{UrbPopDensity}_{i,1850}$ is the year 1850 urban population density of the i^{th} region. $\mathrm{NeibCityDummy}_{i,1850}$ is the year 1850 neighboring city dummy of the i^{th} region. $\mathrm{NeibUrbPopDensity}_{i,1850}$ is the year 1850 neighboring urban population density of the i^{th} region. The vector X_i represents a comprehensive set of regional geographic factors commonly used in the literature including land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in meters, absolute value of latitude, inverse distance to the coast, and inverse distance to a river. The term μ_c represents country fixed effects. To account for any nonlinearity in the relationship between urban population density and income per capita, quadratic terms for both year 1850 urban population density and year 1850 neighboring urban population density, all included in the equation.

In a supplementary specification, we also include a dummy that equals one if a nation's most populous city in 1850 was in that region. Regions having such cities might be economically and politically important and have a relatively large urban population density to other regions within countries in 1850. Doing this enables us to see the extent to which our results are driven by this small group of regions.

We investigate the effect of urban population density in 1850 on regional income in 2005 through a log-linear model and use a quadratic term to capture any nonlinearity of the relationship. One may suggest to use a log-log model instead - in other words, to replace urban population density in 1850 and its quadratic term with the log urban population density in 1850. However, this specification will contaminate our estimates on the year 1850 city dummy, though the estimate of log urban population density remains consistent. That is, the unit of the urban population density in 1850, 10 persons per square kilometer or 100 persons per square kilometer for example, substantially varies the estimate of this urban dummy variable making its estimated coefficient economically meaningless (see Appendix D for a detailed demonstration).[11] Nevertheless, we

[11] We substitute urban population density in 1850, neighboring urban population density in 1850, and their quadratic terms

report some of these regressions to show there are generally consistent elasticities of income today with respect to the year 1850 urbanization density variables in Table A.7.

We check the robustness of results through several strategies. First, we replace per capita GDP in 2005 with other contemporary measures of regional development during 2000 to 2005 such as log average nighttime light intensity, urbanization in 2000, and population density in 2000. Second, we include additional controls such as the inverse distance to capital city, an indicator that the capital city exists in a region, the inverse distance to borders, an indicator that the largest city in 1850 within a contemporary country existed in a region, and an indicator that diamond mines exist in a region. Third, we stratify regions with urban population in 1850 into 5 groups based on urban population density in 1850, and replace urban population density in 1850 with these group dummies. Fourth, we reconstruct our urbanization variables based on different minimum population thresholds and consider neighboring urbanization variables in various distances from the border. In addition, we investigate the existence of persistence in various samples of nations according to continent groups and ex-colonial status. We also look at how the effect of urban population density is differentiated by the largest city size in regions and size of urban population. In the last check, we run quantile regressions.

Following the investigation of early urbanization effects on contemporary economic development, we look for potential channels of persistence. We regress contemporary variables of education, culture, institutions, and infrastructure on year 1850 urbanization variables based on similar model specifications to Equation 1.

Finally, we attempt to go back further to year 1750 and year 1500, and look for the link between the past and today spanning a longer time horizon.

3 Results

3.1 Baseline Results

Table 2 presents four model specifications regressing log income per capita in 2005 on the year 1850 urbanization variables for regions whose income data in 2005 are available and whose countries had settlements in 1850 according to our city data. All estimates include country fixed effects and robust standard errors clustered at the country level are shown in parentheses. We present both within-country and between-country R^2 in regressions. Column (1) is the most parsimonious model in which we capture the early urbanization effect on log income per capita in 2005 through both the year 1850 urban dummy and year 1850 urban population

into log (urban population density in 1850 + 0.00001) and log (neighboring urban population density in 1850 + 0.00001). Year 1850 city dummy and year 1850 neighboring city dummy remain but are not reported in tables.

density. The coefficient of the dummy is 0.087 with a standard error equal to 0.029, while the coefficient of year 1850 urban population density is 0.095 with a standard error of 0.024. These results suggest that regions that had cities in 1850 were likely to record 9 percent greater GDP per capita in 2005. Furthermore, among the regions that did have cities, every additional 100 urban residents per square kilometer was associated with another 10 percent higher GDP per capita. The two urbanization variables together explain 4 percent of within-country variation of income per capita in 2005.

In column (2) we consider the contribution of urbanization of surrounding cities in 1850 to income per capita today, and therefore we add a year 1850 neighboring urban dummy and year 1850 neighboring urban population density. Coefficients of both variables are small in magnitude and insignificant. Coefficients of year 1850 urban dummy and year 1850 urban population density remain close to their values in column (1). Both within-country and between-country R^2 show little change compared to column (1). Columns (3) and (4) assume quadratic effects for both year 1850 urban population density and year 1850 neighboring urban population density. Negative signs of squared density variables indicate that the effects of year 1850 urban population density and year 1850 neighboring urban population density on per capita GDP in 2005 are concave. Substantial increases in within-country R^2 compared to columns (1) and (2) also support models with the quadratic forms.

We present results of our favored model specification in column (4). Estimated coefficients suggest that regions had cities in 1850 were associated with higher GDP per capita in 2005, with a significance of 5 percent. Among regions with urban population in 1850, every additional 100 urban residents per square kilometer (about one standard deviation) was correlated with another 36.6 percent (33.5 minus 2.3 log points) higher GDP per capita, with a significance of 1 percent. Spatial correlation that refers to spillovers of urban development in neighboring areas (using 25 miles away from regions' boundaries) is captured by year 1850 neighboring urban population density and year 1850 neighboring city dummy. Our estimates suggest that a unit change of neighboring urban population density in 1850 was associated with 6.5 percent (6.5 minus 0.2 log points) higher GDP per capita, with a significance of 5 percent. But whether there existed a city in neighborhood areas whose population in 1850 is slightly higher than 5,000 had no prediction about regional income differences in 2005. Positive spillovers are generally supported by results.

We further restrict the sample to regions with a city in 1850 in Appendix Tables A.3. The results remain consistent. In addition, we use 50 miles, 75 miles, and 100 miles as alternative ranges of neighboring areas and reconstruct neighboring urban population density and neighboring city dummy for estimation. We report results in Appendix Table A.6, and none of the strategies greatly change our findings in column (4) of Table 2. Moreover, the coefficients of neighboring city and neighboring urban population density are attenuated with a longer distance used for defining neighboring area. For example, using 100 miles from regions' boundaries to construct neighboring area, the coefficient of neighboring urban population density in 1850 decreases from 0.065 to about 0.006 and become insignificant.

3.2 Urbanization in 1850, Physical Geography, and Development

The importance of physical geography to economic activity has been extensively explained in the literature. Physical geography shapes contemporary income inequalities mainly through three approaches; 1) some geographic and climatic characteristics have a direct impact on economic activities over centuries (Davis and Weinstein, 2002), 2) some of them have played an important role in shaping culture and social norms which persists over hundreds of years (Breinlich et al., 2013), and 3) others triggered path dependence in agglomerations hundreds of years ago though their economic values have long faded away (Bleakley and Lin, 2012).

Physical geography can be captured in many ways, among which temperatures, land suitability, ruggedness of terrain, latitude, and proximity to the coast are highlighted in recent studies. For example, Dell et al. (2012) find cross-country evidence that temperatures have negative effects on agricultural output, industrial output, and political stability. In addition, temperatures and annual precipitation are negatively associated with growth rates. Proximity to the coast measures ease of ocean access, and a shorter distance to coast is often regarded as an advantage to external trade (for example, Frankel and Romer (1999)). Ruggedness is expected to adversely affect productivity. For example, high elevation and ruggedness means higher costs of economic activities such as construction and transportation. Nunn and Puga (2012) find evidence showing a negative impact of ruggedness on economic development is generally true across countries in the world. Absolute value of latitude measures the general distance away from the equator. A longer distance to the equator relates less severe disease environment, less tropical area, and lower temperatures which are beneficial to development (see e.g. Acemoglu et al., 2002).

One might be concerned that the association between contemporary income and our early urbanization variables may therefore simply represent the influence of those environmental characteristics on contemporary income. We investigate the concern in Table 3. In column (1), we report impacts of geographic and climatic characteristics on log income per capital in 2005 without including measures of development in 1850. Temperatures and rainfall both have negative impacts on regional income as expected, though the effect of temperatures is insignificant and rainfall is only significant at 10 percent. Land suitability has a negative and significant impact on income today and is consistent with recent regional studies (for example, Mitton, 2013; Maloney and Valencia Caicedo, 2013). Elevation and terrain ruggedness both have expected effects on income. Nunn and Puga (2012) and Mitton (2013) both find significantly negative impact of ruggedness on regional income. An expected positive correlation between proximity to ocean and regional income is also supported in our findings. The coefficient of inverse distance to river is positive but insignificant. All together, the 8 geographic and climatic variables explain 15 percent of within-country variation and 52 percent of between-country variation.

In column (2), we include a dummy variable indicating regions in which nations' most populous cities in 1850 existed. This small group of regions might be political and economically crucial to their countries and have a relatively high urban population density to other regions within countries in 1850. The dummy therefore enables us to observe the extent to which our results are driven by these regions. Our estimates in column (2) indicate that including the dummy affects geography coefficients - both rainfall and ruggedness become insignificant.

We include our measures of development in 1850 in columns (3) and (4). Persistence remain significant but has slightly lower magnitude in column (3) than in column (4) of Table 2. The effect of the year 1850 city dummy is basically unchanged (the coefficient decreases from 0.07 to 0.068) and the impact of urban population density in 1850 declines from 0.335 to around 0.265. However, some geography factors - ruggedness, absolute value of latitude, and rainfall - turn insignificant, suggesting these factors are likely to function as a trigger of early development which persists over hundreds of years according to path dependence theory. Models with geography controls have within-country R^2 of around 20 percent and between-country R^2 of around 50 percent. Take two regions in China, Jiangsu and Sichuan, as example. Jiangsu had an urban population density of 7.9 persons per square kilometer in 1850, while Sichuan had 0.5 persons per square kilometer.

In column (4), the coefficient of dummy that nation's largest city in 1850 existed in a region is 0.278 and is significant at 1 percent. This is evidence of persistence for those regions. Including the dummy lowers coefficients of year 1850 city dummy and urban population density in 1850. For example the impact of urban population density in 1850 declines to 0.189 but it is still significant at 1 percent. Therefore, persistence is evident in many other regions than just a small group of prominent regions.

As an additional robustness check, we consider 5 additional contemporary controls - inverse distance to capital, inverse distance to borderlines, an indicator equals to 1 if capital city exists in a region, an indicator that diamond mines exist, and the log regional population in 2000. We practice the similar exercise as in Table 3 including the 8 geographic and climatic variables, and report estimates in Table 4. We first display their effects on regional income excluding development in 1850 in columns (1) and (2), and show results based on these variables and development in 1850 in columns (3) and (4). Our results show that the indicator for existence of the national capital city is the only one that has a statistically significant impact on income today. The coefficient of year 1850 city dummy is close to 0 and becomes insignificant, while the coefficient of urban population density in 1850 remain significant at 5 percent though its magnitude falss substantially. These two coefficients are likely to be downward biased as the additional 5 contemporary controls are included as most of them are potentially endogenous and positive correlated early urbanization.

The coefficient on the dummy for the nation's most populous city in 1850 declines substantially and becomes insignificant in columns (2) and (4). Its effect is likely to be taken by the dummy of capital city, as among the 92 capital cities 57 were the largest cities within countries in 1850. Nevertheless, including the 5 contemporary controls that are potentially endogenous does not alter the existence of persistence.

3.3 Alternative Measures of Economic Development

To address drawbacks of using log GDP per capita in 2005 as a outcome - limitations on sample size and varying degrees of measurement error across regions, we use three alternative measures of contemporary development commonly used in regional economics, e.g. log average nighttime light intensity (Hodler and Raschky, 2014), urbanization rate, and log population density (Rappaport and Sachs, 2003). In order for the persistence to be supported, positive relationships between urbanization variables in 1850 and the level of contemporary development using alternative measures are expected.

Estimates using alternative outcomes are displayed in Table 5. In any case, regions that had cities in 1850 are associated with higher level of contemporary development and among regions with urban population in 1850, every additional 100 urban residents per square kilometer was correlated with a higher level of development with a quadratic effect. The coefficients are significant at 1 percent. Positive spillovers are supported. Overall, using alternative measures of economic development leads to the same conclusion as using log GDP per capita does. We also reduce our sample to 1,395 regions in which regional income is available and the conclusions remain the same.

3.4 Is The Relationship Continuous ?

Various results thus far have revealed a positive and concave relationship between urban population density in 1850 and the level of development around 2000 to 2005. However, the evidence of persistence is not widely guaranteed for all regions in the distribution of urban population density. For example, what if the positive correlation is driven by extreme high and low levels of urban population density? If the relationship is generally continuous, one would see a pattern in a pair of numerical coordinates that a region's contemporary development around 2000 to 2005 increases with the region's urban population density in 1850. To verify the existence of the pattern, we apply the following strategy. We stratify regions into 6 groups according to urban population density in 1850, indexed starting from 0 for regions with 0 values of urban population density to 5 for regions with highest values of urban population density. We regress log GDP per capita in 2005 and the other three alternative outcomes on the 6 groups controlling for regional spillovers and the 8 geography factors. A higher coefficient for a larger group number is therefore evidence supporting a positive relationship between outcomes and urban population density in 1850.

In Panel A of Table 6, regions with positive urban population density in 1850 were divided into 5 equal groups, and cutoffs between groups are therefore arbitrary. In Panel B, regions with positive urban population density in 1850 were divided into 5 groups with cutoffs at one sixth of the mean of urban population density - 0.063, one third of the mean - 0.125, one third of the mean plus one standard deviation - 1.226, and one third of the mean plus two standard deviations - 2.326. The base group consists of regions in which urban population density is 0. In almost all cases, coefficients of dummies are positive and are ascending with density groups, suggesting that the effect of urban population density in 1850 on development today is continuous. The evidence of persistence is therefore generally applicable to all regions.

