Comparing Cities in Developed and Developing Countries: Population, Land Area, Building Height and Crowding

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October 12, 2020

Abstract

Historically, richer countries have had larger cities than poorer countries. Today, urban giants are no longer concentrated in rich countries. However, there are clear differences in *physical* city characteristics associated with country incomes. These differences are easily reconciled mathematically as population is the product of land area, structure space per unit land (i.e., heights), and population per unit interior space (i.e., crowding). This paper explores how these components have changed for the whole world and what remains of the association between income and city development using a combination of harmonized old and new databases. We document that cities in richer countries are large because they build "out" and build "up". Cities in poorer countries have become as large because they have crowded "in". Therefore, similar city sizes now hide stark differences in physical urban development. We also show how the Standard Urban Model can account for both similarities and differences in physical urban development across countries.

JEL Codes: R13; R14; R31; R41; R42; O18; O2; O33

Keywords: Urbanization; Cities; Urban Giants; Population; Physical Urban Development; Building Heights; Housing; Land Expansion; Sprawl; Standard Urban Model

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1. Introduction

Other than similar population, cities like New York, Beijing, Sao Paulo, Mexico, Mumbai, Cairo and Dhaka, which are all located in countries with different income and urban technology levels, appear to have little in common. As can be seen in Table 1, while these cities all have the same population (close to 19 million), Beijing, Sao Paulo, Mexico, Mumbai, Cairo and Dhaka are all much less developed economically, whether measured by total GDP – which is 71-97 percent lower than in New York – or satellite night lights – their total sum of night lights is 79-99 percent lower –, and have much less interior space, as measured by either land area – they use 63-97 percent less land – or building heights – tall buildings are 59-90 percent shorter there.

Cities in developing countries are thus relatively large in terms of population size, but not in other dimensions such as land area, interior space, and GDP. Based on the data we have assembled, while cities in developing countries – including low-income countries, lower-middle income countries, and upper-middle income countries, according to the World Bank in 2016 – make up 74% of the total population of our main sample of about 1,000 world cities, they account for 50% of total land area, 36% of total interior space, 42% of total GDP, and 24% of night lights (see Web Appendix Table A1 for details). These patterns are accentuated when reclassifying upper-middle income countries as developed. Although cities in this second group of developing countries make up 31% of population, they account for 17% of land area, 8% of interior space, 9% of GDP, and 5% of night lights (ibid.).

This raises several questions. How can we account for the increasing disconnect between the population and the economic and physical size of cities? Relatedly, how have cities in developing countries become "physically" able to accommodate such large populations, and what does the answer to that question imply for the relation between city population size and income within and across countries? Population is the product of land area, structure space per unit land (i.e., building heights), and population per unit interior space (i.e., crowding). How do such components vary across income levels today, and how can their evolution account for the faster population growth of poor country cities relative to rich country cities?

The main purpose of this paper is to provide careful documentation of the similarities and differences between the cities of rich countries and the cities of similar population but located in poor countries. In the process of making these cross country comparisons, a variety of new data sources are assembled and merged – including a novel data set of all *tall buildings* (above 80 meters) in the world – to reveal new stylized facts about cross country variation in city characteristics.

Using this data, we find that the elasticity of city size with respect to income per capita across countries, which was positive in the past, is now zero. In other words, developing countries are now as likely as developed countries to have large agglomerations. However, urban giants in poor countries are not large cities using measures of economic or physical urban development.

Relatedly, the elasticity of city size with respect to income per capita can be decomposed into the income elasticity of land area, the income elasticity of building height and the income elasticity of occupant density – i.e., how city land areas, building heights and crowding vary with income across countries. First, we find that cities in richer countries are large because they disproportionately build *out* – i.e., use more land – and build *up* – i.e., have taller buildings –. As a result, cities in rich countries have far more interior space. Thus, even if their residents are richer and use more interior space per capita, their cities are still highly populated. Conversely, cities in poorer countries are large despite the fact that they build little interior space. Indeed, we find that they disproportionately crowd *in*, however not necessarily through slum expansion. Second, the faster population growth of cities in poorer countries relative to cities in richer countries since 1960 is due to poor country cities becoming more crowded over time for a given low income level. This effect was strong enough to dominate the fact that rich country cities have been building up more since 1960 for a given high income level. Thus, cities in rich and poor countries have reached similar population sizes, but they have done so in very different ways.

We then ask whether the Standard Urban Model (SUM) initially developed by Alonso (1964), Mills (1967, 1972) and Muth (1969) and subsequently reviewed by Brueckner (1987) and Duranton and Puga (2015) can account for both similarities and differences in city development across countries or whether new models are needed. We find that the SUM can account for the relation between city population size and income, and thus physical urban development, within a single country. We then discuss how the SUM can be used to describe distinct patterns of physical urban development across countries with different income levels, i.e. how cities in poor countries can outgrow cities in rich countries without building as much interior space.

This paper makes several additional contributions. First, we add to the literature on the drivers of city population sizes differentially across richer and poorer countries. As such, our analysis is closely related to Chauvin, Glaeser, Ma and Tobio (2016), but also Quintero and Roberts (2018) and Quintero and Restrepo (2020). Yet, while they analyze how the economic effects of population density vary across countries with different income levels, we focus on how the physical components of population density vary across all countries in the world. A contribution of this paper is to assemble a large data set of physical characteristics for the largest agglomerations in the world. This involved the assembly of various data sets because existing city databases lack information on land area, structures and crowding. Doing so allows us to open the black box of cities and study what they are made of: people, but also land and structures.

