IZA Institute of Labor Economics

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DISCUSSION PAPER SERIES

IZA DP No. 11951

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# ABSTRACT

## Walled Cities and Urban Density in China*

Throughout the imperial era, defensive walls surrounded Chinese cities. Although most city walls have vanished, the cities have survived. We analyze a sample of nearly 300 prefectural-level cities in China, among which about half historically had city walls. We document that cities that had walls in late imperial China have higher population and employment density today, despite the fact that their walls have long gone. Using data from various sources, we test several possible explanations of this fact, including (1) walled cities have a well-defined historical core that helps hold economic activity close to the city center today; (2) walled cities today tend to have different industry compositions that are less conducive to decentralization; (3) walled cities are situated in regions where the local geographies make it less desirable to build out; (4) walled cities have more compact shapes that facilitate high density development; and (5) walled cities are located in regions where rural land is more valuable today and discourages urban sprawl. We find that historically walled cities still have higher density after taking into account all of these factors, which we interpret as evidence of economic persistence.

**JEL Classification:** R11, R12, N95

**Keywords:** urban density, city wall, persistence, China

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* This paper has benefited from comments by Leah Brooks, John Brown, David Cuberes, Wayne Gray, Yannis Ioannides, Yu Liao, Sharon Pailler, Marc Rockmore, three anonymous referees, and seminar participants at Clark University, the AREUEA-ASSA Annual Conference in Chicago, and the 2017 Economic History Society Annual Conference at University of London. We are grateful to Mariaflavia Harari and Vit Paszto for their help with the ArcGIS shape metrics routines. We thank Judith Pereira for her editorial assistance. All errors are our own.

# 1 Introduction

In ancient China, almost all cities built defensive walls (*cheng qiang*) to enclose settlements and protect residents from potential aggressors.[1] These walls typically formed a square shape, made of rammed earth (faced with bricks and stones in later centuries), and had gates, moats, and watch towers. Beyond their defensive purpose, city walls also served as a symbol of a city's status and independence. Cities with better-quality defensive walls (higher, thicker, with more towers) were important strongholds. Larger walled cities often housed higher-level governments with more resources, greater population, and better infrastructure. This practice of building city walls became common in China nearly 3,000 years ago, peaked in the Ming Dynasty (1368-1644), and lasted until the end of the Qing Dynasty (1644-1912). The vast majority of urban residents lived inside walled cities in late imperial China (Chang, 1977). In the early 20th century, most Chinese cities still had defensive walls (Sirén, 1924).

In the late 19th century, the military advantage of defensive walls started to become obsolete with the advent of modern Western firearms. Some walled cities began to lose their commercial advantages as city walls became an obstacle for efficient trade.[2] By the early 20th century, many Chinese city walls had been damaged in wars and were poorly maintained. In the 1950s, the Chinese government launched a movement to demolish old city walls to "shake off the shackles of the past." City walls fell throughout the country. By 1970, almost all city walls were gone, including the massive walls of Beijing (Figure 1).[3]

The large size of the Chinese urban system and the abrupt abolishment of almost all city walls create a unique context for studying some important research questions. In this paper, we examine whether fallen walls have a persistent effect on the physical structure of cities

[1]In this paper, we refer to "city walls" as the defensive walls built around a city. This definition does not include defensive walls like the Great Wall of China, which extended far beyond the borders of a city and were used to enclose regions or mark territorial boundaries.

[2]For instance, as requested by the merchant community of Shanghai, the city's ancient defensive walls, originally constructed to protect urban residents from Wokou raiders in the Ming dynasty, were almost completely demolished at the turn of the 20th century.

[3]Today, only a few Chinese cities have preserved ancient city walls, including Jingzhou, Pingyao, Xi'an, and Xingcheng. Nanjing and Kaifeng are known for their partially preserved city walls.

today. In particular, we analyze a sample of nearly 300 prefectural-level cities in modern China (Figure 2).[4] Using a unique dataset of walled cities in the Qing Dynasty, we identify that about half of these prefectural-level cities historically had defensive walls. Among them, Beijing is a well-known example. Other Chinese cities, such as Shenzhen, emerged in modern times and never had defensive walls. We compare historically walled cities with cities that never had a wall and find that historically walled cities tend to have higher population and employment density today. Using various data sources, we test whether higher urban density can be explained by the presence of a historical city center, industry composition, local terrain ruggedness, city shape, and value of agricultural land in surrounding rural areas. While some of these factors have explanatory power, they do not completely explain the higher density of historically walled cities.

To rationalize these findings, we argue that it is a result of economic persistence. Walled cities initially emerged due to their locational advantages, such as being central places of key transportation and trade networks, surrounded by productive agricultural land, and easy access to key non-agricultural resources (e.g., salt, iron ore, etc.). The construction of city walls could further reinforce these advantages. Walled cities attracted commerce, manufacturing, and supporting services during the early commercialization in China. Defensive walls allowed these sites to accumulate local institutions, capital, and urban amenities. Since the construction and alteration of city walls was costly, economic density within city walls was naturally high. Higher initial economic density in walled cities affected their growth paths in subsequent centuries (Michaels et al., 2012).[5] Even after the city walls disappeared, the higher initial density of the city persisted and led to agglomeration economies that attracted businesses and workers, resulting in higher economic density today. Thus our findings are consistent with a hybrid of the locational fundamentals theory and the theory of path de-

[4]A prefecture in China is an administrative unit comprising, typically, a main central urban area and its much larger surrounding rural area containing many smaller cities, towns, and villages. We refer to the central city (i.e., the city proper) in a prefecture as a "prefectural-level city."

[5]Michaels et al. (2012) document a positive correlation between initial population density and subsequent population growth.

pendence (Davis and Weinstein, 2002).

This paper is a direct extension of Ioannides and Zhang (2017). In their study of walled cities in late imperial China, Ioannides and Zhang first documented that historically walled cities currently have higher population and employment density. However, they did not examine the mechanisms behind this phenomenon. Building upon their research, we propose several plausible explanations of this empirical fact and test the hypotheses with innovative use of new data sources. Thus this paper helps us better understand the persistent effects of history on current economic activities in the context of China.

Our study contributes to the growing literature on the persistence of urban economic activity. A few studies investigate the determinants of spatial density and local response to large economic shocks. Davis and Weinstein (2002) show that relative city sizes are stable in the face of destructive wartime bombing in Japan, suggesting that heterogeneous locational fundamentals are the key factor in determining the spatial distribution of economic activity.[6] Siodla (2015) studies the aftermath of the 1906 San Francisco Fire and shows that residential density increased at least 60 percent in razed areas relative to unburned areas by 1914, and a large density differential still exists today. Maloney and Caicedo (2016) show that in the Americas, areas with high population density in the pre-colonial era tend to be denser and have higher incomes today, suggesting a persistence of economic activity over half a millennium. Others examine the persistence of urban economic activity following a permanent change in locational fundamentals, suggesting the importance of path dependence. Bleakley and Lin (2012) show the continued importance of historical portage sites today despite the obsolescence of their functions as portages. Jedwab et al. (2017) study railways constructed during the colonial era in Kenya and find persistent effects on the location of major cities in the country. Brooks and Lutz (2014) examine intra-urban density in Los Angeles, and find a persistent correlation between present-day population

[6] Davis and Weinstein (2002) inspired a few studies on large shocks to population. Some find transitory effects (Nitsch, 2003; Cuberes and González-Val, 2017), while others find persistent effects (Schumann, 2014; Hanlon, 2017).

density and distance to the long-extinct streetcar. Most recently, Baruah et al. (2018) show that in a sample of over 300 African cities, French-speaking cities have more compact urban development than English-speaking cities long after the colonial era. Our findings add another piece of evidence to this line of research.

More broadly, our study is related to the literature on the role of history in determining the distribution of economic activity across locations. Using data from ten European countries, Wahl (2016) shows a positive relationship between involvement in medieval trade and regional economic development today. He finds that this long-lasting effect exists mainly because medieval trade affects agglomeration and industry concentration. Michaels and Rauch (2018) document that the collapse of the Western Roman Empire wiped out towns in Britain but not in France, which allowed for an improved urban network in Britain but locked many French towns in suboptimal locations. Several studies focus on the context of China. Jia (2014) studies China's treaty ports, cities that were forced to open by treaties between China and Western countries in the late 19th century, and finds long-lasting growth effects more than a century later. Flückiger and Ludwig (2017) show that the climatic suitability for malaria transmission influenced the spatial distribution of Chinese cities in history and this effect still persists today despite the eradication of malaria in the country. Our paper adds a new perspective towards understanding how history influences economies today.[7]

Section 2 presents the empirical model and discusses hypotheses about the economic density difference of historically walled cities in China. Section 3 introduces data sources and measurements. Section 4 reports estimation results and discusses potential explanations. Section 5 provides concluding remarks.

[7] A related and much larger literature uses historical events or policies as exogenous sources of variation to identify certain effects on economic outcomes across cities (e.g., Brakman et al., 2004; Bosker et al., 2007; Redding and Sturm, 2008; Acemoglu et al., 2011; Dittmar, 2011; Redding et al., 2011; Kline and Moretti, 2014; Fan and Zou, 2015; Jedwab and Moradi, 2016) or across locations within a city (e.g., Ahlfeldt et al., 2015; Hornbeck and Keniston, 2017).