Furthermore, we investigate concern that our evidence for the relationship between urban population density and income per capita might be driven by regions with the super cities or regions with huge urban populations. We interact urban population density in 1850 with region groups according to the size of the largest city within regions in Panel A of Appendix Table A.4, and the size of regional urban population in Panel B, respectively. Overall, estimates show that a positive and concave relationship between urban population density and contemporary development is mostly supported in all groups. In addition, we find no evidence that the magnitude of the association is monotonic to either regional population size or population size of regions' largest city.

In Appendix Table A.5, we report quantile regressions of log income per capita in 2005 on urbanization in 1850 for quantiles 0.1 in Panel A, 0.25 in Panel B, 0.5 in Panel C, 0.75 in Panel D, 0.9 in Panel E based on the whole sample. We observe the pattern of persistence in each quantile though magnitudes varies. The median regression estimates (in quantile of 0.5, Panel C) are close to OLS regression estimates. Overall, our quantile regressions suggest that our conclusions based on OLS estimation is less likely to be driven by regions with unusually low/high income per captia in 1850.

All above evidence indicates that our conclusions are less likely to be driven by measurement errors in urban population density in 1850.

3.5 Alternative Minimum Population Threshold

In order to construct measures of development in 1850, we define cities in 1850 using a minimum population of 5,000 as the threshold. One might be worried that the number is so small that many settlements in 1850 with population slightly greater than 5,000 may not be available in any record leading to a measurement error of urban population density in 1850. We do find that for some continents or countries only settlements whose estimated population reaches a much higher number than 5,000 are available in our city data. For example, most settlements in 1850 in Africa and Asia in our data have a population size higher than 15,000.[12] However, if settlements within each country are completely recorded based on a consistent population threshold, then country fixed effects will mitigate the impact of losing of small cities on estimation.

To investigate the potential effect of using various minimum population thresholds on our estimation, we reconstruct variables measuring development in 1850 by using minimum population thresholds of 20,000, 50,000, and 100,000 respectively. We start with a threshold of 20,000 for the reason that Chandler's (1987) work, one of the most influential source of historical cities and the benchmark of many others' work, is based on the same threshold. We report evidence in Tables 7. We find that results based on a minimum population threshold of 20,000 are very similar to the threshold of 5,000. However, the coefficient of urban population density in 1850 diminishes quite a bit when threshold increases from 20,000 to 50,000, and to 100,000. This may suggest that the coefficient may vary according to various regional characteristics such as continent, size of the largest city within regions, and so on. For example, the number of regions whose urban population density is positive drops more quickly in the Americas and Africa than in Asia and Europe when a higher threshold is used. There are 164 out of 196 regions with urban population in 1850 from Asia or Europe when 50,000 is used as a threshold to define city, and 76 out of 90 regions when 100,000 is chosen. We will discuss it in the rest of this section. In sum, though coefficients of urbanization variables vary by different thresholds, the pattern of persistence of economic activities across regions remains robust.

[12]When we raise threshold from 5,000 to 20,000, we find that the number of regions with urban population and the total urban population remain steady. The number of regions with cities in 1850 declines from 205 to 178 for Asia and from 49 to 32 for Africa, and aggregate urban population decreases from 28,878 to 26,846 for Asia and from 3,149 to 2,799 for Africa. However, both numbers drop substantially for Europe and the Americas.

3.6 Evidence in Subsamples

We also check whether the evidence for persistence is driven by regions in a small group of countries characterized by similar characteristics such as countries by various continents or countries by different income groups. We divide the sample into various groups according to different criteria. Table 8 reports regressions for regions in different continent groups. Results on African countries using log GDP per capita and log average nighttime luminosity as dependent variables are reported in Panel A and B, respectively. We have discussed that unavailability and low accuracy are two drawbacks of income data at the regional level. The drawbacks are magnified in Africa. For example, only 123 regions from 13 countries, about one third of regions in Africa, are included in estimation when we use log GDP per capita as dependent variable. Nighttime luminosity is used as a popular substitute of GDP in recent studies focusing Africa (such as, Henderson et al., 2012; Alesina et al., 2012; Storeygard, 2013). The evidence for persistence in Africa is supported with use of log average luminosity as a measure of development.

We report West European countries in Panel C of Table 8, other European countries in D, the Americas in E, American countries excluding the US and Canada in F, and the Asia in G. The effects of early development on log GDP per capita across all country groups follow the same pattern that is found in the whole sample. Magnitudes of the effects vary greatly across groups; the coefficient of urban population density in 1850, for example, is lowest for regions from Western European countries, is moderate for regions in Asia, and highest for regions in the Americas and Non-West Europe. This may partially result from the concavity of the relationship between urban population density in 1850 and log income per capita in 2005. As displayed in Figure 3, regions with densest population in 1850 are mainly from West Europe and least dense population from the Americas and East Europe excluding Africa and Oceania. Partly due to the concavity, the coefficient of urban population density is lower if we mainly focus on regions with a higher density. To further support it, we substitute year 1850 urban population density, year 1850 neighboring urban population density and their quadratic forms with logs of both variables. Results of various groups are shown in Panels A - F of Appendix Table A.7. The coefficient of the log urban population density in 1850 is in a narrow range of 0.08 - 0.11 across different groups.

Because results using log regional income in 2005 as the dependent variable do not support persistence in Africa, excluding African regions from the whole sample should not dramatically change our conclusions based on the whole sample. In Panel A of Table 9, we use log GDP per capita in 2005 as dependent variable and exclude African countries. Estimates are close to those in the whole sample.

Due to the remarkable movement of goods and services and production factors in the US and Canada, regions and cities in these two countries have experienced lots of ups and downs during the 150 years. For example, the US states such as California and Texas that were underdeveloped 150 years ago have been growing rapidly. On the other hand, Louisiana, a state that were prosperous before, is recently one of the poorest states in the US. One would expect the US and Canada would be exceptions to the persistent regional disparities. We investigate this two countries in Panel B of Table 9. Considering that persistence in the two countries may exist in a different model specification, we regress log GDP per capita on year 1850 city dummy and urban population density in 1850 with including or excluding spillover effects from neighboring cities or/and quadratic terms of urban population density in 1850. None of the results support persistent regional inequalities for regions in the US and Canada during the 150 years. As expected, the US and Canada are exceptions to the persistence.

4 Potential Mechanisms

All results so far report persistence in the long run development at the regional level over the past 150 years or longer, and such results are robust to controlling for a comprehensive set of geographic factors, using alternative measures of contemporary economic development, and alternative samples. The interesting question is through what channels is early development linked to income today at the regional level. Many cross-country studies have emphasized the importance of geography, institutions, and culture in determining income differences. However, institutions and culture are less likely to vary much within a country. Conditional on country fixed effects, institutions and culture are unlikely to be the main driving forces behind the link at the regional level.

We use a similar exercise as Putterman and Weil (2010) to look for the potential channels in Table 10. We look at the relationship between urbanization in 1850 and years of education in 2005 without taking any geographic controls in column (1) of Panel A. The coefficient of year 1850 urban dummy is 0.274 with a standard error of 0.08. The coefficient of year 1850 urban population density is 0.599 significant at 1 percent, and its quadratic form is -0.042 significant at 1 percent. Intuitively, residents of regions in which cities existed in 1850 are expected to have more years education today, and an additional 100 inhabitants per square kilometer living urban area in 1850 predicts 0.56 more average years of education in the region. The coefficient of year 1850 neighboring urban dummy is small in magnitude with a negative sign and it is insignificant. Coefficients of year 1850 neighboring urban population density and its quadratic form have the magnitudes about half of those within the region. Both are significant at 5 percent level. The early urbanization variables together explains 10 percent of within-country variation of years of education and 21 percent of between-country variation.

Column (2) of Panel A considers an indicator of culture, trust in others. The urbanization coefficients are close to zero and none of them are significant. Predictive power is also close to zero according to within and between R^2.

In columns (3) - (5) of Panel A we regress three outcomes of regional institutions - informal payments, access to financing, and log days without electricity - on the year 1850 urbanization variables. The correlations are mostly insignificant and difficult to explain. Access to financing reported in column (4) is positively correlated with year 1850 urban dummy, significantly at 10 percent level, reflecting a weak positive impact of early urbanization on contemporary institutions. However, log of days without electricity is positively associated with year 1850 urban dummy, suggesting a negative effect of early urbanization on institutions today.

The remaining two columns of Panel A report the effect of urbanization in 1850 on infrastructure measured by the log power line density in column (6) and log travel time in column (7). Power line density is more likely to reflect the scale of infrastructure while the travel time captures the quality of infrastructure. Both columns show that regions with a higher level of early urbanization in 1850 tend to have larger and more efficient infrastructure. Urbanization in 1850 explains 10 percent of within and 40 percent of between R^2 for log power line density, and 29 percent and 59 percent for log travel time.

In Panel B we show regressions of the same regional outcomes on urbanization in 1850 while including our baseline geographic controls and the log of regional population. Geographic factors are controlled so as to rule out the possibility that early urbanization captures advantageous geographic or natural environment that favor economic development. For example, an ideal geographic condition in the plain helped to build city hundreds of years ago also means a relatively low cost to construct modern infrastructure such as schools, roads, etc. Controlling for current regional population rules out the concern that early urbanization is purely picking up scale effect of population size which may plausibly persist over the past 150 years. Our results in Panel B show that 1) including these controls lowers the effect of urbanization in 1850 by different magnitudes for different outcomes, and 2) urbanization in 1850 is still strongly correlated with contemporary years of education and infrastructure.

Our evidence suggests that both path dependence theory and physical geography are important to understand persistence of economic disparities across regions over the past 150 years. More exactly, dependence theory in our context is closely related to accumulations of human capital and infrastructure over time. For example, Gennaioli et al.'s (2013) discussion of roles of human capital in regional disparities may suggest a long run accumulation of human capital. In their structural model, individuals decide where to live - productive region or unproductive region - subject to a moving cost, and whether to be entrepreneur or workers. A higher human capital stock is expected to be in a more productive region and contributes regional economy through differing roles of individuals - as workers or entrepreneur - and human capital externalizes.

However, results of the exercise are suggestive as one can make the reverse inference that early urban development influences current income level that favors the quality of infrastructure and level of education.

5 Going Back Further

One would expect that contemporary regional disparities might originate even earlier than 1850. We therefore extend the time horizon of this study to 500 years ago. However, AJR (2002) find a reversal of fortune among ex-colonies at the country level. They argue that it is a result of different settlement strategies adopted by European settlers according to population density in colonies in 1500; extractive institutions were more likely to be introduced in places where population were more dense in 500 hundred years ago. Moreover, the reversal was almost complete prior to the middle of the 19th century. Therefore, for ex-colonies, reversal of regions that were prosperous in 500 years ago may not be observed until post nineteenth-century if there exists.

We verify these statements in this section. Instead of looking at all countries in the sample, we separate countries based on their ex-colony status. Table 11 regresses per capita GDP in 2005 on urbanization in 1850 in both colonial countries and other countries separately. Our results show that regions with a higher urbanization 150 years ago tend to be richer today in either ex-colonial countries or other countries. We therefore find evidence that there exists persistence during post-industrialization period. For the time before industrialization, we regress the year 1850 urban population density on the year 1500 urbanization variables in Table 12. The persistence still exists in non-colonial countries. However, there is no evidence indicating regions that were more urbanized in 1500 were still richer than others in 1850 within an ex-colonial country. Overall, these results suggest that economic prosperity can persist for much longer time than 150 years unless the there is institutional reversal.

6 Conclusion

The debate regarding sources of economic prosperity has attracted economists' attention to historical and geographic factors. Existing studies have documented cross-country evidence that economic activities hundreds or thousands of years ago play an important role in shaping the distribution of the world economy today. Previous research also has suggested early development favors long term economic growth through developing growth-promoting elements, such as human capital, culture, and institutions. For inequality of economic development at the sub-national level, however, most of studies are restricted to a single country or several ones, and only a few of them have looked at roles of historical factors, mainly due to limited availability of subnational data, especially historical data.

In this paper, we construct urban population density in 1850 to study regional disparities over the past 150 years. This study complements the literature on the long run within-country differences by introducing a new proxy for regional development in 1850, and by covering regions from most countries in the world. We find widespread evidence in the world that regions had cities in 1850 are associated with higher development today and among regions with urban population in 1850, regions with more dense population are correlated with a higher level of development. We also document that there exist small positive spillovers of urban development in 1850 in neighboring areas.

We briefly look for potential paths of the persistence, such as human capital, culture, institutions, and infrastructure. While not conclusive, urbanization in 150 years ago affects cross-region variations of current human capital and infrastructure. In the last section of the study, we extend time horizon to 500 years ago. Our results suggest regional economic disparities may persist for 500 years or longer but not for ex-colonial countries.