We document the disconnect between urbanization and economic development, much like the literature on "urbanization without growth" (Fay and Opal, 2000a; Glaeser, 2014b; Jedwab and Vollrath, 2015; Castells-Quintana, 2017; Castells-Quintana and Wenban-Smith, 2019). However, we do not attempt to explain the disconnect. Instead, our contribution is to document how this disconnect is *physically* possible. It appears that many residents in the cities of poor countries are willing to live in crowded units, which implies that either they put less value on housing consumption in their utility functions or they choose to live in cities despite relatively low income levels.[1]

By studying how land areas, structure heights, densities and crowding vary across world cities and over time (1960-2015), we complement the few studies on how city structure varies globally. Angel et al. (2005), Angel et al. (2012), the Atlas of Urban Expansion (2016) – which is a follow-up study of the two previous studies – and Khan et al. (2019) examine the correlation between population growth and land expansion since about 1990 for about 90, 120, 200 and 4,000 world cities respectively. These studies all show how city land areas dramatically increase with income. Mahtta et al. (2019) classify 478 cities based on whether they built up or spread out between 2000 and 2015. Our analysis complements this research because we study more than 1,000 cities from 1960 to 2015 simultaneously considering land expansion, building heights and crowding, and discuss how the observed patterns can be interpreted within existing urban theory.

There are excellent studies on some of these aspects of cities in developing countries (e.g., Deng et al., 2008; Brueckner and Selod, 2009; Harari, 2016; Henderson et al., 2016b; Baruah et al., 2017; Ioannides and Zhang, 2017; Gaduh and Civelli, 2018; Selod and Tobin, 2018; Brueckner et al., 2019) and developed countries (e.g., Glaeser and Kahn, 2004; Burchfield et al., 2006; Baum-Snow, 2007; Saiz, 2010; Garcia-Lopez et al., 2015; Liu et al., 2018; Ahlfeldt and McMillen, 2018; Arribas-Bel et

[1]In the last section of the paper, we discuss explanations for this disconnect, such as urban-rural real wage gaps (Gollin et al., 2013; Lagakos et al., 2018; Busso et al., 2020) or amenity gaps (Jedwab et al., 2015; Gollin et al., 2017; Jedwab and Vollrath, 2019) widening for a given income level. Such gaps can be due to urban bias (Ades and Glaeser, 1995; Davis and Henderson, 2003; Castells-Quintana and Royuela, 2015), conflict (Fay and Opal, 2000b; Maystadt and Duranton, 2014), natural disasters (Barrios et al., 2006; Henderson et al., 2016a; Castells-Quintana and McDermott, 2019) or trade (Glaeser, 2014b). We provide new evidence on the physical nature of the urbanization process of poor countries but cannot inform about the drivers of this process (see Henderson and Turner (2020) for a survey of the literature).

al., 2019; Combes et al., 2017, 2019; Jedwab et al., 2020). However, most of these studies focus on one country or city, and examine only one component of city structure at a time. Very few of these studies specifically consider tall buildings (see Ahlfeldt and Barr (2020) for a recent survey of the literature on the economics of skyscrapers). This paper includes novel data on building heights. Our analysis then complements these analyses by giving a bigger picture of the patterns of land expansion, verticalization and crowding across the whole world.

Third, in comparing cities of different sizes over time, it is useful to adopt some theoretical model that can serve as a basis for identifying critical measures. The SUM has been widely used to test relations among city characteristics to determine if they are consistent with theory. The first test associated with examination of urban structure involves computation of urban density gradients, the percent fall in density with distance from the city center. The SUM predicts that density gradients should vary inversely with transportation costs and income but that they should not vary with city size. Mills (1972) demonstrated that density gradients fell for U.S. cities beginning from the middle of the nineteenth century as income rose and transportation technology improved but that the fall was not a function of city size. Subsequently, Mills and Tan (1980) found that density gradients were significantly steeper for cities in low income countries but had also been falling over time. Many papers, such as Thurston and Yezer (1994), have demonstrated that density gradients are independent of city size as well as other factors such as crime and population composition, and that income and transportation cost influence the density gradient as suggested by theory. Overall, testing indicates that negative exponential population density gradients can be used to characterize cities over time and across countries.

The second approach to testing and applying the SUM has involved the literature on sprawl. Brueckner and Fansler (1983) were the first to test the hypothesis that sprawl was a market-based phenomenon following general properties of the SUM identified by Wheaton (1974). Specifically, they showed that city radius is an increasing function of population and income and a decreasing function of transportation cost and the cost of non-urban land. Their seminal work prompted a series of papers such as McGrath (2005) performing similar tests on cities in developed countries where the general finding is that the effects on size are consistent with the predictions of theory. This has led to the general result that larger land area of cities in higher income countries has been generated by improvements in transportation technology and rising income.

Regrettably the data requirements required for computing density gradients or conducting Brueckner-Fansler testing are well beyond what is available for cities around the world that are the object of this paper. Testing for differences in cities between rich and poor countries in this paper is instead based on a more straightforward identity that total population is equal to the product of land area, building heights and crowding, which then all vary with income.[2]

The paper is organized as follows. Section 2. discusses the implications of the SUM for the relation between population and physical characteristics of cities, first within a same country, and then across countries. Section 3. presents the data used in the analysis. Section 4. decomposes for a sample of world cities total population into land, structures, and crowding. Section 5. concludes.