## 2 Empirical Framework

Our empirical work builds directly on the recent research of Ioannides and Zhang (2017). These authors develop a theory of walled cities and use data from the Ming and Qing dynasties to examine the correlation between wall length and population size, the factors that determine the size of walled cities, the quality difference of city walls in frontier regions, the size distribution of walled cities, etc. Part of their analysis explores the long-term effect of city walls and finds that historically walled cities in China have higher population and employment density today; our study builds upon this finding.

Our empirical analysis focuses on the central city in each prefectural-level division in China, dictated primarily by data availability. We refer to these cities as "prefectural-level cities." Following Ioannides and Zhang (2017), we examine the density difference of historically walled cities by estimating the following equation:

$$\log(density_i) = \alpha + \beta wall_i + \mathbf{X}_i\gamma + \epsilon_i \tag{1}$$

where the dependent variable, $density_i$, represents population or employment density of city $i$, measured in logs to allow for potential nonlinear relationships. Population and employment density capture underlying variations in local productivity and quality of life across cities (Haurin, 1980; Glaeser et. al., 1992; Ciccone and Hall, 1996; Rappaport and Sachs, 2003), and reveal individuals' preferences over local areas (Tiebout, 1956). The key independent variable $wall_i$ is a dummy variable indicating the presence of city walls in city $i$ in the 19th century. As found in Ioannides and Zhang (2017), we expect $\beta$ to be positive, implying a higher density in historically walled cities. $\mathbf{X}_i$ is a vector of contemporary city-level characteristics.

In all specifications, we include a city size measure in $\mathbf{X}_i$, given that a standard monocentric city model implies that a larger city has a more productive city center and thus higher density. Also included in $\mathbf{X}_i$ is the average personal income, since one would expect that in richer cities people tend to demand more land and thus have more open space. We also control for whether the city is a provincial capital, because the political hierarchy of cities plays an important role in determining the resources and investment they receive in modern China (Xing and Zhang, 2017).[8] In addition, we control for whether the city is a seaport, since seaports provide a productivity advantage and their expansion is constrained by water, which may affect the density of economic activity.

Building on Ioannides and Zhang (2017), we investigate factors that influence the density of historically walled cities. Given that further controls could potentially explain away the magnitude and statistical significance of the coefficient $\beta$, we utilize additional sources of data to test the following hypotheses.

**Hypothesis 1.** *Historically walled cities have a well-defined historical core that helps hold economic activities close to the city center today.*

Historically walled cities all have a long history, many with origins dating more than 2,000 years. Some (e.g., Hangzhou, Kaifeng, Nanjing, Suzhou, and Xi'an) possess substantial historic significance (Morris, 2013). Even though their city walls are gone, many historical-cultural heritages have survived. Consider Beijing as an example. While Beijing's city walls have been torn down, the magnificent Forbidden City still sits at the center of the metropolitan area; the Temple of Heaven complex is nearby. Sites like these define a distinctive historical center of a city.[9] From the perspective of residents, these sites are valuable urban amenities. Residents may want to live close to the city center so as to maintain easy access to these sites and cultural activities. From the perspective of the local economy, the historical city center may attract tourists and sustain the related accommodation sector that benefits from a high density of activities. We thus collect data on the number of historical-cultural sites in each city and include it in $\mathbf{X}_i$ to test this hypothesis.

[8]This has a long history. Chang (1977, p. 90) analyzes 18 Qing Dynasty provinces and shows that the provincial capital was the largest city in 14 of them. He suggests that these cities had a larger share of open land and surface water devoted to local amenities.

[9]Chang (1977, p. 94) mentions that open areas within city walls were often devoted to parks. Moreover, most lakes and ponds were landscaped for recreational purposes.

**Hypothesis 2.** *Historically walled cities tend to have industry compositions today that are less conducive to decentralization.*

Historically, walled cities emerged and thrived at locations close to key trade routes, large bodies of water, and productive agricultural land (Ioannides and Zhang, 2017). Those that survived have evolved mostly over time into an agglomeration of commercial activities, industrial production, transportation, and other supporting services. Their industry compositions could affect population and employment density because different economic sectors face different cost-benefit tradeoffs when making locational choices. Glaeser and Kahn (2001) show that in American cities, manufacturing, known as the "footloose industry," has experienced the most decentralization, whereas the business and financial services sector values face-to-face communication and has experienced less decentralization. Of course, the Chinese context may be different. With a less developed highway network and greater reliance on railroad transportation, Chinese manufacturing firms may have more incentive to form industrial clusters. Also, unlike the U.S., the service sector in China is dominated by retail and personal services (Au and Henderson, 2006), where businesses are located near customers and compete with similar nearby businesses. All of these have implications for the density of economic activities. We thus collect data on the share of the service sector and the number of industrial enterprises at the city level and include them in our regression to test this hypothesis.

**Hypothesis 3.** *Historically walled cities are situated in regions where local geographies make it less desirable to build out.*

City walls were gigantic physical structures. Consider the 307 walled cities that were prefectural, provincial, or empire capitals in the late Qing Dynasty, which are at similar administrative levels to the prefectural-level cities today in our analysis sample. Their city walls were on average 4.46 $km$ in circumference, 8.5 meters high, 9.4 meters thick at base, and had 11.2 towers. Ninety-four percent of them had moats surrounding the city walls.

Given their sizes and primitive construction technology during the imperial era, walled cities tended to be built in relatively flat areas. The construction of modern cities is much less constrained to flat regions. As Burchfield et al. (2006) show, urban sprawl is positively associated with rugged terrain. Thus one may suspect that historically walled cities tend to have a higher density today mainly because they are more likely to sit in flat regions. We will include a measure of terrain ruggedness in our regression to test this hypothesis.

**Hypothesis 4.** *Historically walled cities have more regular shapes that facilitate high-density urban development.*

According to Zhang (2003, p. 293), more than 70 percent of medieval Chinese cities had square-shaped city walls, primarily due to cultural reasons.[10] In the mid-20th century, when city walls were removed, many cities built wide ring roads along the old walls' footprint. For example, the Second Ring Road replaced Beijing's city walls. Starting from a regular, square-shaped center, formerly walled cities naturally expand in all directions and tend to preserve a rather regular shape. A modern city that emerged in the past century, however, may follow radial highways and railroads, and evolve into an irregular shape. We therefore suspect that historically walled cities might have higher density today because they developed from a more compact urban core. We will test this hypothesis using a few urban shape measures constructed using nighttime light intensity data.

**Hypothesis 5.** *Historically walled cities are located in regions where rural land is more valuable today and discourages urban sprawl.*

Urban economic theory states that urban area ends where agricultural rents exceed urban bid rents. When land is more valuable in agriculture, due to either higher crop yields or higher local demand for food, there will be less urban sprawl and higher urban density.

[10] The Records of Examination of Craftsman (*Kao Gong Ji*), an ancient Chinese book on science and technology, described the monarchy's central city as a perfect square. This book later (in the Han Dynasty, 206 BC – 220 AD) became a Confucius classic and a must-read among Chinese intellectuals for nearly 2,000 years. The book made the Chinese people believe that an ideal city must be square shaped, thus having an important influence on the design of cities in Chinese history.

Ioannides and Zhang (2017) show that walled cities tend to be larger in regions where land is more productive. If the larger walled cities have mostly survived today, the more valuable rural land in the surrounding areas should be more resistant to urban expansion (Brueckner and Fansler, 1983). We will measure land value in the agricultural sector around each city and test whether it can explain the higher density in historically walled cities.

# 3 Data Sources and Measurements

Our data are assembled from various sources.

## 3.1 City characteristics

Our primary source of city level data is the China City Statistical Yearbook, which has been published annually since 1985 and reports a wide range of prefectural-level city characteristics from the previous year.[11] We perform two sets of empirical analysis, using the earliest available data from 1984 and from 2013, which was the most recent wave when we retrieved the data.[12] The earlier year is closer to the fall of city walls and thus represents shorter-term effects; the recent year shows the longer-term effects after three decades of rapid urbanization.[13] While the Chinese economy was still a planned economy in 1984, market forces played a much larger role in allocating resources in 2013.

Our dependent variable, population density, is directly available from the Yearbook data; we calculate employment density by dividing total employment by land area, both from the Yearbook data. We use additional city characteristics from the Yearbook data as control

[11]The data are widely available electronically although the yearbooks are still being published. We will refer to them as the Yearbook data.

[12]The China City Statistical Yearbooks provide only data on registered population and no information on temporary rural migrants is reported. For this reason, there are measurement errors in the population data, especially in recent years when rural-urban migration is common. We will address this issue in the robustness checks below.

[13]According to the 1982 population census, China's urbanization rate was 21.9%; by the 2010 census, it had increased to 49.7%. See these official statistics at http://www.stats.gov.cn/tjsj/Ndsj/2011/html/D0305e.htm.

variables, including city level gross domestic product (GDP), GDP per capita, number of industrial enterprises, and employment share of the service sector (calculated as the ratio of the number of workers in the service sector to that in all sectors).[14]

The number of designated historical-cultural sites in each city is collected by hand from the Beijing Municipal Administration of Cultural Heritage.[15] We also identify whether the city is currently a provincial capital and whether the city is a seaport.