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Table 1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Outcome Variables:					
GDP per capita in 1,000 USD, constant 2005 PPP(A)	12.652	13.387	0.07	143.483	1395
Ln(ave. light den., averaged across 2001-05)(B)	0.257	2.494	-10.776	4.143	2044
Urbanization Rate in 2000(C)	0.432	0.288	0	1	2050
Population Density in 2000(C)	2.855	10.259	0	219.105	2058
Urban population density in 2000(C)	2.818	19.72	0	674.283	2058
Years of Education(A)	7.302	3.073	0.252	13.21	1358
Trust in others(A)	0.27	0.186	0	1	665
Informal payments(A)	1.184	1.474	0	10.254	331
Access to Financing(A)	0.458	0.202	0	1	372
Ln(days without electricity)(A)	2.875	0.719	0.954	4.557	203
Ln(power line density)(A)	1.399	1.01	0	4.869	1395
Ln(travel time)(A)	5.268	0.938	1.423	8.678	1395
Variable of interest:					
A 1850 city in region(E)	0.372	0.484	0	1	2058
- regions with regional income in 2005	0.479	0.499	0	1	1395
Urban pop. den. in 1850(E)	0.336	1.785	0	34.027	766
- regions with regional income in 2005	0.232	1.126	0	15.587	1395
A 1850 neighboring city in region(E)	0.467	0.499	0	1	2058
Neighboring urban pop. den. in 1850(E)	1.503	9.548	0	198.034	962
A 1500 city in region(E)	0.137	0.344	0	1	2058
A 1500 city in country(E)	0.58	0.494	0	1	2058
A 1500 neighboring city in region(E)	0.173	0.379	0	1	2058
Urban pop. den. in 1500(E)	0.088	0.282	0	2.733	282
Neighboring urban pop. den. in 1500(E)	1.038	5.539	0	68.706	357
Baseline regional controls:					
Temperatures in Celsius(G)	16.719	8.419	-15.421	29.588	2058
Land suitability(F)	0.359	0.318	0	0.998	2058
Altitude in 100 meters(G)	5.48	6.366	-0.138	48.786	2058
Ruggedness in 100 meters(H)	1.363	1.354	0	9.99	2058
Rainfall in meter(G)	1.094	0.746	0.001	5.405	2058
Absolute value of latitude(I)	28.902	16.842	0	71	2058
Proximity to coast(B)	0.838	0.162	0.327	1	2058
Proximity to river(B)	0.832	0.163	0.21	1	2058
Largest 1850 city within a country existed(E)	0.069	0.254	0	1	2058
Other regional controls:					
Proximity to capital	0.761	0.196	0.076	1	2058
Proximity to border(B)	0.823	0.161	0.163	1	2058
Capital city exists	0.063	0.243	0	1	2058
Indicator, diamond mine(J)	0.067	0.25	0	1	2058
Ln(oil production/capita)(A)	0.108	0.409	0	4.161	1395

Note: Unit of population density is 100 persons per square kilometers. Data A are from Gennaioli et al. (2013). Data B are from the National Geophysical Data Center (NOAA). Data C are from the Center for International Earth Science Information Network (CIESIN). Data D are from the United Nation (UN). Data E are from Dr. Weil at Brown University. Data F are from Atlas of the Biosphere. Data G are Global Climate Data (WorldClim). Data H are from Nunn and Puga (2012). Data I are from Global Administrative Areas (GADM). Data J are from Peace Research Institute Oslo (PRIO).

Table 2: Regressions of Log Regional Income per Capita in 2005 on Urbanization in 1850

	Dependent Variable: Log of Regional Income per Capita (PPP), 2005			
	(1)	(2)	(3)	(4)
At least a 1850 city	0.086***	0.097***	0.058*	0.070***
	(0.029)	(0.025)	(0.029)	(0.027)
Urban pop. den. 1850	0.095***	0.089***	0.353***	0.335***
	(0.024)	(0.024)	(0.064)	(0.065)
Squ. urban pop. den. 1850			-0.023***	-0.023***
			(0.006)	(0.006)
At least a 1850 neib. city		-0.049		-0.045
		(0.049)		(0.046)
Neib. urban pop. den. 1850		0.009		0.065**
		(0.008)		(0.031)
Squ. neib. urban pop. den. 1850				-0.002**
				(0.001)
Countries	92	92	92	92
Observations	1395	1395	1395	1395
within R^2	0.04	0.05	0.08	0.09
between R^2	0.24	0.17	0.25	0.19

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. No controls are included. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Regressions of Log Regional Income per Capita in 2005 on Urbanization in 1850 and Geographic Controls

	Dependent Variable: Log of Regional Income per Capita (PPP), 2005			
	(1)	(2)	(3)	(4)
At least a 1850 city			0.068**	0.018
			(0.028)	(0.029)
Urban pop. den. 1850			0.267***	0.189***
			(0.056)	(0.057)
Squ. urban pop. den. 1850			-0.018***	-0.014***
			(0.005)	(0.005)
At least a 1850 neib. city			-0.035	-0.035
			(0.032)	(0.031)
Neib. urban pop. den. 1850			0.047	0.059**
			(0.030)	(0.029)
Squ. neib. urban pop. den. 1850			-0.001	-0.002**
			(0.001)	(0.001)
Temperatures	-0.018	-0.018	-0.023	-0.021
	(0.015)	(0.015)	(0.017)	(0.016)
Land suitability	-0.202***	-0.195***	-0.154***	-0.153***
	(0.054)	(0.054)	(0.055)	(0.055)
Elevation (100 meters)	-0.010	-0.011	-0.013	-0.012
	(0.008)	(0.008)	(0.009)	(0.008)
Ruggedness	-0.049**	-0.038	-0.029	-0.027
	(0.023)	(0.023)	(0.022)	(0.022)
Rainfall in meter	-0.080*	-0.067	-0.066	-0.061
	(0.048)	(0.047)	(0.048)	(0.047)
Abs. (latitude)	0.013**	0.012**	0.010	0.011*
	(0.006)	(0.006)	(0.007)	(0.006)
Inverse distance to coast	1.012***	0.913***	0.889***	0.869***
	(0.189)	(0.186)	(0.181)	(0.180)
Inverse distance to river	0.267	0.205	0.195	0.177
	(0.189)	(0.199)	(0.194)	(0.197)
Biggest city in 1850 within countries		0.362***		0.278***
		(0.046)		(0.058)
Countries	92	92	92	92
Observations	1395	1395	1395	1395
within R^2	0.15	0.21	0.20	0.23
between R^2	0.52	0.52	0.56	0.54

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Regressions of Log Regional Income per Capita in 2005 on Urbanization in 1850 and Other Contemporary Controls

	Dependent Variable: Log of Regional Income per Capita (PPP), 2005			
	(1)	(2)	(3)	(4)
At least a 1850 city			0.003	-0.002
			(0.024)	(0.024)
Urban pop. den. 1850			0.118**	0.112**
			(0.050)	(0.051)
Squ. urban pop. den. 1850			-0.009**	-0.009**
			(0.004)	(0.004)
At least a 1850 neib. city			-0.037	-0.038
			(0.036)	(0.036)
Neib. urban pop. den. 1850			0.067**	0.068**
			(0.028)	(0.028)
Squ. neib. urban pop. den. 1850			-0.002**	-0.002**
			(0.001)	(0.001)
Inverse distance to capital	0.008	0.011	-0.010	-0.005
	(0.125)	(0.125)	(0.118)	(0.119)
Inverse distance to border	-0.129	-0.131	-0.137	-0.138
	(0.278)	(0.280)	(0.283)	(0.284)
Capital city exists	0.580***	0.542***	0.535***	0.517***
	(0.047)	(0.061)	(0.054)	(0.059)
Diamond mines exists	0.027	0.024	0.028	0.026
	(0.062)	(0.062)	(0.063)	(0.063)
Ln(population)	-0.001	-0.003	0.004	0.003
	(0.023)	(0.024)	(0.023)	(0.024)
Biggest city in 1850 within countries		0.070		0.040
		(0.052)		(0.053)
Countries	92	92	92	92
Observations	1395	1395	1395	1395
within R^2	0.29	0.29	0.30	0.30
between R^2	0.53	0.53	0.55	0.54

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Regressions of Other Development Outcomes on Urbanization in 1850

	Dependent Variable:					
	Panel A: Ln(Average Nighttime Light Density, Averaged over 2001-2005)			Panel B: Fraction of Population Living in Cities in 2000		
	(1)	(2)	(3)	(1)	(2)	(3)
At least a 1850 city	0.979***	0.812***	0.569***	0.123***	0.114***	0.073***
	(0.107)	(0.098)	(0.089)	(0.019)	(0.019)	(0.017)
Urban pop. den. 1850	0.395***	0.321***	0.171**	0.082***	0.069***	0.043**
	(0.091)	(0.082)	(0.075)	(0.018)	(0.017)	(0.017)
Squ. urban pop. den. 1850	-0.013***	-0.010***	-0.006**	-0.003***	-0.003***	-0.002***
	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)
At least a 1850 neib. city	0.618***	0.455***	0.486***	-0.021	-0.023*	-0.018
	(0.096)	(0.085)	(0.083)	(0.014)	(0.014)	(0.013)
Neib. urban pop. den. 1850	0.031*	0.026*	0.028*	-0.001	-0.002	-0.001
	(0.017)	(0.016)	(0.016)	(0.006)	(0.006)	(0.006)
Squ. neib. urban pop. den. 1850	-0.000**	-0.000*	-0.000**	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Biggest city in 1850 within countries			1.020***			0.173***
			(0.170)			(0.028)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	135	135	135	135	135	135
Observations	2044	2044	2044	2050	2050	2050
within R^2	0.14	0.25	0.27	0.10	0.13	0.16

	Panel C: Ln(Population Density in 2000)		
	(1)	(2)	(3)
At least a 1850 city	0.882***	0.751***	0.518***
	(0.099)	(0.090)	(0.091)
Urban pop. den. 1850	0.660***	0.622***	0.478***
	(0.119)	(0.118)	(0.112)
Squ. urban pop. den. 1850	-0.021***	-0.019***	-0.016***
	(0.004)	(0.004)	(0.004)
At least a 1850 neib. city	0.621***	0.462***	0.492***
	(0.097)	(0.078)	(0.076)
Neib. urban pop. den. 1850	0.044*	0.042*	0.044*
	(0.025)	(0.024)	(0.025)
Squ. neib. urban pop. den. 1850	-0.000*	-0.000*	-0.000*
	(0.000)	(0.000)	(0.000)
Biggest city in 1850 within countries			0.981***
			(0.159)
Baseline Controls Included	No	Yes	Yes
Countries	135	135	135
Observations	2058	2058	2058
within R^2	0.22	0.32	0.35

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Regressions of Log Regional Income per Capita in 2005 on Urbanization in 1850

	Dependent Variable:			
	Ln(GDP per capita, 2005)	Ln(Ave. nighttime luminosity,2001-2005)	Urbanization Rate	Ln(Population) Density in 2000)
	Panel A: Quintiles of Regions for Urban Population Density in 1850			
	(1)	(2)	(3)	(4)
Quintile with Smallest Non-zero Urb. Pop. Den. in 1850	-0.033	0.160	0.020	0.062
	(0.038)	(0.139)	(0.015)	(0.123)
The 2nd Smallest Quintile	0.009	0.734***	0.071***	0.601***
	(0.036)	(0.099)	(0.019)	(0.099)
The 3rd Quintile	0.094**	0.800***	0.091***	0.696***
	(0.038)	(0.106)	(0.016)	(0.112)
The 4th Quintile	0.208***	1.063***	0.181***	1.069***
	(0.043)	(0.177)	(0.028)	(0.170)
Quintile with Largest Urb. Pop. Den. in 1850	0.461***	2.027***	0.339***	2.540***
	(0.055)	(0.217)	(0.037)	(0.227)
At least a 1850 neib. city	-0.055*	0.455***	-0.024*	0.443***
	(0.031)	(0.083)	(0.013)	(0.073)
Neib. urban pop. den. 1850	0.064**	0.037**	0.000	0.059**
	(0.027)	(0.017)	(0.006)	(0.027)
Squ. neib. urban pop. den. 1850	-0.002*	-0.000**	-0.000	-0.000**
	(0.001)	(0.000)	(0.000)	(0.000)
Countries	92	135	135	135
Observations	1395	2044	2050	2058
within R^2	0.23	0.28	0.17	0.38
between R^2	0.57	0.37	0.33	0.37
	Panel B: Alternative Groups of Regions by Urban Population Density in 1850			
	(1)	(2)	(3)	(4)
Regions in which urban population density in 1850 was:				
between 0 to 0.063 (or $\frac{1}{6}mean$)	0.035	0.604***	0.073***	0.481***
	(0.029)	(0.084)	(0.017)	(0.080)
between 0.063 to 0.125(or $\frac{1}{3}mean$)	0.228***	0.970***	0.159***	0.966***
	(0.052)	(0.181)	(0.035)	(0.169)
between 0.125 to 1.226(or $\frac{1}{3}mean + std.dev.$)	0.387***	1.814***	0.302***	2.064***
	(0.067)	(0.219)	(0.041)	(0.209)
between 1.226 to 2.326(or $\frac{1}{3}mean + 2 \times std.dev.$)	0.546***	2.810***	0.516***	3.807***
	(0.132)	(0.416)	(0.051)	(0.338)
greater than 2.326	0.667***	2.241***	0.361***	3.538***
	(0.099)	(0.293)	(0.066)	(0.392)
At least a 1850 neib. city	-0.042	0.476***	-0.020	0.493***
	(0.030)	(0.083)	(0.013)	(0.074)
Neib. urban pop. den. 1850	0.053*	0.034**	-0.000	0.054**
	(0.028)	(0.016)	(0.006)	(0.026)
Squ. neib. urban pop. den. 1850	-0.001*	-0.000**	-0.000	-0.000**
	(0.001)	(0.000)	(0.000)	(0.000)
Countries	92	135	135	135
Observations	1395	2044	2050	2058
within R^2	0.23	0.28	0.17	0.39
between R^2	0.57	0.35	0.36	0.38

Note: The unit of observation is a subnational region. Robust standard errors clustered at the country level are shown in parentheses. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Alternative Minimum Population Thresholds in Creating Urbanization Variables, Regressions of Log Regional Income per Capita in 2005 on Urbanization in 1850