2. Theoretical Motivation for the Empirical Analysis

This section develops the implications of the SUM for patterns of urban development including effects of income (and other factors) *within* and *across* countries. The main results are described here but the full model and the proofs can be found in Web Appendix Section A.

Basic Model. The strong form of the SUM implies that in a city with a dominant central business district, population density will follow a negative exponential distribution $D(k) = D_o e^{-\lambda k}$ where D is population density, D_o is density at the edge of the central business district, λ is the rate at which density falls with distance known as the "population density gradient" and k is distance from the edge of the central business district. This implies that total population, N, is given by:[3]

$$N = \int_0^{k^*} \theta D(k) dk = \int_0^{k^*} \theta D_o e^{-\lambda k} dk \tag{1}$$

where $\theta = 2\pi$ times the fraction of land available for housing and k^* is the distance of the edge of the city itself. Population density $D(k)$ is then the quotient of housing structure density $(H/L)(k)$ and housing consumption per household $h(k)$. Equation (1) can be rewritten as follows:

$$N = \int_0^{k^*} \theta D(k) dk = \int_0^{k^*} \theta (H/L)(k)/h(k) dk. \tag{2}$$

We then use our model to obtain housing structure density and housing consumption per household as a function of the housing price $r(k)$ and the exogenous parameters. Knowing the house price gradient, we obtain the population density gradient as a function of the parameters:

[2] There are also notable examples of applications of the SUM to poor countries (e.g., Brueckner, 1990; Bertraud and Malpezzi, 2001; Bertaud and Brueckner, 2005; Brueckner and Sridhar, 2012).

[3] This is termed a strong form SUM because Brueckner (1982) and Kim and McDonald (1987) demonstrated that, in order for equation (1) to hold strictly, the real income constant own price elasticity of housing demand must be minus one. The model used here is based on Mills (1967) and Muth (1969) and requires stronger assumptions than numerical approaches but it facilitates the demonstration of theoretical results that can be tested against current sources of comparable data on world cities.

$$dln\, D(k)/dk = -\lambda = -t/(\beta v) \text{ or } D(k) = D_o e^{-(t/\beta v)k} \tag{3}$$

where v is total expenditure on housing, t is commuting cost per unit distance, and β is the share of land in housing construction. As a result, total population, N, is equal to

$$N = \int_0^{k^*} \theta D_o e^{-(t/\beta v)k} dk. \tag{4}$$

We then show that, for large cities, the definite integral of equation (4) can be written as:

$$ln\, N = ln\, \theta + ln\, D_0 - 2ln\, \lambda = ln\, \theta + ln\, D_0 - 2ln\, (t/(\beta v)) \tag{5}$$

The elasticity of population with respect to central density is $dlnN/dlnD_0 = 1$, as a given percentage rise in central density raises densities throughout the city by the same percentage. *Holding constant central density* (which also varies with the parameters), factors that flatten the gradient like housing expenditure, v, and the share of land in housing, β, increase population while higher commuting cost t steepens the gradient and hence lowers population.

Varying the Size of Cities within a Given Country. In order to generate cities of different sizes, the standard approach is to formulate an open city version of the SUM in which wages vary due to exogenous labor productivity differences.[4] It is then possible to solve for the relation between earnings paid to workers in the city and total population of the city. Once this relation is established, the implications for other city characteristics can be demonstrated and the question of whether these changes are all proportional to differences in population or not can be determined.

Population growth and land expansion result when labor earnings increase.[5] In addition to expanding the city boundary, the rise in city earnings raises the utility of workers living closer than k^* to exceed that of workers in other cities. Their willingness to pay for housing in the city rises. In order to maintain the iso-utility condition among cities, rents rise throughout the growing city.[6] In particular, given our assumptions, the percentage increase in rent needed to offset a given

[4]The SUM does not include agglomeration economies. However, given the latter, labor productivity differences are likely endogenously determined by city population sizes. For the sake of simplicity, we ignore how city population size affects incomes and focus on how city populations respond to income differences across cities. We are thus modeling the supply of labor to cities leaving the demand for labor exogenous.

[5]Raising earnings by $\triangle y$ means that workers at the city edge who were paying $r(k^*)$ for housing will be willing to pay an additional $\triangle y = t\triangle k$ for transportation to work. The outer boundary of the city can expand by $\triangle k^* = \triangle y/t$. Thus, if y increases in one city, k^* in that city will increase until the workers at the edge are indifferent between working at the CBD or outside the city. As k^* and thus total land area increase, population also increases.

[6]The increase in rent $\triangle r$ required to maintain the iso-utility condition implies that housing expenditure must rise by $h\triangle r$ to offset the increase in earnings $\triangle y$. It follows that $\triangle y = h\triangle r = (h\triangle r)r/r$. Given that housing expenditure $v = rh$ because the real income constant own price elasticity of demand is -1, $\triangle y = vr\triangle/r$.

percentage rise in income is equal to the inverse of the share of housing in income.[7]

We can then use these results and other results shown in the model appendix to obtain the total differential of equation (5) with respect to city earnings. We find what we believe to be a new result. The elasticity of city population size with respect to wages within a given country is equal to:

$$d\,ln\,N/d\,ln\,y = 1/(\beta\eta) + 1/\eta \tag{6}$$

where η is the share of housing in household consumption and β is the share of land in housing supply. Equation (6) implies that the elasticity of population with respect to income is a constant equal to a function of the share of housing in income and the share of land in housing construction. Thus, the elasticity decreases with the importance of housing in household consumption bundles and the share of land in housing construction.[8] The rise in housing price is larger when the share of land inputs, i.e. β, is larger. Indeed, if structure cannot be easily substituted for land, and given significant commuting costs, housing prices will rise more when income increases. Note that there is a transportation cost effect because commuting distance and cost are embodied in the model. However, because transportation cost per unit distance traveled is assumed constant within a country, perhaps because larger cities have more investment in transportation capacity, it does not enter the expression. The rise in housing price has a larger negative effect on population when the fraction of income spent on housing, reflected in η, is larger.