## 3.2 Data on city walls

The data on the presence of city walls in late imperial China are compiled by a group of anthropologists (Yue et al., 2007), and are available from the China Historical Geographic Information System (GIS) archive maintained at Harvard University.[16] This dataset contains a record of every city that served as an administrative capital during the period 1820-1893. It covers 1,761 geographical units and provides detailed information on the presence of city walls, their circumference, height, thickness, and construction materials, the number of gates, towers, and sentry posts on a city wall, the presence and dimensions of moats outside the city wall, etc.[17]

Importantly, the city wall data contain the longitude-latitude coordinates of all of the walled cities in the late Qing Dynasty, which allows us to match walled city locations with current city locations. We construct a dummy variable $wall_i$ for each prefectural-level city contained in the Yearbook data, assigning a value of one to previously walled cities and a value of zero for cities never possessing a wall.[18]

After matching the Yearbook data with the city wall data, we end up with 288 prefectural-

[14] The Chinese government had not yet adopted GDP as an official economic statistic in 1984. Instead, we use the gross industrial output value (GIOV) as the GDP measure in the 1984 sample.

[15] The data are available online at http://www.bjww.gov.cn/wbsj/zdwbdw.htm.

[16] The China Historical GIS was launched in 2001 to establish a database of populated places and historical administrative units for the period of Chinese history between 221 BC and 1911 AD. See http://gis.harvard.edu/services/products/china-historical-gis-chgis for more details.

[17] See Ioannides and Zhang (2017) for a detailed documentation of the city wall data and an example of using the data for economic analysis.

[18] The physical size of a prefectural-level city today is much larger than a typical walled city in history. Thus, in some cases, more than one walled city is linked to a single city today.

level cities in the 1984 sample, among which 145 are identified as historically walled cities. The 2013 sample consists of 286 prefectural-level cities, 176 of which are identified as historically walled cities.[19]

### 3.3 Terrain ruggedness index

To test whether local geographies can explain a higher economic density at historically walled cities today, we use a terrain ruggedness index created by Nunn and Puga (2012).[20] This index for a point on the earth's surface captures the difference in elevation between this point and the surrounding points on the 30 arc-second grid. More specifically, the terrain ruggedness index at a point is given by the square root of the sum of the squared differences in elevation between the point and the eight adjacent points. With this index, we create a 50 *km* buffer circle around the centroid of each prefectural-level city in our sample (see Figure 3 for two illustrations), and then calculate the weighted average terrain ruggedness index within the buffer zone using the value of the land area of each 30 by 30 arc-second cell as the weights.[21] Thus a higher average terrain ruggedness index in the buffer zone means that the city sits in a less flat region.

### 3.4 Urban shape metrics

To check whether historically walled cities have a more regular shape today, we calculate various shape indexes using nighttime light intensity data retrieved from the Defense Meteorological Satellite Program Operational Linescan System (DMSP/OLS) Nighttime Lights dataset.[22] These data are available for every year starting in 1992. We therefore have to

[19]The constitution of the 1984 sample differs from the 2013 sample due to changed administrative divisions during this period. This is part of the reason why we perform two sets of cross-sectional analyses instead of panel data regressions.

[20]These terrain ruggedness data are downloaded from Diego Puga's data archive http://diegopuga.org/data/rugged/.

[21]As Nunn and Puga (2012) point out, it is important to use a weighted average index because the sea-level surface that corresponds to a 30 by 30 arc-second cell is not constant, but varies in proportion to the cosine of its latitude.

[22]For a thorough description of the dataset, please see Donaldson and Storeygard (2016) and Harari (2016).

use the 1992 nighttime light intensity data to map urban areas in the 1984 sample. For the 2013 sample, we use the light data from the same year. We first overlap the city centroids with the nighttime light intensity data. For each city in our sample, we consider spatially contiguous areas surrounding the city coordinates with luminosity above a threshold of 45 as the urban area.[23] See Figure 4 for an illustration of how we delineate the urban area of Beijing using the 2013 nighttime light intensity data.

Following Harari (2016), we calculate four sets of indexes: Cohesion Index, Proximity Index, Spin Index, and Range Index. The *cohesion index* is defined as the average distance between all pairs of interior points in an urban area. The *proximity index* measures the average distance from all interior points to the centroid of the urban area. The *spin index* is the average of the square of the distances between all interior points and the centroid of the urban area. The *range index* measures the maximum distance between two points on the perimeter of the urban area, indicating the longest possible commute trip within the city. All four measures are normalized by calculating the ratio of the corresponding index of an equal area circle and that of the urban shape. Our empirical analysis uses the normalized cohesion index as the benchmark measure of urban shapes and uses other indexes for robustness checks. Figure 5 illustrates how these urban shape metrics map to the urban area. Conditional on urban footprint area, higher values of the normalized indexes indicate shorter within-city trips and thus more compact urban shapes.

### 3.5 Agricultural land value

To test whether historically walled cities have more valuable rural land in surrounding areas today, we divide the primary sector gross output by the agricultural land area in the prefecture and use it as a proxy for the value of agricultural land. The data on agricultural land

[23] The DMSP/OLS Nighttime Lights dataset has a resolution of 30 arc-seconds (approximately 1 square $km$). Light intensity is measured by a real number ranging from 0 to 63, with a higher number indicating a brighter 30 arc-second cell. Harari (2016), with a goal of capturing the whole urban area, uses a baseline luminosity threshold of 35. Here, we use a higher threshold because city walls are unlikely to shape today's urban edges.

area are available from the China City Statistical Yearbook, but not reported every year. The data first became available in 1994, so we use the agricultural land values in 1994 for the 1984 regressions. For the 2013 regressions, we use the agricultural land values in 2005.[24] Agricultural land value has 66 missing values in the 1984 sample and 3 missing values in the 2013 sample. In order to maintain the sample size, we impute the missing values using the values from the nearest cities.[25]

### 3.6 Visualization and descriptive statistics

Figures 6 and 7 show the population and employment density of cities in our samples. In each figure, a square represents a historically walled city; a circle represents a city that never had city walls. It is clear that a large number of the historically walled cities are located in the east and south regions. Cities in the west and northeast are less likely to have had walls. In the west, there are two reasons for this: First, this region had fewer walled cities in history, due to lower land productivity and other unfavorable geographic conditions compared to the rest of China. Second, the walled cities in this region are less likely to have survived as major cities today. Many walled cities in this region were originally built as military strongholds on the frontiers between Han Chinese and minority ethnic groups, and therefore lost their locational advantages, as cities today thrive on economic rather than military successes. The northeast, on the other hand, is a resource rich region, and many of the major cities there emerged in the early 20th century under the Russian or Japanese occupation. For example, China's "Steel Capital" (Anshan), "Coal Capital" (Fushun), and "Oil Capital" (Daqing) are all in this region; none of them were important cities in the imperial era.

In Figures 6 and 7, using color schemes, we also indicate the population and employment density of cities; cities with higher density are depicted in darker colors. In both figures, we

[24] The agricultural land area data are also available in 2006 but have too many missing values (for 25 of 286 cities). So we decided to use the data in 2005. Note that our empirical analysis uses cross-sectional variation of agricultural land value, which is rather stable despite the large year-to-year changes of land value due to inflation and other macroeconomic factors.

[25] In most cases, the nearest cities do have non-imputed values. In two cases, we need to use the value from the fourth nearest city.

see that historically walled cities tend to have higher population and employment density, the key fact we document and explain in this study.

Table 1 presents descriptive statistics for all of the variables used in our regression analysis. For both 1984 and 2013 samples, we present statistics separately for historically walled and non-walled cities. Consistent with the patterns visualized in Figures 6 and 7, historically walled cities have higher population and employment density. The 1984 sample has an average density of 1,331 persons per square kilometer in historically walled cities, but only 736 persons per square kilometer in non-walled cities. The 2013 sample has a density of 1,011 persons per square kilometer in historically walled cities, but only 751 persons per square kilometer in non-walled cities. These numbers also imply that over time, population density declined in historically walled cities but remained essentially unchanged in non-walled cities. The differences in employment density show a similar pattern.

Table 1 also displays significant differences along other dimensions between historically walled and non-walled cities. For example, in the 1984 sample, historically walled cities have an average GDP per capita of 0.219 (tens of thousands yuan), but non-walled cities have an average of 0.175; 17 percent of historically walled cities are provincial capitals, compared to only two percent of non-walled cities; historically walled cities have an average terrain ruggedness index of 17.5, but non-walled cities on average have an index of 19.3. While we do not observe a significant difference in shape, other control variables may be able to explain some of the density differences between historically walled and non-walled cities.

# 4 Empirical Results

## 4.1 Main results

Table 2 presents the baseline regression results. Columns (1) - (2) are population and employment density regressions using the 1984 data, and columns (3) - (4) are the same regressions using the 2013 data. In these baseline regressions, we only control for log GDP, log per capita GDP, whether the city is a provincial capital, and whether the city is a seaport. We will add additional control variables below to test hypotheses 1-5.