	Dependent Variable: Log of Regional Income per Capita (PPP), 2005					
	Panel A: Based on localities with a minimum population of 20,000			Panel B: Based on localities with a minimum population of 50,000		
	(1)	(2)	(3)	(1)	(2)	(3)
At least a 1850 city	0.080***	0.064**	0.003	0.138***	0.106**	0.030
	(0.030)	(0.032)	(0.031)	(0.049)	(0.050)	(0.046)
Urban pop. den. 1850	0.345***	0.280***	0.211***	0.306***	0.239***	0.182**
	(0.068)	(0.061)	(0.060)	(0.079)	(0.072)	(0.073)
Squ. urban pop. den. 1850	-0.023***	-0.019***	-0.015***	-0.020***	-0.015***	-0.013**
	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)	(0.005)
At least a 1850 neib. city	0.006	0.003	0.004	0.013	-0.021	-0.008
	(0.026)	(0.026)	(0.025)	(0.051)	(0.037)	(0.034)
Neib. urban pop. den. 1850	0.118*	0.083	0.091	0.032	0.023	0.023
	(0.060)	(0.066)	(0.063)	(0.048)	(0.056)	(0.054)
Squ. neib. urban pop. den. 1850	-0.010*	-0.007	-0.007	-0.002	-0.002	-0.002
	(0.005)	(0.006)	(0.005)	(0.004)	(0.004)	(0.004)
Biggest city in 1850 within countries			0.281***			0.293***
			(0.058)			(0.055)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	92	92	92	92	92	92
Observations	1395	1395	1395	1395	1395	1395
within R^2	0.08	0.20	0.23	0.06	0.19	0.22

	Panel C: Based on localities with a minimum population of 100,000		
	(1)	(2)	(3)
At least a 1850 city	0.128**	0.097	0.020
	(0.063)	(0.074)	(0.077)
Urban pop. den. 1850	0.246***	0.189**	0.120
	(0.080)	(0.079)	(0.082)
Squ. urban pop. den. 1850	-0.016***	-0.013**	-0.009
	(0.006)	(0.006)	(0.006)
At least a 1850 neib. city	0.006	-0.034	-0.015
	(0.067)	(0.063)	(0.060)
Neib. urban pop. den. 1850	0.041	0.022	0.021
	(0.079)	(0.088)	(0.082)
Squ. neib. urban pop. den. 1850	-0.003	-0.002	-0.002
	(0.006)	(0.007)	(0.006)
Biggest city in 1850 within countries			0.326***
			(0.053)
Baseline Controls Included	No	Yes	Yes
Countries	92	92	92
Observations	1395	1395	1395
within R^2	0.04	0.17	0.21

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Robustness to Country Groups Based on Continent, Regressions of Log Regional Income per Capita in 2005 on Urbanization in 1850

	Dependent Variable: Log of Regional Income per Capita (PPP), 2005					
	Panel A: Africa			Panel B: Africa using average luminosity		
	(1)	(2)	(3)	(1)	(2)	(3)
At least a 1850 city	0.022	0.029	-0.243	0.987**	0.555*	-0.253
	(0.166)	(0.168)	(0.226)	(0.425)	(0.300)	(0.399)
Urban pop. den. 1850	3.882	-1.760	1.003	1.338**	0.813**	0.501
	(5.537)	(5.047)	(4.725)	(0.489)	(0.367)	(0.346)
Squ. urban pop. den. 1850	-5.446	7.212	-5.466	-0.095**	-0.059*	-0.039
	(17.525)	(15.953)	(15.127)	(0.039)	(0.030)	(0.028)
At least a 1850 neib. city	-0.119	-0.085	-0.147	0.856**	0.047	0.030
	(0.098)	(0.116)	(0.128)	(0.342)	(0.235)	(0.238)
Neib. urban pop. den. 1850	0.542	-2.240	-1.623	0.617	0.322	0.304
	(2.023)	(2.542)	(2.405)	(0.610)	(0.661)	(0.650)
Squ. neib. urban pop. den. 1850	-0.059	0.500	0.376	0.052	0.035	0.043
	(0.413)	(0.519)	(0.491)	(0.138)	(0.123)	(0.121)
Biggest city in 1850 within countries			0.412			1.554***
			(0.256)			(0.546)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	13	13	13	28	28	28
Observations	123	123	123	357	357	357
within R^2	0.06	0.35	0.39	0.11	0.44	0.47
between R^2	0.13	0.50	0.37	0.50	0.02	0.00
	Panel C: West Europe			Panel D: Rest Europe		
	(1)	(2)	(3)	(1)	(2)	(3)
At least a 1850 city	0.084*	0.096*	0.091**	0.147***	0.174**	0.133*
	(0.047)	(0.049)	(0.040)	(0.043)	(0.063)	(0.066)
Urban pop. den. 1850	0.113***	0.131***	0.071**	0.844*	0.790	0.311
	(0.035)	(0.035)	(0.028)	(0.449)	(0.491)	(0.582)
Squ. urban pop. den. 1850	-0.006**	-0.007**	-0.004**	-0.169	-0.154	-0.020
	(0.003)	(0.003)	(0.002)	(0.138)	(0.156)	(0.179)
At least a 1850 neib. city	-0.007	-0.033	-0.055	-0.285*	-0.154**	-0.151**
	(0.025)	(0.034)	(0.032)	(0.150)	(0.072)	(0.064)
Neib. urban pop. den. 1850	0.046***	0.055***	0.073***	0.921	0.288	0.448
	(0.015)	(0.017)	(0.018)	(0.626)	(0.440)	(0.390)
Squ. neib. urban pop. den. 1850	-0.001***	-0.002***	-0.002***	-1.107	-0.302	-0.455
	(0.000)	(0.000)	(0.001)	(0.741)	(0.482)	(0.455)
Biggest city in 1850 within countries			0.226**			0.349**
			(0.103)			(0.147)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	16	16	16	18	18	18
Observations	214	214	214	290	290	290
within R^2	0.26	0.32	0.37	0.18	0.49	0.52
between R^2	0.01	0.02	0.10	0.04	0.01	0.01

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Table 8 – Continued

	Panel E: The Americas			Panel F: The Americas no US & Canada		
	(1)	(2)	(3)	(1)	(2)	(3)
At least a 1850 city	0.037	0.048	0.021	0.046	0.045	0.009
	(0.046)	(0.047)	(0.052)	(0.059)	(0.065)	(0.070)
Urban pop. den. 1850	0.781***	0.710***	0.528**	0.850***	0.756**	0.440
	(0.182)	(0.239)	(0.217)	(0.257)	(0.323)	(0.308)
Squ. urban pop. den. 1850	-0.103**	-0.090	-0.057	-0.116*	-0.097	-0.041
	(0.042)	(0.054)	(0.049)	(0.055)	(0.068)	(0.064)
At least a 1850 neib. city	-0.081	-0.047	-0.051	-0.087	-0.058	-0.062
	(0.058)	(0.055)	(0.053)	(0.069)	(0.066)	(0.063)
Neib. urban pop. den. 1850	0.565*	0.399	0.407*	0.446	0.324	0.378
	(0.296)	(0.234)	(0.231)	(0.449)	(0.369)	(0.391)
Squ. neib. urban pop. den. 1850	-0.094	-0.059	-0.060	-0.067	-0.041	-0.052
	(0.067)	(0.053)	(0.053)	(0.102)	(0.084)	(0.089)
Biggest city in 1850 within countries			0.227**			0.280**
			(0.094)			(0.119)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	20	20	20	18	18	18
Observations	387	387	387	324	324	324
within R^2	0.12	0.31	0.32	0.10	0.30	0.32
between R^2	0.03	0.50	0.47	0.05	0.22	0.20

	Panel G: Asia		
	(1)	(2)	(3)
At least a 1850 city	0.035	0.043	-0.004
	(0.047)	(0.049)	(0.042)
Urban pop. den. 1850	0.481***	0.420***	0.332**
	(0.142)	(0.119)	(0.148)
Squ. urban pop. den. 1850	-0.037***	-0.033***	-0.027**
	(0.012)	(0.010)	(0.012)
At least a 1850 neib. city	0.080	0.071	0.077
	(0.054)	(0.055)	(0.054)
Neib. urban pop. den. 1850	0.159	0.124	0.124
	(0.179)	(0.208)	(0.201)
Squ. neib. urban pop. den. 1850	-0.012	-0.010	-0.010
	(0.014)	(0.016)	(0.016)
Biggest city in 1850 within countries			0.242*
			(0.120)
Baseline Controls Included	No	Yes	Yes
Countries	24	24	24
Observations	373	373	373
within R^2	0.12	0.22	0.24
between R^2	0.21	0.46	0.45

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Evidence in Subsample: Non African Countries, and US & Canada

	Dependent Variable: Log of Regional Income per Capita (PPP), 2005						
	Panel A: Excluding Africa			Panel B: US and Canada excluding			
	(1)	(2)	(3)	(1)	(2)	(3)	(4)
At least a 1850 city	0.069**	0.072**	0.030	0.076*	0.053	0.070	0.051
	(0.028)	(0.030)	(0.029)	(0.008)	(0.019)	(0.019)	(0.027)
Urban pop. den. 1850	0.337***	0.268***	0.187***	0.199	-0.075	0.906	-0.126
	(0.065)	(0.056)	(0.057)	(0.350)	(0.132)	(1.889)	(0.703)
Squ. urban pop. den. 1850	-0.023***	-0.018***	-0.014***			-2.073	-0.284
	(0.006)	(0.005)	(0.005)			(4.590)	(3.138)
At least a 1850 city nearby	-0.043	-0.026	-0.025		0.053		0.047
	(0.048)	(0.034)	(0.033)		(0.053)		(0.029)
Neib. urban pop. den. 1850	0.049*	0.035	0.047*		0.474**		0.832
	(0.028)	(0.029)	(0.028)		(0.022)		(1.250)
Squ. neib. urban pop. den. 1850	-0.002*	-0.001	-0.001*				-0.421
	(0.001)	(0.001)	(0.001)				(1.452)
Biggest city in 1850 within countries			0.280***				
			(0.061)				
Baseline Controls Included	No	Yes	Yes	Yes	Yes	Yes	Yes
Countries	79	79	79	2	2	2	2
Observations	1272	1272	1272	62	62	62	62
within R^2	0.09	0.21	0.24	0.38	0.46	0.38	0.46
between R^2	0.18	0.47	0.45	1.00	1.00	1.00	1.00

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. All estimates include country fixed effects. For the US and Canada in Panel B, District of Colombia is excluded. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 10: Impact of Urbanization in 1850 on Contemporary Education, Culture, Institution, and Infrastructure

	Dependent Variable:						
	Years of Education in 2000	Trust in others	Informal Payments	Access to Financing	Ln Days of no electricity	Ln power line density	Ln travel time
	Panel A: Without baseline controls						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
At least a 1850 city	0.273***	0.006	0.105	0.044*	0.270**	0.243***	-0.367***
	(0.080)	(0.010)	(0.141)	(0.024)	(0.105)	(0.045)	(0.069)
Urban pop. den. 1850	0.600***	-0.018	0.132	-0.014	-0.028	0.193	-0.819***
	(0.141)	(0.012)	(0.101)	(0.017)	(0.088)	(0.135)	(0.131)
Squ. urban pop. den. 1850	-0.042***	0.001*	-0.003	0.001	-0.002	-0.025*	0.055***
	(0.013)	(0.001)	(0.008)	(0.001)	(0.007)	(0.014)	(0.014)
At least a 1850 neib. city	-0.041	-0.017**	0.116	-0.023	-0.055	0.294***	-0.373***
	(0.057)	(0.008)	(0.110)	(0.023)	(0.117)	(0.053)	(0.064)
Neib. urban pop. den. 1850	0.267**	-0.001	-1.117**	0.254**	-0.008	0.088	-0.248**
	(0.122)	(0.008)	(0.452)	(0.113)	(0.413)	(0.106)	(0.094)
Squ. neib. urban pop. den. 1850	-0.009**	-0.000	0.239**	-0.051**	-0.010	-0.001	0.007**
	(0.004)	(0.000)	(0.100)	(0.024)	(0.091)	(0.003)	(0.003)
Countries	90	61	65	68	64	92	92
Observations	1358	665	331	372	203	1395	1395
within R^2	0.10	0.01	0.02	0.04	0.04	0.10	0.29
between R^2	0.21	0.01	0.07	0.00	0.00	0.40	0.58
	Panel B: With baseline controls and regional population						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
At least a 1850 city	0.122*	0.009	0.124	0.037	0.309**	0.159***	-0.234***
	(0.070)	(0.011)	(0.153)	(0.028)	(0.131)	(0.040)	(0.056)
Urban pop. den. 1850	0.284**	-0.020	0.077	-0.015	-0.064	0.088	-0.666***
	(0.129)	(0.014)	(0.125)	(0.020)	(0.123)	(0.139)	(0.141)
Squ. urban pop. den. 1850	-0.024**	0.001*	0.002	0.001	-0.000	-0.018	0.045***
	(0.010)	(0.001)	(0.010)	(0.002)	(0.010)	(0.013)	(0.013)
At least a 1850 neib. city	-0.031	-0.016*	0.083	-0.030	-0.139	0.232***	-0.257***
	(0.052)	(0.008)	(0.107)	(0.024)	(0.144)	(0.053)	(0.046)
Neib. urban pop. den. 1850	0.275**	-0.003	-1.214**	0.259**	-0.155	0.083	-0.215**
	(0.109)	(0.009)	(0.501)	(0.098)	(0.385)	(0.103)	(0.097)
Squ. neib. urban pop. den. 1850	-0.010***	-0.000	0.265**	-0.051**	0.028	-0.000	0.006**
	(0.003)	(0.000)	(0.110)	(0.021)	(0.086)	(0.003)	(0.003)
Biggest city in 1850 within countries	0.817***	-0.006	0.000	0.017	0.010	0.171*	-0.119
	(0.120)	(0.012)	(0.093)	(0.020)	(0.097)	(0.096)	(0.088)
Countries	90	61	65	68	64	92	92
Observations	1358	665	331	372	203	1395	1395
within R^2	0.21	0.02	0.05	0.06	0.14	0.15	0.44
between R^2	0.52	0.01	0.14	0.03	0.12	0.52	0.40