The claim that, using a version of the SUM consistent with a negative exponential population density function, the urban wage premium (UWP) is a simple function of two parameters, the share of land in housing and the fraction of income spent on housing, suggests that the UWP may not vary across low and high income countries. It is useful to consider how close equation (6) is to existing estimates of the U.S. UWP. It is possible to calculate the elasticity for the U.S. because there are well accepted values for the share of housing in consumption in income, η = 0.3, and for the share of land in housing, β = 0.2 (Glaeser and Gyourko, 2018). Using these values, the calculated elasticity is 20. Inverting this expression, we obtain a premium of 0.05, so a 20% rise in population implies a 1% rise in earnings presumably generated by agglomeration economies. The general consensus is that the U.S. urban wage premium is 0.05-0.06 (Combes and Gobillon, 2015). In Web Appendix Section F1., we discuss how these estimates are remarkably consistent across countries and with the prediction implied by equation (6). Furthermore, empirical testing

[7]Letting η be the fraction of income spent on housing so that $v = \eta y$, this implies $y = \eta y \Delta r/r$ or $\Delta y/y = \eta \Delta r/r$ or that $dlny = \eta dlnr$ and $dlnr/dlny = 1/\eta$.

[8]This result is consistent with but not based directly upon the Rosen-Roback model (Rosen, 1979; Roback, 1982), which states that, in order to attract labor, growing cities must overcome rising housing prices.

performed in Web Appendix Section F2. suggests that the UWP might be one characteristic of cities that does not vary with country income per capita as predicted by the model.

Strict application of Equation (6) to differences in the UWP across countries involves a joint hypothesis. First that the application of the version of the SUM in this paper to cities in high and low income countries is correct. Second, that the parameters, β and η, do not vary systematically across these countries, or if they do vary, that they vary inversely so that Equation (6) still gives the same UWP. Thus, the results of empirical tests reported in the Web Appendix Section F1. could possibly be viewed as an indication that this joint hypothesis holds in the data.

Other propositions are also presented in the model appendix. As expected, within a given country, higher income cities use more land and have higher structure, interior, and population densities. They accommodate larger populations by building "out" and "up" and crowding "in".

Comparing Cities in Developed Countries and Developing Countries The claim, based on the discussion above, that *within* a country there is a regular relation among land area, building heights, and population and interior densities, needs not hold *across* countries. In contrast, mobility is usually not free across countries.[9] Comparing developed and developing cities, there are also obvious differences in key parameters. First, real incomes are an order of magnitude higher in the cities of developed countries, and thus total expenditure on housing is much higher. It follows that housing consumption per household is higher. Superior building technology and better institutions mean that it is easier to build up. Lastly, it might be that commuting costs are lower in developed countries due to advanced commuting technology there. However, one element of commuting cost is the opportunity cost of time and, given that wages are an order of magnitude higher in developed cities, this inequality is ambiguous.

The implications of differences in the parameters for city structure are evident in equation (3) above and equation (7) below. Equation (3) shows that the slope of the population density gradient flattens as commuting costs decrease (since building out becomes cheaper), the importance of land in construction increases (the city then disproportionately needs land and must build out to grow), and income increases (housing space demand increases with income). This result is important because, comparing developed or developing cities with equal population, if the density function of the developed city is flatter because of higher income and possibly better commuting technology (i.e. lower commuting costs), then the radius of the developed city is larger

[9]We thus abstract from cases where countries have an integrated labor market, as in Europe, or where borders can be porous, as in some African countries. We also ignore how highly skilled migrants may face lower border costs.

and the central density of the developed city must be lower. This relation is shown in Figure 1, which plots the population density functions of a developed city and a developing city of similar sizes. Overall, the developed city uses more land and is less dense.

Equation (7) reproduced here then implies that structure density (housing H divided by land L) at distance k is determined by construction technology (A), the share of housing in land (β), the price of structure inputs (p_s), and the price of housing space at distance k ($r(k)$):[10]

$$(H/L)(k) = ln\,(A\phi) + [(1-\beta)/\beta]ln\,r(k) - (1-\beta)/\beta ln\,p_s \tag{7}$$

Consider central structure density at $(H/L)(0)$. Equation (7) suggests that unless the price of structure inputs p_s is much lower or the housing price in the center $r(0)$ is much higher in developing cities, the positive relation between construction technology (A) and development should produce higher central structure densities in developed cities. We also find that the declining slope of the structure density gradient is $d\,ln\,(H/L)/dk = -t(1-\beta)/(\beta v)$. It is flatter in richer countries as housing expenditure v is higher by an order of magnitude.[11] Figure 2 displays the relation between structure density functions of cities with the same population size in developed and developing countries. As seen, the developed city has higher structure density. It also has more total interior space, given the higher structure density *and* larger land area.

Finally, if the developing city has higher overall density and lower structure density, the only possibility is that it has higher interior, or occupant, density (N/H where N is population). Accordingly, the SUM suggests systematic differences between cities in high and low income countries that will be examined in the empirical tests below.