In all four columns, the historically walled city dummy has a positive, statistically significant coefficient. In 1984, the population and employment density of historically walled cities are 83% and 67% higher, respectively.[26] In 2013, the population and employment density of historically walled cities are 35% and 42% higher, respectively. These are all substantial differences. Over time, the density differences of historically walled cities declined. From 1984-2013, all cities in China expanded. The total built-up urban area of prefectural-level cities increased from 8,842 $km^2$ in 1984 to 36,450 $km^2$ in 2013. It appears that the historically walled cities have been sprawling, narrowing the density gap. Despite this development, historically walled cities continue to have much higher population and employment density half a century after the removal of city walls, suggesting a persistent effect of history on urban activities.

The four control variables in the baseline regressions also have some explanatory power. We use log GDP primarily as a city size control.[27] It has a positive coefficient in all four columns and is statistically significant in three regressions. Larger cities tend to have higher densities. Log per capita GDP, a measure of local income, also has statistically significant coefficients. In 1984, richer cities had both higher population and employment density. In 2013, however, the coefficient in the population density regression reverses, implying that richer cities now have lower population density, likely because richer urban residents demand more open space as a valuable amenity. In addition, provincial capitals seem to have lower population density and higher employment density; seaports have both higher population and higher employment density. These results make intuitive sense, although they are not

[26] Given the specification of equation (1), an estimated coefficient of the historically walled city dummy, $\hat{\beta}$, implies that density at historically walled cities is higher by $(e^{\hat{\beta}} - 1)$*100 percent. Thus, for example, in column (1) of Table 2 the estimate $\hat{\beta} = 0.603$ implies that population density at historically walled cities is 83% $(= e^{0.603} - 1)$ higher.

[27] Log population is perhaps a more commonly used city size control. However, given that the left-side density variable contains log population, Ioannides and Zhang (2017) argue that log GDP is a more reasonable size control in this case. We follow their practice to control for log GDP in these baseline regressions. As a robustness check, we controlled for log population instead of log GDP; the results are similar.

statistically significant.

To test hypotheses 1-5, we add six more control variables to the baseline regressions, including the number of historical-cultural sites, the share of the service sector, the number of industrial enterprises (in log), terrain ruggedness index, normalized cohesion index, and agricultural land value (in log). Table 3 presents the results. As indicated by the substantially higher $R^2$'s, these additional control variables improve the fit of the statistical model. In every specification, the coefficient of the walled city dummy is smaller in magnitude, but still statistically significant. In 1984, the population and employment density of historically walled cities are 52% and 40% higher than non-walled cities, respectively, substantially lower than the 83% and 67% estimated in the baseline regressions. In 2013, the population and employment density of historically walled cities are 32% and 40% higher than non-walled cities, respectively, slightly lower than the 35% and 42% estimated in the baseline regressions. Therefore, after adding these new controls, we still find that historically walled cities have significantly higher population and employment density long after the city walls are demolished, and that this difference declined over time in the case of population density but remained the same in the case of employment density.

The coefficient of the number of historical-cultural sites is small, inconsistent across specifications, and never statistically significant, suggesting that rich cultural heritage of the historically walled cities has little to do with their higher density today. Industry composition does matter. The share of the service sector has a positive and statistically significant coefficient in the 1984 regressions; the coefficient reverses sign in 2013 and is statistically significant in the employment density regression. In 1984, China had a planned economy; by 2013, its transition to a market economy was nearly completed. Also, as China became wealthier during this period, the share of its service sector increased substantially (from 14.2% to 42.4%). The reversed sign of the coefficient perhaps reflects these institutional and structural changes. In contrast, log of number of industrial enterprises has a positive and statistically significant coefficient in the 1984 sample, possibly because the manufacturing sector is a major employer and benefits from agglomeration economies. The inclusion of these two industry composition variables reduces the density difference of the historically walled cities in 1984 but less so in 2013. Thus the data partially support hypothesis 2. The terrain ruggedness index always has a significant, negative coefficient in all of the regressions, implying that cities built on more rugged terrain have lower population and employment density. Thus the data also support hypothesis 3.[28] The cohesion index, although it always has a positive sign, is never statistically significant. Agricultural land value has a positive coefficient, consistent with hypothesis 5, and is statistically significant in all but the 1984 employment density regression.[29]

Overall, results in Table 3 suggest that some of the factors we discussed in hypotheses 1-5, particularly industry composition, terrain ruggedness, and agricultural land value, indeed matter in explaining population and employment density in Chinese cities. In 1984, these factors explain some of the density differences between historically walled and non-walled cities. However, much of the density differences remain unaccounted for. Among all of the explanatory variables included in the four density regressions in Table 3, the historically walled city dummy has the most consistently significant effect. This is rather remarkable.

## 4.2 Robustness checks

We next perform robustness checks to determine how sensitive our results are to alternative sample constructions and urban shape measures. We report the results in Table 4. Panel A reproduces the baseline results from Table 3 to facilitate comparison, and the other panels

[28] The terrain ruggedness index used in Table 3 is the average within a 50 *km* circle. As a robustness check, we also tried the average index within a 20 *km* circle. The results are qualitatively identical: Terrain ruggedness is always negatively and significantly correlated with the density measures; neither the magnitude nor the statistical significance of the coefficient for the historically walled city dummy is affected.

[29] The six control variables added in Table 3 are conceptually different, so it seems reasonable to include all of them simultaneously without worrying about losing explanatory power due to multicollinearity. We also tried adding one control variable at a time. For the 1984 regressions, the coefficient of the historically walled city dummy is always higher in these alternative specifications, suggesting that together they can explain more of the density difference. For the 2013 regressions, in a few cases adding only one control gives a lower coefficient of the historically walled city dummy, implying that multicollinearity is more of a concern in the 2013 samples. Regardless, the qualitative results are still the same. To conserve space, we are not presenting the results from these alternative regressions; they are available upon request.

present results from each robustness check. To conserve space, for each regression we report only the coefficient of the historically walled city dummy and the number of observations in the sample.

#### 4.2.1 Dropping outliers

The economic density variables have rather large standard deviations, as shown in the summary statistics. For instance, in the 2013 sample of 286 cities, the population density ranges between 15 and 8,248 persons per square kilometer. While the variance is much less dramatic when we use log density as the dependent variable, there is still some concern that extreme density values could drive our main results. We thus drop all the outlier cities with a density value more than two standard deviations away from the sample mean and rerun the regressions. Results in panel B show that compared to the estimates in Table 3, the coefficient of historically walled cities is slightly higher in 1984 and somewhat lower in 2013. The density difference is still statistically significant for all four samples.

#### 4.2.2 Dropping cities that still have significant portions of city walls

In all regressions presented in Tables 2-3, we included the few cities that still have full or partial walls. To make sure that the density differences are not driven by these cities, we remove all the prefectural-level cities with at least two kilometers of remaining city walls, including Chaozhou, Jingzhou, Kaifeng, Nanjing, Shangqiu, Suzhou, Taizhou, and Xi'an.[30] Panel C shows that excluding these cities does not affect our main results.

#### 4.2.3 Dropping frontier provinces

As shown in Figures 6-7, in frontier regions outside of China Proper, there are fewer historically walled cities. To check whether these regions drive our results, we rerun regressions by

[30] As mentioned above, Pingyao and Xingcheng still have complete sets of city walls today. However, they are not prefectural-level cities and thus not in our samples. Datong, a prefectural-level city, has 7.3 *km* of city walls, but it was all rebuilt in the past decade as a man-made tourist attraction. We therefore do not exclude Datong in this robustness check.

dropping cities in six frontier provinces including Xizang, Qinghai, Xinjiang, Inner Mongolia, Heilongjiang, and Jilin. Results in panel D show that excluding frontier cities will substantially reduce the walled-city coefficients in 1984, making the effect much more similar to the effect found in 2013. Again, the coefficient is still statistically significant in all four columns.

#### 4.2.4 Controlling for regional fixed effects

Regression results in Table 3 are partly based on cross-region variation, i.e., estimated by comparing cities in different regions and far away from each other. One may argue, for example, that cities in the north and those in the south emerged in different time periods and contexts and thus are not directly comparable. We thus add region dummies to the regressions to control for regional fixed effects, estimating coefficients using only within-region variation.[31] Results in panel E show that all four coefficients become smaller and only one of them, from the population density regression in 1984, remains (only marginally) statistically significant. We have thus learned that cross-region variation plays a crucial role in improving the precision of our main estimates.

#### 4.2.5 Using common sample of cities

A key result from Table 3 is that the population density difference of historically walled cities declined over time but the employment density difference did not change. However, because the constitution of prefectural-level cities changed between 1984 and 2013, one wonders whether the decline is a result of differing samples. We thus select the subset of 214 cities that appear in all four samples and rerun the four regressions using the same sample. Results in panel F indicate that for population density the coefficient of the walled city dummy still decreases from 1984 to 2013, but to a lesser extent. On the other hand, the coefficient cannot

[31] Following standard practice, we divide Mainland China into seven different regions: North (Beijing, Tianjin, Hebei, Shandong, Shanxi); Northeast (Liaoning, Jilin, Heilongjiang, Inner Mongolia); East (Shanghai, Jiangsu, Zhejiang, Fujian); Central (Henan, Anhui, Jiangxi, Hubei, Hunan); South (Guangdong, Guangxi, Hainan); Northwest (Shaanxi, Gansu, Ningxia, Xinjiang); Southwest (Sichuan, Chongqing, Guizhou, Yunnan, Qinghai, Xizang).

be estimated precisely for employment density in 1984, perhaps due to the significantly reduced sample size (from 288 to 214).