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. Baseline controls are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 11: Persistence with Colonized Countries, Regressions of Log Income per Capita in 2005 on Urbanization in 1850

	Dependent Variable: Log of Regional Income per Capita (PPP), 2005					
	Colonized countries					
	Panel A: Fixed-effects			Panel B: Control for 1500 population density		
	(1)	(2)	(3)	(1)	(2)	(3)
At least a 1850 city	0.032	0.021	-0.030	0.040	0.028	-0.019
	(0.037)	(0.033)	(0.038)	(0.037)	(0.034)	(0.038)
Urban pop. den. 1850	0.805***	0.625***	0.512**	0.810***	0.634***	0.528***
	(0.172)	(0.178)	(0.195)	(0.171)	(0.177)	(0.192)
Squ. urban pop. den. 1850	-0.116***	-0.088**	-0.070	-0.118***	-0.091**	-0.074*
	(0.040)	(0.042)	(0.043)	(0.040)	(0.042)	(0.043)
At least a 1850 neib. city	-0.048	-0.036	-0.040	-0.041	-0.028	-0.031
	(0.044)	(0.042)	(0.042)	(0.044)	(0.041)	(0.041)
Neib. urban pop. den. 1850	0.533***	0.383**	0.374**	0.543***	0.392**	0.383**
	(0.126)	(0.169)	(0.156)	(0.125)	(0.173)	(0.161)
Squ. neib. urban pop. den. 1850	-0.070**	-0.042	-0.040	-0.072**	-0.045	-0.042
	(0.030)	(0.037)	(0.035)	(0.030)	(0.038)	(0.035)
Biggest city in 1850 within countries			0.244***			0.228***
			(0.078)			(0.076)
log population density 1500 (baseline)				-0.368***	-0.296***	-0.299***
				(0.090)	(0.072)	(0.072)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	43	43	43	43	43	43
Observations	658	658	658	658	658	658
within R^2	0.11	0.20	0.22	0.11	0.20	0.22
between R^2	0.02	0.39	0.35	0.32	0.46	0.45

	Panel C: Non colonized countries		
	(1)	(2)	(3)
At least a 1850 city	0.103**	0.127***	0.081**
	(0.039)	(0.043)	(0.039)
Urban pop. den. 1850	0.258***	0.205***	0.117**
	(0.063)	(0.055)	(0.058)
Squ. urban pop. den. 1850	-0.017***	-0.013***	-0.008*
	(0.005)	(0.005)	(0.004)
At least a 1850 neib. city	-0.077	-0.070*	-0.062
	(0.081)	(0.041)	(0.041)
Neib. urban pop. den. 1850	0.025**	0.020	0.036**
	(0.012)	(0.013)	(0.017)
Squ. neib. urban pop. den. 1850	-0.001**	-0.001*	-0.001**
	(0.000)	(0.000)	(0.000)
Biggest city in 1850 within countries			0.303***
			(0.083)
Baseline Controls Included	No	Yes	Yes
Countries	49	49	49
Observations	737	737	737
within R^2	0.11	0.32	0.35
between R^2	0.14	0.46	0.44

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. Fixed-effects estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 12: Persistence with Colonized Countries, Regressions of Urban Population Density in 1850 on Urbanization in 1500

	Dependent Variable: Urban Population Density in 1850					
	Panel A: Colonized countries				Panel B: Non colonized countries	
	Fixed-effects		Random-effects			
	(1)	(2)	(3)	(4)	(1)	(2)
At least a 1500 city	96.539	84.061	105.564*	94.282*	84.771***	80.317***
	(64.204)	(55.888)	(62.918)	(55.238)	(24.686)	(24.956)
Urban pop. den. 1500	-73.672	-77.246	-55.838	-70.910	858.119**	830.115**
	(305.957)	(327.503)	(315.405)	(323.880)	(329.808)	(325.682)
Squ. urban pop. den. 1500	33.108	36.271	23.622	28.736	-349.755**	-339.341**
	(113.126)	(123.198)	(116.931)	(121.757)	(138.496)	(135.946)
At least a 1850 neib. city	72.467	66.114	65.137	59.038	22.177	15.977
	(62.095)	(50.217)	(53.979)	(46.693)	(20.466)	(17.132)
Neib. urban pop. den. 1500	-366.713	-348.027	-414.339	-405.785	1.439	1.200
	(312.695)	(255.514)	(330.433)	(291.503)	(1.793)	(1.759)
Squ. neib. urban pop. den. 1500	285.567	271.904	323.374	315.101	-0.016	-0.013
	(235.102)	(198.234)	(253.964)	(226.030)	(0.021)	(0.020)
log population density 1500 (baseline)			-2.225	2.877		
			(7.923)	(9.935)		
Baseline Controls Included	No	Yes	No	Yes	No	Yes
Countries	30	30	30	30	46	46
Observations	598	598	598	598	710	710
within R^2	0.10	0.16	0.10	0.14	0.16	0.18
between R^2	0.33	0.19	0.36	0.36	0.19	0.15

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. Fixed-effects estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

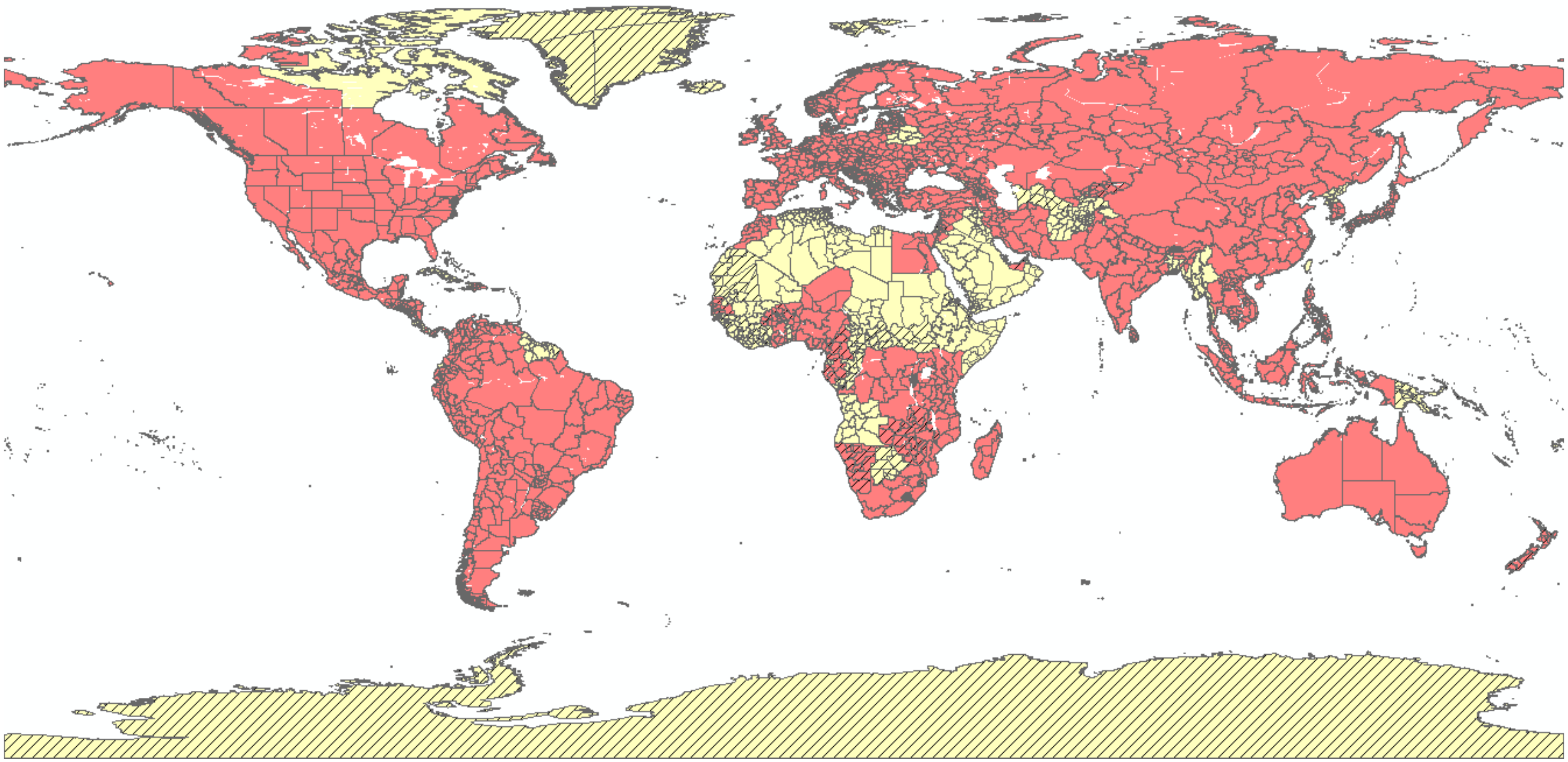
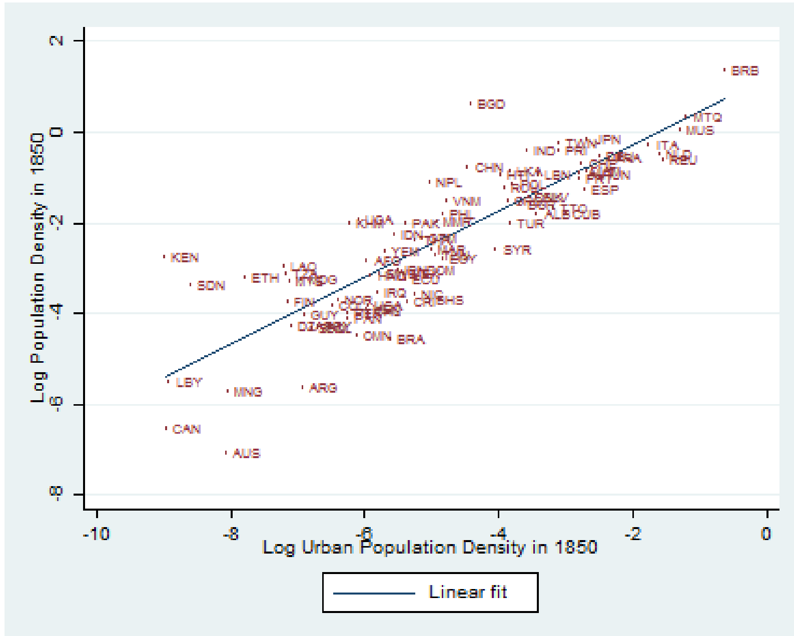
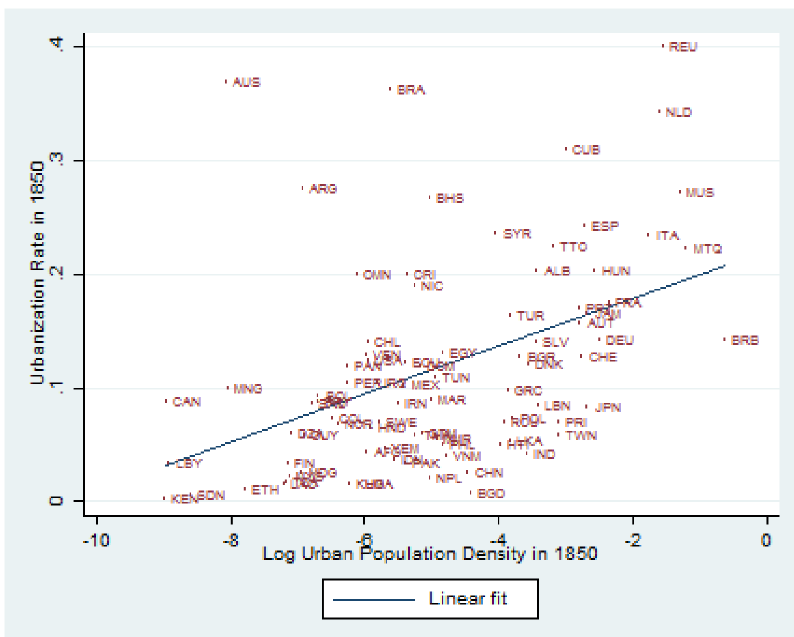


Figure 1: Subdivisions across The World

Note: Shaded areas present regions whose income per capita in 2005 is available. Simple hatched areas consist of countries that do not appear in our data for cities in 1850.



(a) Log Pop. Density & Log Urb. Pop. Density, in 1850



(b) Urbanization Rate & Log Urb. Pop. Density, in 1850

Figure 2: Log Urban Population Density, Urbanization Rate, and Log Population Density

Note: A country's urban population in 1850 is the total population living in cities of the country. City in 1850 is defined with a minimum population threshold of 5,000. Data of total population in 1850 at the country level are collected from McEvedy and Jones (1978). Unit of population density and urban population density is 100 persons per square kilometer.