Decomposition of Total City Population Across Countries. We do not have information on the various parameters of the model for enough world cities. Therefore, for our empirical analysis, it will be useful to consider a simple decomposition of the determinants of total city population. In particular, total city population is the product of *land area*, *structure density* or interior space per unit land (i.e., heights), and *occupant density* or population per unit interior space (i.e., interior crowding):

$$N = L(H/L)(N/H) \tag{8}$$

where N = population, L = land area, H = interior space, so that (H/L) = structure density and (N/H) = occupant density. This equation is written in terms of a product of averages rather than

[10] In order to economize on notation let $\phi = (1-\beta)(1-\beta)\beta\beta)$ which is strictly positive.

[11] It could also be that the structure density gradient is flatter in cities in developed countries because t falls with improved transportation technology. While this is true, transportation cost also includes the value of time which rises with income. Therefore, the relation between t and economic development may be ambiguous.

an integral as in equation (2). Next, total differentiation of equation (8) with respect to per capita income y yields:

$$dlnN/dlny = dlnL/dlny + dln(H/L)/dlny + dln(N/H)/dlny. \tag{9}$$

Thus, the elasticity of city population size with respect to income should be equal to the sum of the elasticities of land area, structure density and occupant density with respect to income. We will investigate how our measures of *land area*, *structure density* and *occupant density* vary across income levels today, as well as in the past. The goal of this exercise is to improve our understanding of how the evolution of these components can account for the faster population growth of cities in poor countries compared to rich countries.

3. Data on the World's Largest Agglomerations

For our decomposition exercises, we need data on populations, incomes, land areas, and building heights. One contribution of this study is thus to assemble databases that characterize cities across countries with different income levels, focusing on the year 2015, but also studying earlier years.

United Nations (2018). This database gives the population of each urban agglomeration of at least 300,000 inhabitants every five years from 1950 to 2015 (N = 1,860). These agglomerations are "commuting zones" including central business districts, suburban areas, and satellite towns.

Demographia (2005, 2017). These databases give the population and land area (sq km) of many agglomerations of at least 500,000 inhabitants circa 2000 (N = 360) and most agglomerations of at least 500,000 inhabitants circa 2016, which is used as a proxy for 2015 (N = 1,042). Note that the data are imperfect for the year 2000 because many agglomerations in developing countries are omitted and little detail is provided on how land areas were estimated. For the year 2016, estimates come from censuses and satellite imagery, and are thus more reliable.

CTBUH (2018). The Council on Tall Buildings and Urban Habitat (CTBUH) maintains a publicly available online database of all *tall buildings* throughout the world.[12] For each building, there is a webpage showing its characteristics. Research assistants extracted the needed data from each webpage. We know the years construction was proposed and/or started and/or completed. Next, we know architectural height and/or height at the tip and/or height of the highest occupied floor and/or height of the observatory and/or the number of floors. Web Appendix Section B describes how we use these characteristics to impute consistent measures of completion times and heights for all buildings. According to CTBUH's website, they do not use a consistent definition of tall

[12]The full online database can be found here: http://www.skyscrapercenter.com/. As one example, here is the webpage for the Burj Khalifa in Dubai: http://www.skyscrapercenter.com/building/burj-khalifa/3.

buildings. However, in the data, the mode of the Kernel distribution of heights is 80 meters (see Web Appendix Figure A1). Given floor heights of about 4 meters, this corresponds to buildings of about 20 floors. As described in Web Appendix Section B, we believe that the database mostly captures buildings above 80 meters, and restrict our analysis to 14,729 such buildings.

Finally, one may question the quality of this data. According to their website, the data has been "collected by the Council for more than 40 years [...] The Council relies on its extensive member network [of academics, land developers, architectural firms, builders, city administrations, and banks] and the public to maintain" the database and "an Editorial Board from around the world helps maintain" it. The data set appears reliable. We thus use it to construct an index of the stock of tall buildings for each city, which we use as a proxy for the stocks of all buildings.

Main Sample. We focus our analysis on 1,010 agglomerations of at least 300,000 inhabitants in 2015 in United Nations (2018) *and* data on land area in Demographia (2017) (Web Appendix Figure A2 shows their location). 405 of them have tall buildings in our data. For the other agglomerations where no tall building is listed, we arbitrarily allocate one-half of a tall building (40 m) whenever it is necessary to use logarithms of average tall building heights in our work.

World Bank (2018). The World Development Indicators database of the World Bank provides national per capita GDP (PPP and constant 2011 international $) for each country-year from 1990 to 2017. We then use per capita GDP growth rates from Maddison (2008) (in 1990 Geary-Khamis dollars, which is equivalent to PPP in constant international $) to reconstruct per capita GDP from 1890 to 1990. In order to avoid our measures of per capita GDP being contaminated by fluctuations in factors like commodity prices, we use two-year moving averages.

European Commission (2018). This database reports, for the years 1970, 1990, 2000 and 2015, estimates of land areas and populations for 11,836 cities of at least 50,000 inhabitants in 2015. Land areas are based on satellite images and machine learning to identify building footprints and distinguish urban agglomerations. The advantage of this data set is that a consistent method is used across all cities and countries. However, a common algorithm for all cities and countries may miss city- or country-specific idiosyncrasies in land use patterns that only a more administrative country-specific treatment of census or satellite data would yield.