#### 4.2.6 Using alternative urban shape indexes

Regressions in Table 3 use the normalized cohesion index to test whether compactness of an urban area can explain the persistence of economic density. We now try alternative shape indexes including the normalized proximity index, spin index, and range index. Results in panels G-I are almost identical to those in Table 3. We calculate pair-wise correlation coefficients among the four shape indexes and find them to range between 0.659 and 0.995. That is, although these indexes are conceptually different, they contain similar information, which explains why it does not matter which one is used.[32] It is worth noting that although none of the shape indexes are statistically significant in any of the regressions, they always have positive coefficients, consistent with the hypothesis that more compact cities have higher density.

#### 4.2.7 Using 2010 Census data to measure population and employment density

We have used data from the China City Statistical Yearbooks to measure population and employment density as well as some city-level controls. The Yearbook data are widely used by researchers for its easy availability and annual update of a wide range of city characteristics for more than three decades. However, it has a well-known problem: City-level population and employment estimates in the yearbooks are based on the location of residence registration and thus tend to under-represent rural-to-urban migrant workers. This is not an issue for our 1984 regressions because internal migration was tightly controlled at that time, but it causes a concern for our 2013 regressions when migrant workers had become common in most Chinese cities. One worries about whether unaccounted migrant workers is the real reason for the observed lower density in non-walled cities.

[32] We also tried different luminosity thresholds to delineate urban areas and calculate shape indexes. The results remain the same.

To address this concern, we acquired population and employment data from the 2010 Census which was carefully designed to capture all migrants who have lived in urban areas for more than six months.[33] We first compare the 2010 Census data and the 2010 Yearbook data (collected from the 2011 edition of the yearbook). As suspected, the Census data tend to report higher population and employment values due to a better coverage of temporary migrants. Despite this, data from the two sources are highly correlated: The Census and Yearbook city population data have a correlation coefficient of 0.94; their city employment data have a correlation coefficient of 0.91. We next use the 2010 Census data to calculate population and employment density and run a set of regressions for year 2010 with the same specifications as in Tables 2 and 3. (We also use 2010 values of the economic control variables, collected from the Yearbook data.) The results also show that historically walled cities have higher population and employment density. In the specification with fewer controls (as in Table 2), the walled city dummy coefficients are 0.341 and 0.359 in log population and employment density regressions, respectively; additional controls (as in Table 3) will reduce these coefficients to 0.205 and 0.201, respectively. All of these coefficients are still statistically significant. That is, density measures constructed from the 2010 Census data produce qualitatively similar results as those from the Yearbook data.

Overall, these robustness checks show that our main results are insensitive to alternative sample constructions and uses of different urban shape measures. They also reveal that we do need cross-region variation in order to precisely measure the differences in population and employment density between historically walled and non-walled cities.

## 4.3 Discussion

To interpret our results, consider a social planner's problem to build two cities on two sites that are identical in every possible sense, except that one of them has a set of defensive walls. Since building city walls is costly, it makes economic sense to develop greater economic

[33]We thank Yingcheng Li and Hongliang Zhang for sharing the 2010 Census data.

density in the walled city so as to save some construction costs.[34] It thus would not be surprising to see higher density in walled cities if city walls were still in use. However, why do historically walled cities still have significantly higher population and employment density today, decades after the city walls were demolished?

The local fundamentals theory gives one possible explanation. This theory holds that permanent features, such as terrain ruggedness, land productivity, rivers, harbors, etc., could make some locations more suitable for urban economic activity than others (Davis and Weinstein, 2002). Since these features change little over time, they lead to persistence of economic outcomes. This theory could explain our findings if historically walled cities have different local features and are fundamentally different places from others. Some of the control variables included in our regression analysis are motivated by this theory. The statistical significance of the terrain ruggedness index and the agricultural land value is consistent with this theory. There could be other fundamental factors, some perhaps even unobservable, that influence economic density but are not included in our model. The fact that our findings become weaker after controlling for regional fixed effects makes this explanation plausible.

A competing but nonexclusive explanation comes from the theory of path dependence. This theory emphasizes that the development path of a dynamic economic system is not necessarily unique when multiple equilibria exist. An insignificant random factor (e.g., a small initial advantage of a location) could lead a system to one development path, locking in that path due to increasing returns (Arthur, 1994; Fujita et al., 1999). The inclusion of some of the control variables in our empirical analysis, such as the number of historical-cultural sites, industry composition, and urban shape indexes, partially addresses this theory. However, there are likely other unaccounted sources of path dependence.

For example, path dependence may result from zoning practice in history. Even if walled

[34] In the imperial era, central and local governments often shared the costs of building and maintaining the city walls. Local leaders usually faced very tight budget constraints. See Su (1092) for an attempt to strike down a local government's proposal to the emperor to expand their city walls.

cities were not fundamentally different from other places, the physical constraint of city walls required that government quarters, commercial centers, and residential areas had to exist in closer proximity. Increasing returns imply that over time land becomes more valuable when used in the same way as in history. This can be a result of both specialized durable infrastructure (e.g., the White House and the Capitol Building have made their surrounding areas most suitable for government operations) and acquired reputation as intangible assets (e.g., Wall Street will be more valuable when used by the financial sector). Consider central Beijing as an example. Within one mile of Tiananmen Square, there are three densely built shopping districts (Qianmen, Wangfujing, and Xidan). A modern urban planner may consider this design redundant. Indeed, the three shopping districts owe their existence today mainly to historical antecedents: By the Qing Dynasty they were already well-known shopping centers inside the city walls. Even long after the city walls are gone, the land in these areas still commands the highest value for commercial uses. Casual observation suggests many other examples in which functional zoning follows different patterns in historically walled cities, yet it is challenging to systematically measure this difference.

Another possible channel for path dependence is the urban road network. Barrington-Leigh and Millard-Ball (2015) show that urban sprawl is related to the connectivity of street networks, and Baum-Snow (2007) shows that highways facilitate suburbanization of the central city population, both in the context of the U.S. Baum-Snow et al. (2017) show that roads and railroads cause decentralization of population and industrial activities in China. It is possible that historically walled cities have different road networks today. As mentioned above, Chinese walled cities usually had a square shape with a grid road network. It is well known that road networks persist for a long time.[35] Thus historically walled cities may have inherited a grid-type road network and expanded by adding ring roads that are more conducive to high-density economic activities today.[36]

[35] This is why urban economists often use historical road networks as an instrumental variable for today's road networks. See, e.g., Baum-Snow et al. (2017).

[36] Our discussion here focuses on the role of path dependence in urban development. However, it is worth pointing out that as a core concept of the historical institutionalism approach in social science, path

# 5 Conclusion

We document the fact that historically walled cities have higher population and employment density today than non-walled cities, many decades after the city walls were demolished. We propose a few possible explanations of this difference, positing that historically walled cities may have more cultural attractions, different industry compositions, less rugged terrain, more compact urban shapes, and higher land values in surrounding rural areas. We devise an empirical test taking these explanations into account. Although our hypothesized factors can explain some of the observed density differences between walled and non-walled cities, the remaining differences are still large in magnitude and statistically significant. We speculate about potential factors that may account for the remaining differences. Our findings provide insights into the evolution of cities and contribute to the urban economics literature on the persistence of economic activity.

We conduct our empirical analysis at the prefectural city level primarily due to the availability of data for larger cities. As mentioned in the data section, our walled city data for the Qing Dynasty have more than 1,600 observations and we know the exact location of each of these walled cities in history. Thus this analysis can be extended to lower tier cities (e.g., the sample of nearly 2,900 county seats in China today), as long as density measures and other characteristics can be obtained for these smaller cities. Ioannides and Zhang (2017) also analyzed 1,178 walled cities in the earlier Ming Dynasty, so this study can also be extended to allow for a deeper historical dimension. Such studies will not only increase the power of our current test, but could also enable us to explore other issues related to the persistence of urban activities. We leave these for future research.

dependence is found to be relevant in many different fields, including for example other subfields of economics (David, 1985; North, 1990), political science (Pierson, 2000; Pierson and Skocpol, 2002), sociology (Mahoney, 2000), and planning (Sorensen, 2015).