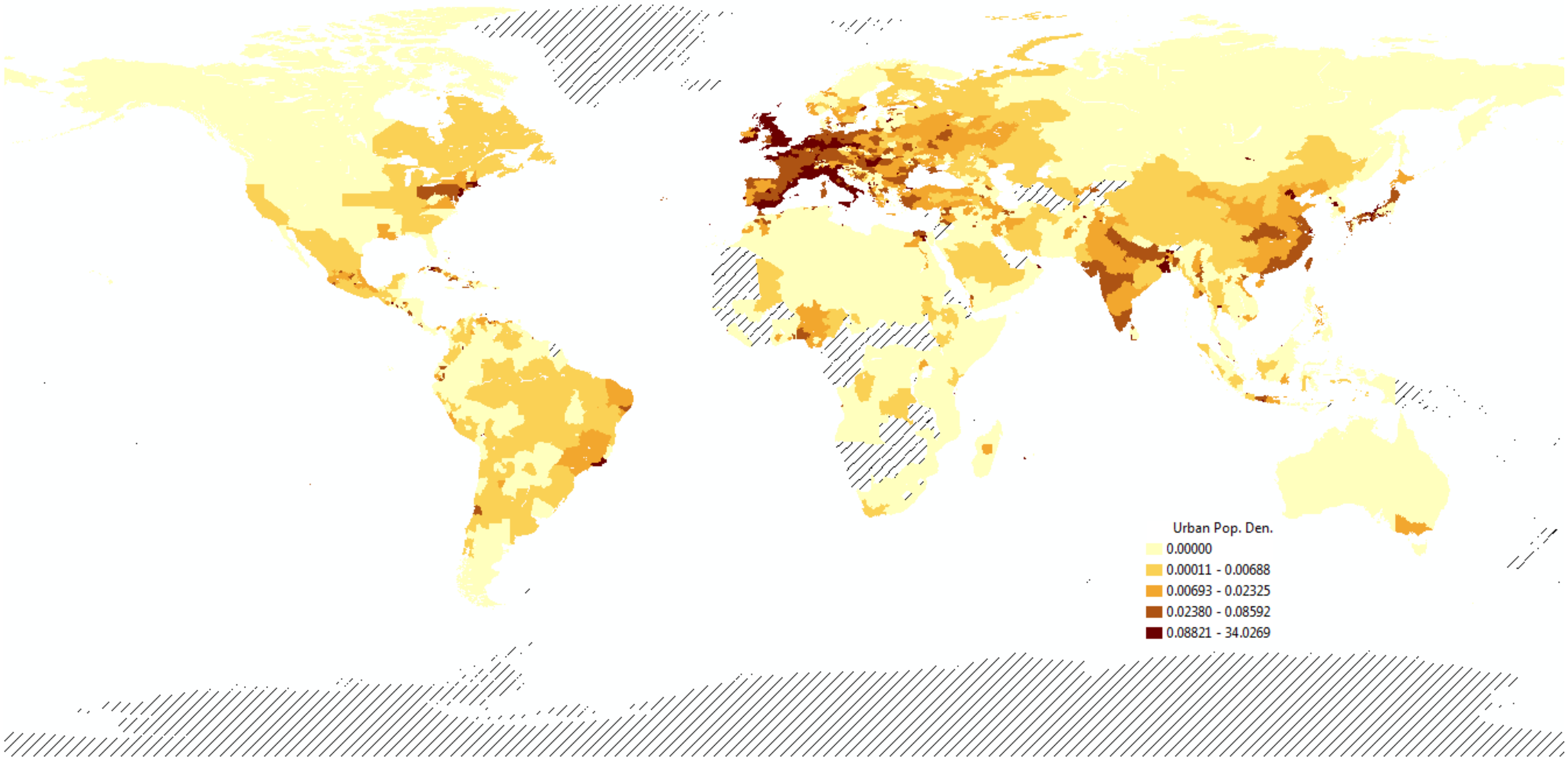


Figure 3: Distribution of Urban Population in 1850

Note: Simple hatched areas consist of countries that do not appear in our data for cities in 1850. Shaded areas consist of regions with urban population in 1850, and the darker regions is more densely populated in 1850. Unit of urban population density is 100 persons per square kilometer.

A Appendix Tables

Table A.1: Number of Regions by Country

Code	Country	Sample Regions	No. of Regions year 1850 localities inhabitants over (5,000)	Population in 1,000 year 1850 localities inhabitants over (5,000)	No. of Regions year 1850 localities inhabitants over (20,000)	(50,000)	(100,000)
CHN	China	32	31	11243	31	24	15
GBR	United Kingdom	12	12	8674	12	12	6
IND	India	35	22	7909	16	13	10
FRA	France	22	22	6314	22	12	5
ITA	Italy	20	20	5848	13	10	8
DEU	Germany	16	16	3840	15	8	3
ESP	Spain	19	16	3633	13	5	3
USA	United States	51	26	2981	25	9	6
JPN	Japan	47	32	2670	32	10	4
BRA	Brazil	27	19	2628	15	3	3
RUS	Russia	80	47	2537	22	5	2
TUR	Turkey	12	12	1807	12	4	2
BEL	Belgium	11	11	1264	8	6	2
NGA	Nigeria	7	5	1188	5	3	0
UKR	Ukraine	27	22	1064	11	3	0
NLD	Netherlands	14	12	1029	8	2	2
POL	Poland	16	16	945	9	3	2
HUN	Hungary	7	7	867	3	1	1
MEX	Mexico	32	27	795	14	3	1
EGY	Egypt	4	3	715	3	1	1
IRN	Iran	30	15	642	14	4	0
AUT	Austria	9	9	630	3	2	1
IDN	Indonesia	33	12	601	8	3	1
PRT	Portugal	7	7	594	3	2	1
IRL	Ireland	2	2	565	1	1	1
ROU	Romania	8	8	564	8	2	0
CUB	Cuba	15	10	496	7	2	1
MMR	Myanmar	14	7	436	5	3	1
PAK	Pakistan	8	4	375	3	2	0
SYR	Syria	14	4	330	4	2	1
BGR	Bulgaria	6	6	318	6	0	0
CHE	Switzerland	26	14	318	4	0	0
GRC	Greece	14	9	295	3	1	0
ARG	Argentina	24	13	276	3	1	0
MAR	Morocco	15	5	270	5	3	0
UZB	Uzbekistan	5	5	247	5	3	0
SWE	Sweden	8	6	246	2	1	0
KOR	South Korea	7	2	241	2	1	1
VNM	Vietnam	8	3	240	3	3	0
THA	Thailand	7	3	234	3	1	1
AUS	Australia	11	1	222	1	1	1
CAN	Canada	13	5	221	5	0	0
CZE	Czech Republic	8	5	221	2	1	1
CHL	Chile	13	8	210	2	1	0
PER	Peru	25	10	207	4	1	0
PHL	Philippines	17	4	200	2	1	1
SAU	Saudi Arabia	13	6	193	5	0	0
VEN	Venezuela	24	12	193	4	0	0
DNK	Denmark	14	5	180	1	1	1
DZA	Algeria	48	7	179	3	1	0
SRB	Serbia	19	3	170	1	0	0
AFG	Afghanistan	32	5	164	4	1	0
SVK	Slovakia	8	7	154	1	0	0
BGD	Bangladesh	6	3	153	3	1	0
BLR	Belarus	6	6	146	2	0	0
COL	Colombia	33	13	145	1	0	0
TWN	Taiwan	4	2	145	2	1	0
IRQ	Iraq	18	4	130	3	1	0
YEM	Yemen	21	4	130	4	0	0
LKA	Sri Lanka	9	3	120	3	1	0
BOL	Bolivia	9	6	116	3	0	0
TUN	Tunisia	24	1	110	1	1	1
NOR	Norway	19	7	103	2	0	0
ALB	Albania	12	8	102	2	0	0
ECU	Ecuador	22	4	97	3	0	0
LVA	Latvia	26	3	94	2	1	0

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Table A.1 – Continued

NPL	Nepal	5	1	90	1	0	0
MDA	Moldova	5	3	86	1	1	0
BIH	Bosnia - Herzegovina	3	2	85	1	1	0
MLI	Mali	9	3	84	2	0	0
LTU	Lithuania	10	2	71	1	1	0
JAM	Jamaica	14	1	66	1	0	0
NER	Niger	8	2	66	2	0	0
PRK	North Korea	14	1	62	1	1	0
COD	Dem. Rep. Congo	11	2	60	2	0	0
MNG	Mongolia	22	1	60	1	0	0
OMN	Oman	8	1	60	1	1	0
TZA	Tanzania	26	1	60	1	1	0
NIC	Nicaragua	18	3	57	1	0	0
HRV	Croatia	20	5	56	0	0	0
SLV	El Salvador	14	3	56	1	0	0
GTM	Guatemala	8	3	54	1	0	0
FIN	Finland	5	3	50	1	0	0
MDG	Madagascar	6	1	50	1	1	0
MUS	Mauritius	12	1	49	1	0	0
REU	Reunion	4	3	48	0	0	0
HTI	Haiti	10	4	45	1	0	0
UGA	Uganda	6	1	45	1	0	0
PRY	Paraguay	18	1	44	1	0	0
GEO	Georgia	12	2	42	1	0	0
EST	Estonia	16	3	40	1	0	0
ETH	Ethiopia	11	2	39	1	0	0
AZE	Azerbaijan	11	2	36	1	0	0
BRN	Brunei	4	1	36	1	0	0
PRI	Puerto Rico	79	2	35	1	0	0
LBN	Lebanon	6	2	34	1	0	0
BEN	Benin	12	2	33	0	0	0
ARM	Armenia	12	1	30	1	0	0
KHM	Cambodia	15	1	30	1	0	0
KWT	Kuwait	5	1	30	1	0	0
MAC	Macao	1	1	29	1	0	0
MTQ	Martinique	4	2	29	1	0	0
SDN	Sudan	6	2	29	1	0	0
HND	Honduras	18	2	26	0	0	0
MKD	Macedonia	8	2	26	1	0	0
ZAF	South Africa	10	1	26	1	0	0
DOM	Dominican Republic	9	2	24	0	0	0
SVN	Slovenia	12	2	24	0	0	0
LUX	Luxembourg	3	1	22	1	0	0
MYS	Malaysia	13	2	22	0	0	0
BRB	Barbados	11	1	20	1	0	0
TCD	Chad	18	1	20	1	0	0
CRI	Costa Rica	7	1	20	1	0	0
LBY	Libya	32	1	20	1	0	0
SUR	Suriname	10	1	20	1	0	0
KO-	Kosovo	7	1	19	0	0	0
GHA	Ghana	10	1	18	0	0	0
TTO	Trinidad - Tobago	14	1	18	0	0	0
GUY	Guyana	10	1	17	0	0	0
LAO	Laos	18	1	15	0	0	0
AGO	Angola	18	1	14	0	0	0
PAN	Panama	12	1	12	0	0	0
SLE	Sierra Leone	4	1	11	0	0	0
KAZ	Kazakhstan	6	1	10	0	0	0
BHS	Bahamas	32	1	8	0	0	0
SMR	San Marino	9	1	7	0	0	0
KEN	Kenya	8	1	6	0	0	0
TGO	Togo	5	1	6	0	0	0
BHR	Bahrain	5	1	5	0	0	0
BLZ	Belize	6	0	0	0	0	0
GMB	Gambia	6	0	0	0	0	0
LBR	Liberia	15	0	0	0	0	0
MNE	Montenegro	21	0	0	0	0	0
MOZ	Mozambique	10	0	0	0	0	0
SOM	Somalia	18	0	0	0	0	0
URY	Uruguay	19	0	0	0	0	0
Africa (28 countries):		363	49	3149	32	11	2
Americas (31 countries):		601	183	8921	97	20	11
Asia (36 countries):		528	205	28878	178	81	37
Europe (39 countries):		555	334	41352	187	83	39

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Table A.1 – Continued

Oceania (1 country):	11	1	222	1	1	1
World Total (135 countries):	2058	772	82523	495	196	90

Note: The 3rd column shows the total number of regions included in each country. The 4th and 5th columns are the number of regions that had settlements in 1850 and total population across these settlements, respectively, focusing on settlements with population higher than 5,000. The rest of columns display the number of settlements based on a minimum population of 20,000, 50,000, and 100,000, respectively. The last several rows show the information at the continent level. Countries are sorted according to the year 1850 population in settlements with population greater than 5,000.

Table A.2: Variables, Descriptions, and Sources

Variable	Description	Sources
	Outcome Variables:	
GDP per capita	Regional income per capita in PPP constant 2005 international dollars in 2005.	Gennaioli et al. (2013).
Ln(ave. light den., averaged across 2001-05)	The logarithm of average nighttime light intensity yearly averaged through 2001 to 2005. To produce the regional numbers, we load the night lights data in 5 years from 2001 to 2005 and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We take the ratio of total light intensity in each region to the land area of the region.	National Geophysical Data Center (NOAA). GADM database of Global Administrative Areas.
Urban pop. den. in 2000	Regional population density in the urban areas in 2000 in 100 persons per square kilometer. To produce the numbers, we load global settlement points grid and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We take the ratio of total population living in the urban within a region to the land area of the region.	Center for International Earth Science Information Network (CIESIN). GADM database of Global Administrative Areas.
Trust in others	Percent of respondents who think most people can be trusted.	Gennaioli et al. (2013).
Informal payments	Percent of sales goes as informal payments to public officials for activities such as customs, taxes, licenses, etc, averaged across all respondents within regions.	Gennaioli et al. (2013).
Access to Financing	Percent of respondents think that access to financing is at least a moderate obstacle to business.	Gennaioli et al. (2013).
Ln(days without electricity)	The logarithm of 1 plus the regional average of days with no electricity in the past year reported by respondents.	Gennaioli et al. (2013).
Ln(power line density)	The logarithm of 1 plus the length in kilometers of power lines per 10 square kilometers in 2007.	Gennaioli et al. (2013).
Ln(travel time)	The logarithm of the regional average of estimated travel time in minutes to the neatest city with population greater than 50,000 in 2000.	Gennaioli et al. (2013).
	Variable of interest:	
A 1850 city in region	A dummy indicating regions in which at least a locality with population greater than 5,000 existed in 1850. To generate this variable, we load coordinates of the localities in 1850 and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We code 1 for regions contain at least one of these coordinates; 0, otherwise.	Chandler (1987), Bairoch (1988), Eggimann (1994), and Rozenblat. GADM database of Global Administrative Areas.