Atlas of Urban Expansion (2016). This database features a global sample of 200 cities supposed to be representative of the universe of agglomerations of 100,000 people or more in the world in 2010. Data for some variables are reported for 1990, 2000, and 2014 (which we use as a proxy for 2015). The data were created based on census estimates and satellite imagery. Finally, the Atlas of

Urban Expansion (2016) also reports land area for 25 large world cities circa 1960 and circa 1890. We obtain their 1960 populations from United Nations (2018) and their 1890 populations from Wikipedia (2020). We also obtain land area and population data for 13 additional large world cities in 1890 (source: New York State (1895)). We thus consider 25 + 13 = 38 large cities in 1890.

4. Comparing Cities in Developed and Developing Countries

4.1. City Population Size and Country Economic Development

Are urban giants concentrated in richer countries? This is tested using the larger data set from United Nations (2018). As can be seen in Figure 3, for 1,773 agglomerations of more than 300,000 inhabitants in 2015, there is no relation between log population size and economic development proxied by log national per capita GDP (PPP). Indeed, low-, middle- and high-income countries have as many large agglomerations on average (e.g., Dar es Salaam and Kinshasa vs. Delhi and Manila vs. Osaka and New York). Note that the figure highlights 30 agglomerations that are either among the 100 largest in the world in 2015 or have been selected due to particular characteristics that will be discussed below.

Column (1) of row 1 in Table 2 shows the elasticity of log city population size with respect to log national per capita GDP. In column (2), we weight observations by population size in 2015, thus giving more weight to the giants. Columns (3) and (4) repeat columns (1) and (2) but control for log country population in 2015 since larger countries may have mechanically larger cities. The elasticity is close to 0 across the four specifications, and never significant.[13] Likewise, if we focus on the main sample (N = 1,010), elasticities remain close to 0 (see row 2).[14]

Has this lack of association between per capita income and city size been stable over time? We find that the elasticity has decreased over time (see Panel A of Table 3). For the main sample of 1,010 agglomerations, it was 0.02, 0.13***, 0.25***, 0.33*** and 0.43*** in 2015, 2000, 1990, 1975 and 1960, respectively (row 1). Using weights, it was 0.05, 0.17*, 0.27**, 0.32*** and 0.33*** (row 2).

When plotting the relation over time (using weights), one can see that changes were driven by developing country cities becoming larger given a certain income level (Figure 5(a)). The largest cities of developing countries thus outgrew the largest cities of developed countries.

[13]Note that standard errors are clustered at the country level in all regressions.

[14]In Web Appx. Section C and Web Appx. Table A2, we show results hold if we use other data sets of city populations or imperfect city-level measures of economic development. Results also hold if we drop each country one by one or remove the largest cities of each country, to study non-primate cities only (not shown but available upon request).

4.2. City Land Area and Country Economic Development

Figure 4 shows that, for 1,010 large agglomerations, there is a strong positive relation between log city land area (sq km) and log national per capita GDP (PPP). For example, New York has almost the same population as Dhaka, Cairo and Beijing but it uses about 32, 6 and 3 times more land, respectively. Likewise, Moscow and Los Angeles have almost the same population as Lagos and Manila but the former use about 3-4 times more land.

The estimated regression coefficient of log city land area on log national per capita GDP is 0.52*** ($R2 = 0.19$), which we report in column (1) of row 3 in Table 2. Thus, the land area of urban agglomerations increases by 2^{52}-1 $\approx$ 43% when per capita income doubles. Alternatively, agglomerations in high-income countries consume on average 6.0-6.8 times more land than cities in low-income countries. The area-income relation is similar when focusing on the giants. Weighting observations by city population, the coefficient becomes 0.58*** ($R2 = 0.17$, col. (2)).

These results suggest that the entire urban systems of richer countries use more land than the entire urban systems of poorer countries. If we control for log city population size, elasticities are similar, at 0.50***-0.54*** ($R2 = 0.67$-0.79, col. (3)-(4)), which is not surprising since the elasticity of population size with respect to income is close to 0. This implies that there is also much more land available per capita in the cities of richer countries. With higher incomes, people consume more housing and thus more land (Section 2.). Higher incomes are also associated with better commuting technologies, which allow residents to access more land at a cheaper cost.

In the rest of the analysis, we privilege specifications where we do not control for city population size, since our main goal is to explain why entire urban systems in developing countries have become on average as populous as entire urban systems in developed countries.[15]

When studying the evolution of the elasticity over time, the problem with Demographia (2005) is that it has only one-third of the cities in Demographia (2017). Patterns over time become evident when we focus on a balanced sample of 232 cities that exists in both datasets. In that case, the income elasticity of land area decreases by 0.31-0.29 between 2000 and 2015 (not shown). However, this balanced sample may not be representative of the whole world. If we use built-up area data from European Commission (2018) and focus on the main sample of 1,010 cities, elasticities are relatively similar between 1975 and 2015 (see Panel B of Table 3). In other words, land expansion did not become disproportionately more important in poorer countries, or richer countries, over

[15]Classical measurement error in city land area would only affect precision. We then find that results hold if we (Web Appx. Section D and Appx. Table A3): (i) use other data sets of city land areas; (ii) use measures of residential land area available for a smaller sample of cities; and (iii) imperfect city-level measures of economic development.

time. When plotting the relation between log (built-up) area and log national per capita GDP in each year (using weights), one can see that it has not changed over time (see Figure 5(b)).