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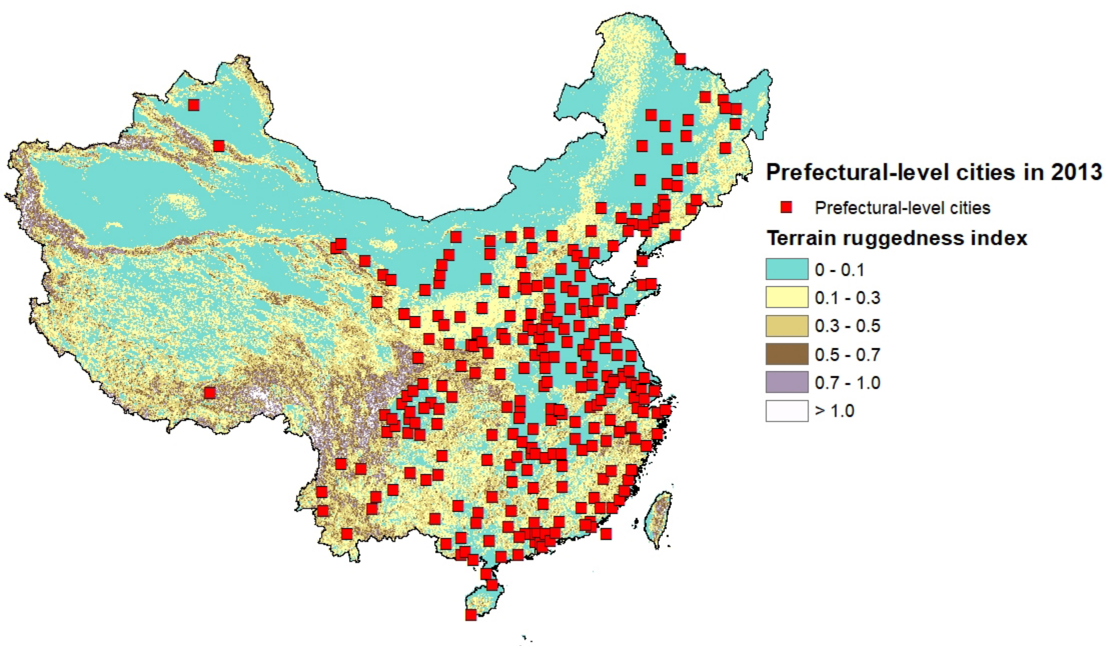
Figure 1: Beijing—an example of a walled city in history

(a) Beijing in 1874

(b) Beijing in 2012

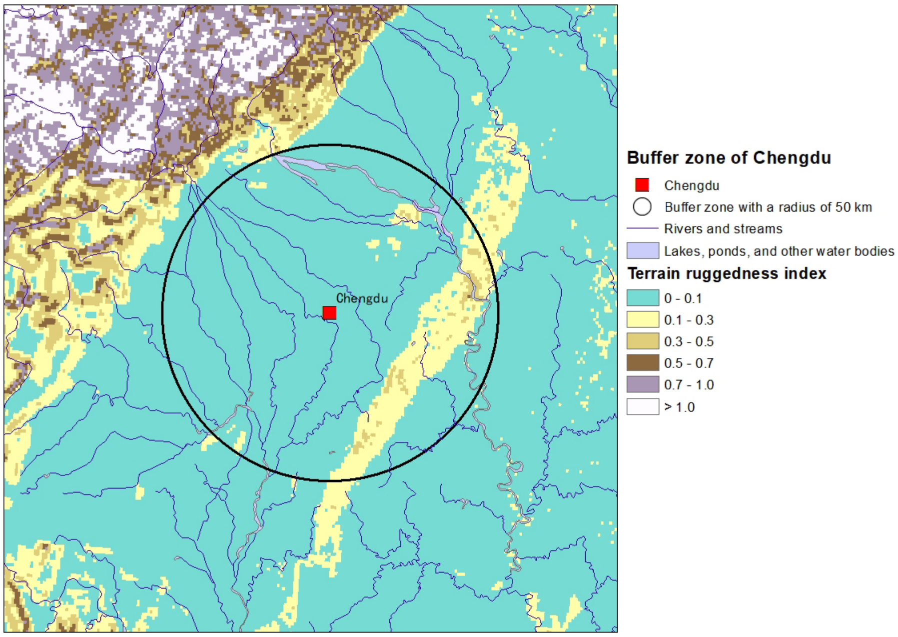
Sources: http://www.photographium.com/south-gate-beijing-china-1874, http://shelu.net/, with authors' modifications. Beijing's inner city wall had a circumference of 24 *km*, which was almost all removed in the 1960s. A 1.5-*km* section behind the corner tower remains today.

Figure 2: Prefectural-level cities in China, 2013

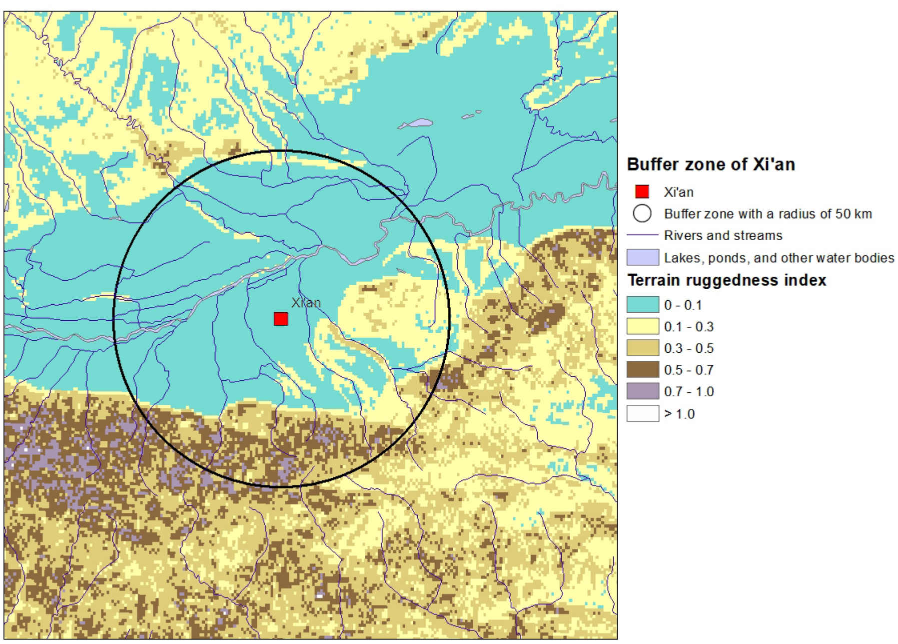



Note: See section 3.3 for the definition of the terrain ruggedness index.

Figure 3: Illustrations of buffer zones

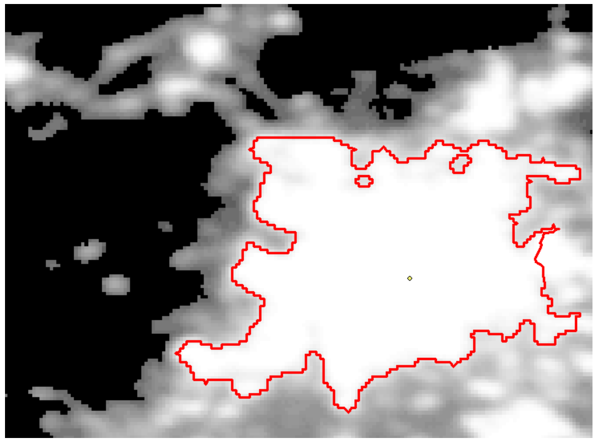



(a) Chengdu – a city on a vast plain with mountains in the distant northwest



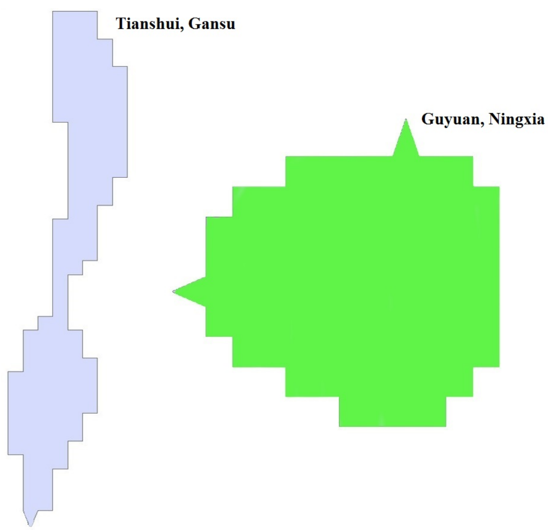

(b) Xi'an – a city on a flood plain with mountains nearby in the south

Figure 4: Delineating the Beijing area using 2013 nighttime light intensity data



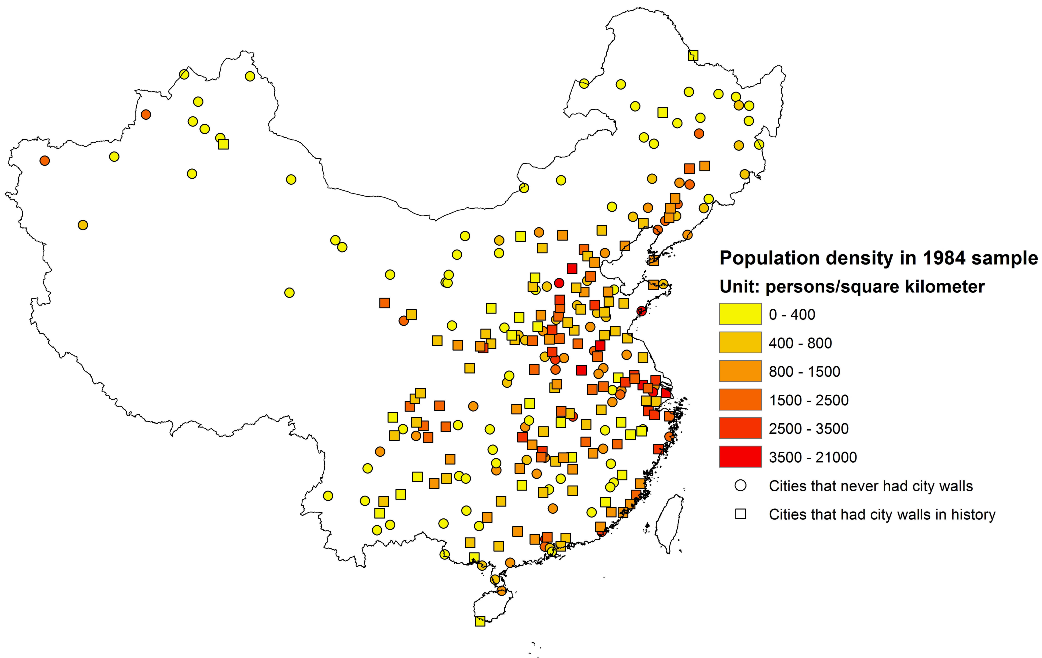
Note: We consider the spatially contiguous lighted areas surrounding the city coordinates with luminosity above a threshold of 45 as the urban area.