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A 1850 city neighboring in region	A dummy identifying one or more year 1850 cities existed within 25 miles geodesic distance away from the regions. To generate this variable, we load coordinates of the localities in 1850 and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We code 1 for regions if outside the regions within 25 miles away from the regions' boundaries there exists at least one of these coordinates; 0, otherwise.	Chandler (1987), Bairoch (1988), Eggimann (1994), and Rozenblat. GADM database of Global Administrative Areas.
Urban pop. den. in 1850	Regional population density in the urban areas in 1850 in 100 urban inhabitants per square kilometer. To generate this variable, we load localities in 1850 with population greater than 5,000 and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We take ratio of the total population in cities within regions to the land area of the regions.	Chandler (1987), Bairoch (1988), Eggimann (1994), and Rozenblat. GADM database of Global Administrative Areas.
Neighboring urban pop. den. in 1850	100 surrounding urban inhabitants per square kilometer of the region. To generate this variable, we load localities in 1850 with population greater than 5,000 and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We take ratio of the total population in cities within 25 miles away from regions' boundaries to the land area of the regions.	Chandler (1987), Bairoch (1988), Eggimann (1994), and Rozenblat. GADM database of Global Administrative Areas.
	Baseline regional controls:	
Temperature	Average temperature during 1950 - 2000 in Celsius. To produce the regional numbers, we load the global temperature grid and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We take average of the temperature within regions.	Global Climate Data (WorldClim). GADM database of Global Administrative Areas.
Land suitability	An index of the suitability for agriculture based on temperature and soil quality measurements. To produce the regional numbers, we load the world suitability for agriculture grid and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We take average of the index within regions.	Global Climate Data (WorldClim). GADM database of Global Administrative Areas.
Altitude	Average altitude in regions in 100 meters. To produce the regional numbers, we load the global altitude grid and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We take average of the value within regions.	Global Climate Data (WorldClim). GADM database of Global Administrative Areas.
Ruggedness	Average terrain ruggedness in regions in 100 meters. To produce the regional numbers, we load the global terrain ruggedness index grid and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We take average of the value within regions.	Nunn and Puga (2012). GADM database of Global Administrative Areas.
Rainfall	Average precipitation in regions during 1950 - 2000 in meter. To produce the regional numbers, we load the global precipitation grid and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We take average of the value within regions.	Global Climate Data (WorldClim). GADM database of Global Administrative Areas.
Absolute value of latitude	Absolute value of latitude of regional centroid. To produce the regional numbers, we load the worldwide regions' digital map derived from the Database of Global Administrative Areas. We generate regions' median centroid and keep coordinates of them.	GADM database of Global Administrative Areas.
Inverse distance to coast	The reciprocal of 1 plus the distance of regions' centroid to the nearest coastlines in 1,000 kilometers. To produce the numbers, we load the world coastline grid and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We generate regions' median centroid and keep coordinates of them. We calculate the distance of the centroid to nearest coastlines.	National Geophysical Data Center (NOAA). GADM database of Global Administrative Areas.
Inverse distance to river	The reciprocal of 1 plus the distance of regions' centroid to the nearest rivers in 1,000 kilometers. To produce the numbers, we load the world river grid and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We generate regions' median centroid and keep coordinates of them. We calculate the distance of the centroid to nearest rivers.	National Geophysical Data Center (NOAA). GADM database of Global Administrative Areas.
	Other regional controls:	

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Table A.2 – Continued

Inverse distance to capital	The reciprocal of 1 plus the distance of regions' centroid to their own national capitals in 1,000 kilometers. To produce the numbers, we input national capitals' coordinates and make the world capitals grid and load the worldwide regions' digital map derived from the Database of Global Administrative Areas. We generate regions' median centroid and keep coordinates of them. We calculate the distance of the centroid to national capitals.	GADM database of Global Administrative Areas.
Inverse distance to border	The reciprocal of 1 plus the distance of regions' centroid to the nearest national borderlines in 1,000 kilometers. To produce the numbers, we load the world national borderlines grid and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We generate regions' median centroid and keep coordinates of them. We calculate the distance of the centroid to nearest national borderlines.	National Geophysical Data Center (NOAA). GADM database of Global Administrative Areas.
Capital city exists	A dummy indicating regions in which national capitals exist. To produce the numbers, we input national capitals' coordinates and make the world capitals grid and load the worldwide regions' digital map derived from the Database of Global Administrative Areas. We code 1 for regions contain national capitals; 0, otherwise.	GADM database of Global Administrative Areas.
Indicator, largest 1850 city within a country	A dummy indicating regions in which the biggest year 1850 locality (localities if there were several with the same population size) within contemporary national boundaries existed. To generate this variable, we load coordinates of all localities in 1850 and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We look for the localities with the largest population size within each contemporary national boundary and code 1 for regions contain any of these localities; 0, otherwise.	Chandler (1987), Bairoch (1988), Eggimann (1994), and Rozenblat. GADM database of Global Administrative Areas.
Indicator, diamond mine	A dummy equals to one if a diamond mine exists in a region. To produce the numbers, we load diamond mine grid and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We code 1 for regions that intersect with at least a diamond mine.	Peace Research Institute Oslo (PRIO). GADM database of Global Administrative Areas.
Log population	The number of inhabitants in the region in 2000. To produce the numbers, we load global population grid and the worldwide regions' digital map derived from the Database of Global Administrative Areas. We sum population within regions.	Center for International Earth Science Information Network (CIESIN). GADM database of Global Administrative Areas.
Years of Education	Average years of schooling beyond primary school for those who are 15 years old and older.	Gennaioli et al. (2013).
Ln(oil production/capita)	Logarithm of 1 plus the estimated per capita volume of cumulative oil production and reserves in millions of barrels of oil	Gennaioli et al. (2013).

Table A.3: Regressions of Log Regional Income per Capita in 2005 on Urbanization in 1850, For Regions with Positive Urban Population

	Dependent Variable: Log of Regional Income per Capita (PPP), 2005							
	Panel A: Regions with Urbanization				Panel B: Regions without Urbanization			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
At least a 1850 city								
Urban pop. den. 1850	0.100***	0.104***	0.358***	0.367***				
	(0.026)	(0.036)	(0.065)	(0.068)				
Squ. urban pop. den. 1850			-0.023***	-0.024***				
			(0.006)	(0.006)				
At least a 1850 neib. city		0.029		0.049		-0.082		-0.098
		(0.048)		(0.042)		(0.068)		(0.068)

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Table A.3 – Continued

Neib. urban pop. den. 1850		-0.006		0.025		0.017		0.113*
		(0.020)		(0.024)		(0.014)		(0.062)
Squ. neib. urban pop. den. 1850				-0.002				-0.003*
				(0.001)				(0.002)
Countries	88	88	88	88	77	77	77	77
Observations	668	668	668	668	727	727	727	727
within R^2	0.09	0.09	0.17	0.18	0.00	0.01	0.00	0.02
between R^2	0.02	0.04	0.02	0.07	0.01	0.00	0.01	0.00

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. No controls are included. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.4: Regressions of Log Regional Income per Capita in 2005 on Urbanization in 1850

	Dependent Variable:			
	Ln(GDP per capita, 2005)	Ln(Ave. nighttime luminosity,2001-2005)	Urbanization Rate	Ln(Population) Density in 2000)
	Panel A: Interactions b/w Urban Pop. Den. in 1850 and Biggest City Sizes			
	(1)	(2)	(3)	(4)
At least a 1850 city	0.061**	0.729***	0.100***	0.665***
	(0.030)	(0.096)	(0.018)	(0.090)
Regions within which population in biggest city in 1850 > 100,000, 90 regions				
Urban pop. den. in 1850	0.215***	0.760***	0.140***	1.312***
	(0.059)	(0.144)	(0.019)	(0.173)
Squ. urban pop. den. in 1850	-0.013***	-0.048***	-0.008***	-0.078***
	(0.004)	(0.011)	(0.002)	(0.014)
Regions within which population in biggest city in 1850 was between 50,000 - 100,000, 105 regions				
Urban pop. den. in 1850	0.782***	2.351***	0.544***	2.672***
	(0.257)	(0.377)	(0.061)	(0.573)
Squ. urban pop. den. in 1850	-0.117**	-0.362***	-0.142***	-0.323***
	(0.056)	(0.082)	(0.014)	(0.123)
Regions within which population in biggest city in 1850 was between 20,000 - 50,000, 296 regions				
Urban pop. den. in 1850	0.422***	1.078***	0.217***	1.390***
	(0.068)	(0.327)	(0.058)	(0.427)
Squ. urban pop. den. in 1850	-0.035***	-0.091***	-0.016***	-0.103***
	(0.006)	(0.028)	(0.005)	(0.037)
Regions within which population in biggest city in 1850 was between 5,000 - 20,000, 275 regions				
Urban pop. den. in 1850	0.212	0.022	-0.029	0.058
	(0.470)	(0.097)	(0.030)	(0.141)
Squ. urban pop. den. in 1850	0.049	-0.000	0.000	-0.001
	(0.319)	(0.003)	(0.001)	(0.004)
At least a 1850 neib. city	-0.041	0.472***	-0.020	0.483***
	(0.031)	(0.081)	(0.013)	(0.074)
Neib. urban pop. den. 1850	0.057*	0.031**	-0.001	0.048**
	(0.029)	(0.015)	(0.006)	(0.023)
Squ. neib. urban pop. den. 1850	-0.002*	-0.000**	-0.000	-0.000**
	(0.001)	(0.000)	(0.000)	(0.000)
Countries	92	135	135	135
Observations	1395	2044	2050	2058
within R^2	0.21	0.27	0.17	0.36
between R^2	0.55	0.32	0.34	0.35

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Table A.4 – Continued

	Dependent Variable:			
	Ln(GDP per capita, 2005)	Ln(Ave. nighttime luminosity,2001-2005)	Urbanization Rate	Ln(Population) Density in 2000)
	Panel B: Interactions b/w Urban Pop. Den. in 1850 and Quintiles of Regions for Urban Population in 1850			
	(1)	(2)	(3)	(4)
At least a 1850 city	0.046	0.724***	0.098***	0.635***
	(0.030)	(0.096)	(0.018)	(0.089)
Quintile with Largest Urban Population in 1850				
Urban pop. den. in 1850	0.237***	0.818***	0.145***	1.415***
	(0.065)	(0.165)	(0.024)	(0.191)
Squ. urban pop. den. in 1850	-0.015***	-0.053***	-0.009***	-0.085***
	(0.005)	(0.013)	(0.002)	(0.016)
The 2nd Largest Quintile				
Urban pop. den. in 1850	0.718***	1.151***	0.138	1.746***
	(0.250)	(0.203)	(0.086)	(0.268)
Squ. urban pop. den. in 1850	-0.109*	-0.092***	-0.010	-0.131***
	(0.059)	(0.017)	(0.007)	(0.022)
The 3rd Quintile				
Urban pop. den. in 1850	0.446***	1.524***	0.326***	2.032***
	(0.114)	(0.532)	(0.075)	(0.529)
Squ. urban pop. den. in 1850	-0.040***	-0.152***	-0.028***	-0.188***
	(0.011)	(0.056)	(0.008)	(0.054)
The 4th Quintile				
Urban pop. den. in 1850	2.225***	0.278*	0.054***	0.600***
	(0.732)	(0.157)	(0.013)	(0.155)
Squ. urban pop. den. in 1850	-0.185***	-0.008*	-0.002***	-0.017***
	(0.062)	(0.005)	(0.000)	(0.005)
Quintile with Smallest Urban Population in 1850				
Urban pop. den. in 1850	0.203	0.664	0.233***	1.192**
	(0.719)	(0.595)	(0.084)	(0.480)
Squ. urban pop. den. in 1850	0.066	-0.050	-0.019***	-0.088**
	(0.488)	(0.042)	(0.006)	(0.034)
At least a 1850 neib. city	-0.033	0.491***	-0.016	0.511***
	(0.033)	(0.083)	(0.013)	(0.075)
Neib. urban pop. den. 1850	0.056	0.031*	-0.002	0.047*
	(0.035)	(0.017)	(0.006)	(0.026)
Squ. neib. urban pop. den. 1850	-0.002	-0.000**	-0.000	-0.000**
	(0.001)	(0.000)	(0.000)	(0.000)
Countries	92	135	135	135
Observations	1395	2044	2050	2058
within R^2	0.22	0.27	0.16	0.37
between R^2	0.55	0.34	0.36	0.38

Note: The unit of observation is a subnational region. Robust standard errors clustered at the country level are shown in parentheses. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.5: Quantile Regressions of Log Income per Capita on Urbanization in 1850