4.3. City Building Heights and Country Economic Development

To obtain average height, we divide the sum of tall building heights (m) by land area (000s sq km).[16] Due to data limitations, we restrict our analysis to the main sample of 1,010 agglomerations. Also note that we use data on *all* tall buildings, not just residential buildings. In the basic version of the SUM, employment is concentrated in a central business district which workers commute to from non-central areas of the city. However, there are several reasons why we may want to consider all buildings. First of all, to "fit" people in a city, both housing space and commercial space are needed and their supplies are intrinsically related. If there are office towers, the commercial sector uses less land, so more land can be available for housing, and fewer residential towers are needed. Given the commercial and housing sectors compete for land, considering residential buildings would miss possibly important substitutability effects.[17] Second, we just studied how land area varied with income, even if this includes both residential and commercial uses. For the study of heights to be consistent, one must also include commercial uses. Third, to compute average height, we divide the sum of tall building heights by land area. Were we to use residential building heights in our main analysis, we would need to divide their sum by residential land area. However, residential area is not available for many cities in our sample and when present may be measured with substantial error. Our measure of average height reflects both residential and commercial construction. Nonetheless, as a robustness check, we find that results hold if we use residential buildings (buildings where one of the functions is "residential").[18]

As shown in Figure 6, we obtain a strong positive relation between log average building height (m) and log national per capita GDP (PPP). For example, New York has almost the same population as Dhaka, Cairo and Beijing but its tall (80m+) buildings are on average about 10, 8 and 6 times taller, respectively. Likewise, Shanghai has almost the same population as Mexico and Delhi but its tall buildings are on average about 3 and 100 times taller, respectively. There are interesting outliers as well. For example, Hong Kong, Macao, Singapore, Dubai, Panama City and Pyongyang are all located well above the regression line. These cities are well-known for their skyline, which gives us confidence in the quality of our tall building data set.

When regressing log average building height on log per capita GDP (see col. (1) of row 4 in

[16] Using the mean of heights in our database would be misleading for cities with a small number of very tall buildings.
[17] In our data, residential and commercial buildings both account for half of tall buildings today.
[18] We divide the sum of residential tall building heights (m) by land area, even if land area includes commercial uses.

Table 2), the estimated coefficient is 0.34*** (R2 = 0.06). If the observations are weighted by city population, the coefficient becomes 0.71*** (col. (2); R2 = 0.16). Controlling for log city population size, elasticities are similar, at 0.33*** and 0.68*** respectively (col. (3)-(4); R2 = 0.16-0.35). Thus, average building heights increase by 2^{33}-1 $\approx$ 26% when income doubles. The elasticity more than doubles (2^{68}-1 $\approx$ 60%) when giving more weight to urban giants. Alternatively, cities in high-income countries have on average buildings that are 11 times taller than cities in low-income countries (3 times without weights).[19]

Regarding the elasticity's evolution over time, land area used to compute average building heights is observed for 2015 and comes from Demographia (2017). If we focus on 232 cities that also exist in Demographia (2005), we find that the income elasticity of building height increased by 0.19 (unweighted) and 0.25 (weighted) between 2000 and 2015 (not shown). Given elasticities of 0.34 and 0.71 in 2015, this gives elasticities of 0.15 and 0.46 in 2000. If we use (built-up) land areas from European Commission (2018), the unweighted elasticity increased from -0.19*** in 1975 to 0.06 in 1990, 0.22*** in 2000 and 0.40*** in 2015 and the weighted elasticity increased from 0.24 to 0.44***, 0.59*** and 0.75*** (see Panel C of Table 3). Panel A of Appx. Table A5 shows that patterns hold for average building heights constructed using residential buildings only.[20]

The relation between log average building heights and log national per capita GDP in each year is plotted in Figure 5(c) (using the built–up areas of European Commission (2018) to compute average building height; using population weights). It is clear that the higher elasticities over time are coming from cities in developed countries having increasingly taller buildings. Thus, cities in richer countries have disproportionately grown by building up.

4.4. City Interior Space and Country Economic Development

Total interior space is proxied by the sum of tall building heights (m). As shown in Figure 7, we obtain a strong positive relation between log average building height (m) and log national per capita GDP (PPP). New York has almost the same population as Dhaka, Cairo and Beijing but it has 316, 51 and 17 times more interior space (in tall buildings), respectively. Likewise, Shanghai has almost the same population as Mexico and Delhi but it has 5 and 187 more interior space, respectively. In particular, New York has 316, 51 and 17 times more interior space than Dhaka,

[19] Classical measurement error in building heights would only affect precision. Next, for our main hypothesis that developed country cities disproportionately grow by building up, non-classical measurement error is an issue if and only if we over-estimate the elasticity. This could happen if our data disproportionately miss *tall* buildings in poorer countries or if *non-tall* buildings (low-rise buildings, houses, shacks and tents) are taller in poorer countries. In Web Appx. Section E, we discard these possibilities and discuss related robustness checks shown in Appx. Table A4.

[20] These results also hold if we use purely residential buildings, i.e. buildings whose only function is "residential" in our buildings database (not shown but available upon request).

Cairo and Beijing because, relative to these cities, it uses 32, 6 and 3 times more land and its (tall) buildings are 10, 8 and 6 times taller, respectively. Indeed, 32*10 = 320 $\approx$ 316, 6*8 = 48 $\approx$ 51, and 3*6 = 18 $\approx$ 17. We thus see that richer country cities have more space because they both use more land *and* have taller buildings. However, for some city comparisons, land area is the main difference (e.g., New York uses relatively more land than Dhaka, since 32 $>$ 10), or building height (e.g., New York has relatively taller buildings than Beijing, since 6 $>$ 3).