Figure 5: Urban shape metrics: an illustration

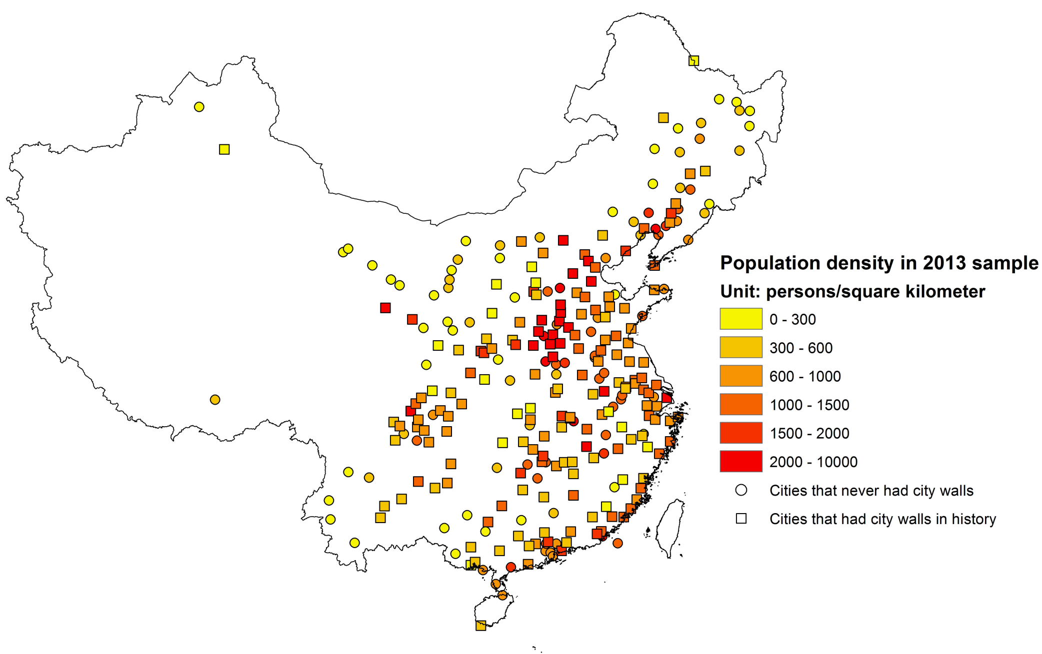



| Shape metric | Tianshui | | Guyuan | |
|---|---|---|---|---|
| | | Normalized | | Normalized |
| Cohesion, 100 $km$ | 0.104 | 0.463 | 0.039 | 0.994 |
| Proximity, 100 $km$ | 0.081 | 0.438 | 0.029 | 0.999 |
| Spin, $10^4$ $km$ | 0.008 | 0.177 | 0.001 | 0.966 |
| Range, $km$ | 0.313 | 0.341 | 0.106 | 0.806 |

Figure 6: Population density of prefectural-level cities



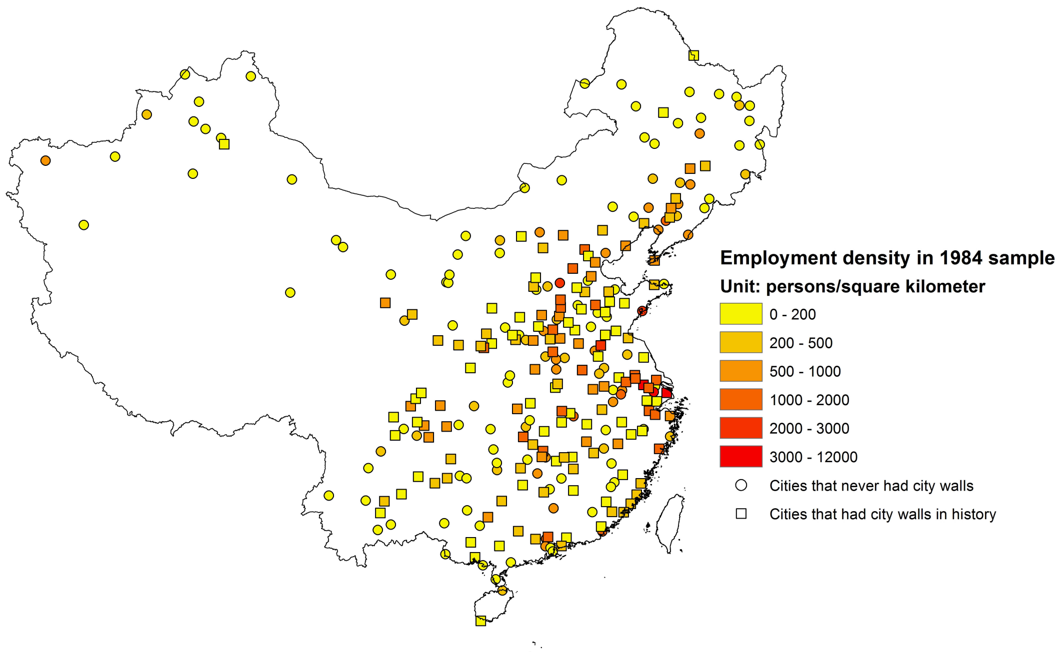

(a) 1984 population density



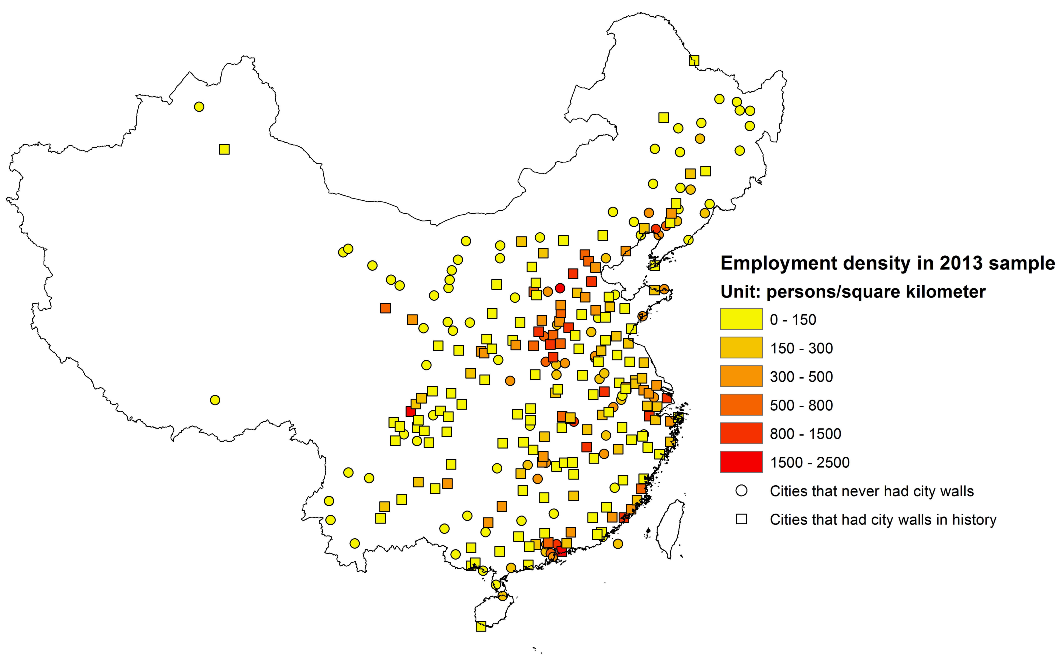

(b) 2013 population density

Note: A square represents a historically walled city; a circle represents a city that never had city walls. A darker color indicates higher population density.

Figure 7: Employment density of prefectural-level cities




(a) 1984 employment density




(b) 2013 employment density

Note: A square represents a historically walled city; a circle represents a city that never had city walls. A darker color indicates higher employment density.