	Dependent: Log of Regional Income per Capita, 2005					
	Panel A: Quantile Regressions, 0.1			Panel B: Quantile Regressions, 0.25		
	(1)	(2)	(3)	(1)	(2)	(3)
At least a 1850 city	0.129***	0.119***	0.085**	0.101***	0.077***	0.053*
	(0.031)	(0.033)	(0.034)	(0.028)	(0.026)	(0.028)
Urban pop. den. 1850	0.123***	0.130***	0.125**	0.272***	0.246***	0.168***
	(0.045)	(0.048)	(0.050)	(0.040)	(0.038)	(0.040)
Squ. urban pop. den. 1850	-0.007*	-0.008**	-0.008**	-0.019***	-0.018***	-0.012***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
At least a 1850 neib. city	-0.034	-0.060*	-0.065**	-0.034	-0.079***	-0.075***
	(0.030)	(0.033)	(0.032)	(0.027)	(0.026)	(0.026)
Neib. urban pop. den. 1850	0.028	0.024	0.029	0.025	0.021	0.020
	(0.029)	(0.031)	(0.030)	(0.026)	(0.024)	(0.024)
Squ. neib. urban pop. den. 1850	-0.001	-0.001	-0.001	-0.001	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Biggest city in 1850 within countries			0.106*			0.177***
			(0.056)			(0.045)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	92	92	92	92	92	92
Observations	1395	1395	1395	1395	1395	1395
	Panel C: Quantile Regressions, 0.5			Panel D: Quantile Regressions, 0.75		
	(1)	(2)	(3)	(1)	(2)	(3)
At least a 1850 city	0.043	0.050**	0.027	0.037	0.046	-0.006
	(0.027)	(0.025)	(0.027)	(0.032)	(0.032)	(0.034)
Urban pop. den. 1850	0.327***	0.284***	0.147***	0.442***	0.351***	0.160***
	(0.039)	(0.036)	(0.039)	(0.046)	(0.046)	(0.050)
Squ. urban pop. den. 1850	-0.024***	-0.020***	-0.010***	-0.026***	-0.021***	-0.010***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
At least a 1850 neib. city	-0.022	-0.034	-0.038	-0.035	-0.004	-0.004
	(0.026)	(0.024)	(0.025)	(0.031)	(0.031)	(0.032)
Neib. urban pop. den. 1850	0.038	0.029	0.032	0.083***	0.074**	0.088***
	(0.025)	(0.023)	(0.024)	(0.030)	(0.029)	(0.030)
Squ. neib. urban pop. den. 1850	-0.001	-0.001	-0.001	-0.002**	-0.002**	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Biggest city in 1850 within countries			0.282***			0.418***
			(0.044)			(0.056)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	92	92	92	92	92	92
Observations	1395	1395	1395	1395	1395	1395
	Panel E: Quantile Regressions, 0.9					
	(1)	(2)	(3)			
At least a 1850 city	0.069	0.099	-0.020			
	(0.065)	(0.063)	(0.057)			
Urban pop. den. 1850	0.481***	0.385***	0.351***			
	(0.094)	(0.091)	(0.083)			
Squ. urban pop. den. 1850	-0.029***	-0.024***	-0.023***			
	(0.008)	(0.008)	(0.007)			
At least a 1850 neib. city	-0.061	-0.028	-0.018			
	(0.063)	(0.062)	(0.053)			
Neib. urban pop. den. 1850	0.152**	0.142**	0.136***			
	(0.060)	(0.058)	(0.050)			
Squ. neib. urban pop. den. 1850	-0.005**	-0.004**	-0.004**			
	(0.002)	(0.002)	(0.002)			
Biggest city in 1850 within countries			0.448***			
			(0.093)			
Baseline Controls Included	No	Yes	Yes			
Countries	92	92	92			
Observations	1395	1395	1395			

Note: The unit of observation is a subnational region. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.6: Robustness to Variations in Distance to Neighboring Cities, Regressions of Log Regional Income per Capita in 2005 on Urbanization in 1850

	Dependent: Log of Regional Income per Capita, 2005					
	Panel A: Neighboring cities within 50 miles away from region			Panel B: Neighboring cities within 75 miles away from region		
	(1)	(2)	(3)	(1)	(2)	(3)
At least a 1850 city	0.078***	0.072***	0.023	0.076***	0.071**	0.021
	(0.026)	(0.027)	(0.028)	(0.028)	(0.028)	(0.028)
Urban pop. den. 1850	0.338***	0.271***	0.193***	0.326***	0.261***	0.179***
	(0.064)	(0.056)	(0.058)	(0.067)	(0.058)	(0.062)
Squ. urban pop. den. 1850	-0.022***	-0.018***	-0.014***	-0.023***	-0.018***	-0.014**
	(0.006)	(0.005)	(0.005)	(0.007)	(0.005)	(0.005)
At least a 1850 neib. city	-0.093	-0.080*	-0.066	-0.097	-0.080	-0.066
	(0.058)	(0.046)	(0.046)	(0.068)	(0.061)	(0.058)
Neib. urban pop. den. 1850	0.040**	0.025	0.024	0.012	0.009	0.012
	(0.016)	(0.015)	(0.017)	(0.011)	(0.010)	(0.010)
Squ. neib. urban pop. den. 1850	-0.001**	-0.000*	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Biggest city in 1850 within countries			0.264***			0.272***
			(0.059)			(0.058)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	92	92	92	92	92	92
Observations	1395	1395	1395	1395	1395	1395
within R^2	0.09	0.21	0.23	0.09	0.21	0.23
between R^2	0.17	0.56	0.54	0.16	0.56	0.54

	Panel C: Neighboring cities within 100 miles away from region		
	(1)	(2)	(3)
At least a 1850 city	0.076***	0.071**	0.021
	(0.028)	(0.027)	(0.028)
Urban pop. den. 1850	0.335***	0.268***	0.191***
	(0.067)	(0.057)	(0.059)
Squ. urban pop. den. 1850	-0.023***	-0.018***	-0.014***
	(0.006)	(0.005)	(0.005)
At least a 1850 neib. city	-0.106	-0.090	-0.074
	(0.078)	(0.067)	(0.064)
Neib. urban pop. den. 1850	0.007	0.005	0.006
	(0.005)	(0.005)	(0.005)
Squ. neib. urban pop. den. 1850	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
Biggest city in 1850 within countries			0.267***
			(0.057)
Baseline Controls Included	No	Yes	Yes
Countries	92	92	92
Observations	1395	1395	1395
within R^2	0.09	0.21	0.23
between R^2	0.18	0.56	0.54

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. All estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.7: Elasticities of income per capita in 2005 with respect to urban population density in 1850

	Dependent: Log of Regional Income per Capita, 2005					
	Panel A: The whole world			Panel B: Asia		
	(1)	(2)	(3)	(1)	(2)	(3)
ln(urban pop. den. 1850)	0.092***	0.076***	0.054***	0.112***	0.089***	0.069***
	(0.009)	(0.008)	(0.009)	(0.014)	(0.012)	(0.014)
ln(neib. urban pop. den. 1850)	0.043***	0.027**	0.031**	0.065*	0.045	0.048
	(0.013)	(0.013)	(0.013)	(0.036)	(0.040)	(0.040)
Biggest city in 1850 within countries			0.249***			0.254**
			(0.053)			(0.102)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	92	92	92	24	24	24
Observations	1395	1395	1395	373	373	373
within R^2	0.11	0.22	0.24	0.16	0.23	0.24
between R^2	0.23	0.56	0.55	0.15	0.42	0.41
	Panel C: Western Europe			Panel D: Non-Western Europe		
	(1)	(2)	(3)	(1)	(2)	(3)
ln(urban pop. den. 1850)	0.076***	0.086***	0.066***	0.110**	0.120***	0.088***
	(0.013)	(0.012)	(0.014)	(0.043)	(0.033)	(0.022)
ln(neib. urban pop. den. 1850)	0.021*	0.020	0.023*	-0.001	-0.022	-0.008
	(0.012)	(0.013)	(0.013)	(0.014)	(0.013)	(0.013)
Biggest city in 1850 within countries			0.149			0.270*
			(0.091)			(0.136)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	16	16	16	18	18	18
Observations	214	214	214	290	290	290
within R^2	0.24	0.31	0.33	0.17	0.50	0.52
between R^2	0.00	0.02	0.06	0.00	0.01	0.01
	Panel E: The Americas			Panel F: The Americas no US & Canada		
	(1)	(2)	(3)	(1)	(2)	(3)
ln(urban pop. den. 1850)	0.090***	0.075***	0.048**	0.091***	0.074***	0.037
	(0.013)	(0.015)	(0.019)	(0.017)	(0.019)	(0.025)
ln(neib. urban pop. den. 1850)	0.056**	0.051**	0.056**	0.077**	0.074***	0.074***
	(0.023)	(0.021)	(0.020)	(0.028)	(0.019)	(0.018)
Biggest city in 1850 within countries			0.260**			0.308**
			(0.109)			(0.129)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	20	20	20	18	18	18
Observations	387	387	387	324	324	324
within R^2	0.11	0.29	0.30	0.10	0.29	0.31
between R^2	0.08	0.49	0.45	0.11	0.19	0.16
	Panel I: Ex-colonial countries			Panel J: Non ex-colonial countries		
	(1)	(2)	(3)	(1)	(2)	(3)
ln(urban pop. den. 1850)	0.084***	0.057***	0.037***	0.099***	0.083***	0.056***
	(0.012)	(0.011)	(0.014)	(0.015)	(0.013)	(0.013)
ln(neib. urban pop. den. 1850)	0.080***	0.062***	0.065***	0.022**	0.007	0.013*
	(0.024)	(0.023)	(0.022)	(0.008)	(0.008)	(0.007)
Biggest city in 1850 within countries			0.270***			0.244***
			(0.081)			(0.073)
Baseline Controls Included	No	Yes	Yes	No	Yes	Yes
Countries	43	43	43	49	49	49
Observations	658	658	658	737	737	737
within R^2	0.09	0.18	0.20	0.15	0.34	0.36
between R^2	0.00	0.34	0.30	0.23	0.48	0.47

Note: The unit of observation is a subnational region. Robust standard errors are shown in parentheses. Baseline controls included are land suitability, temperatures in Celsius, altitude in 100 meters, ruggedness in 100 meters, rainfall in millimeter, absolute value of latitude (integer), inverse distance to coast, and inverse distance to river. Fixed-effects estimates include country fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B Definition of Region

This section describes regions used in this paper. We match Gennaioli et al.'s (2013) regions with the Database of Global Administrative Areas Map version 2 (GADMv2). For regions that are not included in Gennaioli et al. (2013), subdivisions at the largest disaggregated level provided in GADMv2 are used. Most of Gennaioli et al.'s (2013) regions are the first-level administrative divisions, and other regions require combining two or more such subdivisions according to at what aggregate level a variable is available. We find those regions' boundaries in the GADMv2. Among Gennaioli et al.'s 1,537 regions, there are 17 regions whose boundaries are not available at the most disaggregated level of the GADMv2. We aggregated the 17 regions into 8 bigger ones that can be found in the GADMv2. The 8 regions (with regions being aggregated displayed after colon) are Copenhagen: Copenhagen and Frederiksberg and Copenhagen county, Daugavpils: Daugavpils city and Daugavpils district, Jelgava: Jelgava city and Jelgava district, Liepaja: Liepaja city and Liepaja district, Rezekne: Rezekne city and Rezekne district, Riga: Riga city, Jurmala city, and Riga district, Ventspils: Ventspils city and Ventspils district, and Selangor: Selangor and Wilayah Persekutuan. Data for the 8 aggregated regions are calculated as the population-weighted average of the regions being combined. Finally, we exclude regions in countries that do not have a single region with settlement data.

C Urban Population

In this study, we include any location that has a recorded population of 5,000 or more in 1850 from our sources. In an effort to enlarge our sample, we also include locations with records from 1825 and 1875 but absent in 1850. Only Melbourne is therefore considered as a city in 1850 though its estimated population, 222,000 according to Rozenblat's estimates, is only available in 1875. When all of our data sources taken together, we have 2,803 settlements spanning 141 contemporary countries in 1850 with a population of 5,000 or greater. However, a city is considered identified only if we are able to confirm in which region the city locates. There are another 29 settlements in 1850 that fit the definition of city but are excluded because their locations are unidentified. These 2,803 settlements are from 772 regions. Among these regions, 6 are city states - Gibraltar, Guernsey, Hong Kong, Macao, Malta, and Singapore, we drop them in the study. We end up with 766 regions in our whole sample had urban areas in 1850.

D Why Not A Log-Log Model ?

This section explains why the use of a log-log specification can invalidate our estimates. Consider the simplest case where the only two variables of interest are the dummy variable for the existence of a city and the region's urban population density. Our urban population density measure is positive and continuous for some observations (regions with cities) and 0 for others. Thus, depending on the observation(i.e. region), the implied estimation takes one of two forms,

$$\mathrm{LnY}_i = \begin{cases} \beta_0 + \delta_i + \beta_1 \mathrm{Ln} x_i + \mu_i & \text{if region } i \text{ has a positive } x \\ \beta_0 + \mu_i & \text{otherwise,} \end{cases} \tag{D.1}$$

where for the i^{th} observation, β_1 is the elasticity of Y_i with respect to x, δ captures the difference in LnY_i between regions with a positive value of x and regions with a value of 0; we are interested in both variables. The coefficient β_0 is constant which are the same for both types of regions, and μ_i is a white noise.

Unit of variable x is arbitrarily chosen. The unit in 100 person per square kilometer is not theoretically more correct than 1 person per square kilometer. However, scaling of x will eventually contaminate the estimated δ. We show this in the following two equations in which we scale up x by 100 times.

$$\mathrm{LnY}_i = \begin{cases} \beta_0 + \delta_i + \beta_1 \mathrm{Ln}(x_i * 100) + \mu_i & \text{if region } i \text{ has a positive } x \\ \beta_0 + \mu_i & \text{otherwise,} \end{cases} \tag{D.2}$$

$$\mathrm{LnY}_i = \begin{cases} \beta_0 + [\delta_i + \beta_1 \mathrm{Ln}(100)] + \beta_1 \mathrm{Ln} x_i + \mu_i & \text{if region } i \text{ has a positive } x \\ \beta_0 + \mu_i & \text{otherwise,} \end{cases} \tag{D.3}$$

In Equation B.2, we scaling up x by 100 times. Because $\mathrm{Ln}(x_i * 100)$ is equal to $\mathrm{Ln}x_i$ plus Ln(100), then we have Equation B.3. The estimated β_1 is the same as it is estimated in Equation B.1. However, δ and a constant, Ln(100), resulted from scaling up of x are estimated as a whole. Because the unique 'real' unit of x that does not exist, we therefore are not able to depart the constant from δ.