Table 1: Summary statistics: cities with and without defensive walls in history

| | 1984 | | | 2013 | | |
|---|---|---|---|---|---|---|
| | Obs. | Mean | Std. dev. | Obs. | Mean | Std. dev. |
| **Panel A: historically walled cities** | | | | | | |
| Population density (persons/$km^2$) | 145 | 1330.903 | 1856.885 | 176 | 1011.292 | 793.697 |
| Employment density (persons/$km^2$) | 145 | 561.502 | 1034.386 | 171 | 274.494 | 346.546 |
| No. of historical-cultural sites | 145 | 7.717 | 13.122 | 176 | 6.722 | 12.123 |
| Share of service sector | 145 | 0.145 | 0.066 | 176 | 0.503 | 0.136 |
| No. of industrial enterprises | 145 | 592.021 | 740.896 | 176 | 659.932 | 1163.490 |
| Terrain ruggedness index | 145 | 17.532 | 15.905 | 176 | 18.506 | 16.114 |
| Normalized cohesion index | 145 | 0.929 | 0.082 | 176 | 0.873 | 0.100 |
| Agricultural land value ($10^4$ yuan/hectare) | 145 | 1.725 | 2.359 | 176 | 797.98 | 5602.56 |
| GDP ($10^8$ yuan) | 145 | 24.375 | 57.750 | 176 | 1560 | 3030 |
| GDP per capita ($10^4$ yuan) | 145 | 0.219 | 0.169 | 176 | 6.955 | 4.975 |
| Provincial capital | 145 | 0.166 | 0.373 | 176 | 0.148 | 0.356 |
| Seaport | 145 | 0.117 | 0.323 | 176 | 0.114 | 0.318 |
| **Panel B: non-walled cities** | | | | | | |
| Population density (persons/$km^2$) | 143 | 735.958 | 945.319 | 110 | 751.034 | 939.530 |
| Employment density (persons/$km^2$) | 143 | 292.599 | 489.370 | 104 | 184.912 | 259.164 |
| No. of historical-cultural sites | 143 | 2.189 | 4.021 | 110 | 2.855 | 4.447 |
| Share of service sector | 143 | 0.140 | 0.085 | 109 | 0.488 | 0.164 |
| No. of industrial enterprises | 143 | 269.105 | 290.915 | 110 | 404.718 | 941.113 |
| Terrain ruggedness index | 143 | 19.312 | 17.912 | 110 | 18.667 | 20.178 |
| Normalized cohesion index | 143 | 0.930 | 0.105 | 110 | 0.854 | 0.109 |
| Agricultural land value ($10^4$ yuan/hectare) | 143 | 1.377 | 1.011 | 110 | 269.85 | 227.08 |
| GDP ($10^8$ yuan) | 143 | 8.886 | 13.801 | 110 | 798.222 | 1.230 |
| GDP per capita ($10^4$ yuan) | 143 | 0.175 | 0.165 | 110 | 7.141 | 5.881 |
| Provincial capital | 143 | 0.021 | 0.144 | 110 | 0.036 | 0.188 |
| Seaport | 143 | 0.070 | 0.256 | 110 | 0.100 | 0.301 |

Table 2: Density differences: baseline estimation

| | 1984 | | 2013 | |
|---|---|---|---|---|
| | log(pop. den.) | log(emp. den.) | log(pop. den.) | log(emp. den.) |
| | (1) | (2) | (3) | (4) |
| Historically walled city | 0.603*** | 0.513*** | 0.299*** | 0.351*** |
| | (0.135) | (0.100) | (0.139) | (0.122) |
| Log(GDP)[a] | 0.318*** | 0.0888 | 0.491*** | 0.424*** |
| | (0.083) | (0.085) | (0.076) | (0.096) |
| Log(GDP per capita)[a] | 0.382*** | 1.157*** | -0.230** | 0.508*** |
| | (0.114) | (0.117) | (0.113) | (0.140) |
| Provincial capital | -0.264 | 0.258 | -0.237 | 0.0510 |
| | (0.251) | (0.258) | (0.187) | (0.233) |
| Seaport | 0.306 | 0.339 | 0.109 | 0.175 |
| | (0.219) | (0.225) | (0.160) | (0.197) |
| Constant | Yes | Yes | Yes | Yes |
| $R^2$ | 0.410 | 0.585 | 0.277 | 0.445 |
| No. of observations | 288 | 288 | 286 | 275 |

Standard errors in parentheses. * $p < 0.1$, **$p < 0.05$, ***$p < 0.01$. [a] Note that we use Gross Industrial Output Value (per capita) instead of GDP (per capita) for the 1984 sample because the official GDP statistics were not computed in China at that time.

Table 3: Density differences: testing hypotheses with additional controls

| | 1984 | | 2013 | |
|---|---|---|---|---|
| | log(pop. den.) (1) | log(emp. den.) (2) | log(pop. den.) (3) | log(emp. den.) (4) |
| Historically walled city | 0.417*** | 0.337** | 0.276*** | 0.337*** |
| | (0.127) | (0.133) | (0.099) | (0.118) |
| **Hyp 1:** No. of historical-cultural sites | 0.00009 | 0.00513 | -0.00694 | 0.00206 |
| | (0.007) | (0.007) | (0.006) | (0.007) |
| **Hyp 2:** Share of service sector | 4.108*** | 1.774* | -0.452 | -1.924*** |
| | (0.959) | (1.000) | (0.378) | (0.441) |
| **Hyp 2:** Log(no. of industrial enterprises) | 0.589*** | 0.819*** | 0.0842 | 0.109 |
| | (0.136) | (0.141) | (0.080) | (0.094) |
| **Hyp 3:** Terrain ruggedness index | -0.00806** | -0.00967** | -0.0124*** | -0.0124*** |
| | (0.004) | (0.004) | (0.003) | (0.003) |
| **Hyp 4:** Normalized cohesion index | 0.909 | 0.779 | 0.0931 | 0.320 |
| | (0.647) | (0.669) | (0.463) | (0.547) |
| **Hyp 5:** Log(Agricultural land value) | 0.172* | 0.00205 | 0.222*** | 0.214*** |
| | (0.098) | (0.102) | (0.066) | (0.077) |
| Log(GDP)[a] | -0.205 | -0.615*** | 0.250** | -0.0264 |
| | (0.136) | (0.142) | (0.122) | (0.143) |
| Log(GDP per capita)[a] | 0.934*** | 1.724*** | -0.224* | 0.540*** |
| | (0.142) | (0.148) | (0.114) | (0.137) |
| Provincial capital | -0.345 | 0.0334 | 0.219 | 0.825*** |
| | (0.240) | (0.248) | (0.212) | (0.248) |
| Seaport | -0.127 | 0.0912 | -0.0246 | 0.163* |
| | (0.226) | (0.236) | (0.166) | (0.199) |
| Constant | Yes | Yes | Yes | Yes |
| $R^2$ | 0.513 | 0.647 | 0.377 | 0.537 |
| No. of observations | 288 | 288 | 284 | 275 |

Standard errors in parentheses. * $p < 0.1$, **$p < 0.05$, ***$p < 0.01$. [a] Note that we use Gross Industrial Output Value (per capita) instead of GDP (per capita) for the 1984 sample because the official GDP statistics were not computed in China at that time.

Table 4: Reestimating density differences: robustness checks

| | 1984 | | 2013 | |
|---|---|---|---|---|
| | log(pop. den.) | log(emp. den.) | log(pop. den.) | log(emp. den.) |
| | (1) | (2) | (3) | (4) |
| A. Baseline results from Table 3 | 0.417*** | 0.337** | 0.276*** | 0.337*** |
| | (0.127) | (0.133) | (0.099) | (0.118) |
| No. of observations | 288 | 288 | 284 | 275 |
| B. Dropping outliers | 0.455*** | 0.367*** | 0.195** | 0.248** |
| | (0.129) | (0.135) | (0.096) | (0.111) |
| No. of observations | 281 | 281 | 257 | 257 |
| C. Dropping cities that still have walls | 0.422*** | 0.334** | 0.262** | 0.320*** |
| | (0.130) | (0.135) | (0.101) | (0.120) |
| No. of observations | 282 | 282 | 276 | 267 |
| D. Dropping frontier provinces | 0.212** | 0.198* | 0.220** | 0.248** |
| | (0.102) | (0.118) | (0.101) | (0.124) |
| No. of observations | 236 | 236 | 254 | 245 |
| E. Controlling for regional fixed effects | 0.224* | 0.202 | 0.144 | 0.177 |
| | (0.129) | (0.137) | (0.098) | (0.116) |
| No. of observations | 288 | 288 | 284 | 275 |
| F. Using common cities | 0.295** | 0.195 | 0.250** | 0.294** |
| | (0.120) | (0.128) | (0.121) | (0.137) |
| No. of observations | 214 | 214 | 214 | 214 |
| G. Using proximity index | 0.411*** | 0.330** | 0.275*** | 0.336*** |
| | (0.128) | (0.133) | (0.099) | (0.118) |
| No. of observations | 288 | 288 | 284 | 275 |
| H. Using spin index | 0.413*** | 0.333** | 0.275*** | 0.337*** |
| | (0.128) | (0.133) | (0.099) | (0.118) |
| No. of observations | 288 | 288 | 284 | 275 |
| I. Using range index | 0.420*** | 0.339** | 0.278*** | 0.340*** |
| | (0.127) | (0.133) | (0.099) | (0.118) |
| No. of observations | 288 | 288 | 284 | 275 |

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. In each robustness check, the first row presents the coefficients of the "historically walled city" dummy, with specifications identical to those in Table 3.