Knowing the area-income and height-income elasticities allows estimation of the elasticity of total interior space with respect to income. When not weighting by population, this gives 0.52*** + 0.34*** = 0.86***. When weighting by population, this gives 0.58*** + 0.71*** = 1.29***. We verify this by estimating the elasticity directly, i.e. by regressing the log sum of tall building heights on log national per capita GDP (see row 5 of Table 2). Thus, interior space increases by 2^{86}-1 $\approx$ 82% when per capita income doubles. The elasticity is then 50% higher when more weight is given to larger cities, due to taller buildings there. Alternatively, cities in high-income countries have on average 71 times more interior space (in tall buildings) than cities in low-income countries (18 times when not using weights). We found that this is due to cities in high-income countries consuming 7 times more land (6 when not using weights) and having 11 times taller tall buildings (3 times without weights). Indeed, 7*11 = 77 $\approx$ 71 and 6*3 = 18. If we give all cities the same weight, then land is more important (6 $>$ 3). For larger cities, heights are more important (11 $>$ 7), which is not surprising since larger cities disproportionately grow by building up.[21]

Over time, the elasticity of area with respect to income decreased or remained the same whereas the height-income elasticity increased. Thus the height effect dominated the land area effect in determining the change in space elasticity. Indeed, while the interior space-income elasticity was 0.17* in 1960, it was 0.31***, 0.50***, 0.65*** and 0.86*** in 1975, 1990, 2000 and 2015, respectively (see Panel D of Table 3). The weighted elasticity then increased from 0.59** in 1960 to 0.79***, 0.95***, 1.08*** and 1.28*** in 1975, 1990, 2000 and 2015 (ibid.). Panel B of Appx. Table A5 shows that patterns hold for interior space constructed using residential buildings only.

When plotting the relation between interior space and income over time, it is driven by increases in interior space for richer countries (Figure 5(d); using population weights). Because these increases did not come from rising income elasticities of land area, they can be entirely attributed to cities in rich countries disproportionately building up for a given high income level.

[21]We verify that these elasticities remain relatively similar if we implement the same robustness checks as described above for the building heights and income data, since interior space is constructed in our analysis using building heights only (not shown but available upon request).

4.5. City Population Density and Country Economic Development

Given taller buildings in the cities of richer countries, one would expect the cities of the developed world to be more densely populated (per unit of land area). At the same time, these cities are more likely to build out, which would reduce density. As shown in Figure 8, for the 1,010 agglomerations of the main sample in 2015, there is a strong negative relation between log city population density (inhabitants per sq km) and log national per capita GDP (PPP). For example, New York has almost the same population as Dhaka, Cairo and Beijing but it is 30, 6 and 3 times less dense, respectively. Likewise, Los Angeles and Moscow have almost the same population as Manila, Lagos and Kinshasa but they are 3, 4 and 10 times less dense, respectively. In particular, New York is 30, 6 and 3 times less dense than Dhaka, Cairo and Beijing because, relative to these cities, it uses 32, 6 and 3 times more land, respectively.

When regressing log city population density on log per capita GDP, the estimated coefficient is -0.50*** (R2 = 0.34; N = 1,010; col. (1) of row 6 in Table 2). When weighting observations by population, the coefficient becomes -0.53*** (R2 = 0.39; N = 1,010; col. (2)). Alternatively, the agglomerations of high-income countries are 5-6 times less dense than the ones of low-income countries, particularly because the agglomerations of high-income countries use 6-7 times more land. These negative population density-income elasticities contrast with the positive density-income elasticities estimated for groups of cities belonging to a same country in the extensive literature on agglomeration effects (Duranton and Puga, 2020).[22]

Over time, the city population size-income elasticity has decreased because city population sizes disproportionately increased in poorer countries. However, the city area-income elasticity decreased or remained the same. Therefore, density patterns are ambiguous. If we use land area from Demographia (2017), we find that the population density-income elasticity slightly *increased* over time, by about 0.14-0.16. Given elasticities of -0.50/-0.53 in 2015, this would give elasticities of -0.34/-0.39 in 2000. If we use (built-up) land area from European Commission (2018) to compute population density, elasticities *decreased* over time, from 0.09/-0.03 in 1975 to -0.24***/-0.29*** in 2015 (see Panel E of Table 3). The patterns relying on European Commission (2018) (and using population weights) for the years 1975, 1990, 2000 and 2015 are shown in Figure 5(a). As can be seen, population density has dramatically increased in the cities of poorer countries over time, because population increased more rapidly than land area for a given low income level.

[22]We verify that these elasticities remain relatively similar if we implement the same robustness checks as described above for the population, land area and income data (not shown but available upon request).

4.6. City Occupant Density and Country Economic Development

Population density falls with income (elasticity around -0.50/-0.53). This could be because city land areas increase relatively more than city heights with income. Indeed, the income elasticity of land area is higher than the income elasticity of building heights when not using population weights (0.52 vs. 0.34). However, if we use population weights, the income elasticity of land area is lower than the income elasticity of building heights (0.58 vs. 0.71). Thus, this explanation does not hold for the largest cities. A major explanation, especially for larger cities, is that occupant density, i.e. the density within housing and commercial units, is disproportionately higher in the cities of poorer countries. In other words, the cities of poorer countries have less interior space per sq km but also more people in their interior space, and thus have greater population density per unit land. This hypothesis can be tested. There is limited data on space consumption across the world. But we can use the height data from CTBUH (2018) and the population data from United Nations (2018) to obtain for the same 1,010 cities the number of city residents divided by the sum of tall building heights. As before, the assumption is that cities without tall buildings have half a tall building (40 m), hence a limited tall building stock.

Figure 9 shows a strong negative relation between log city occupant density and log national per capita GDP (PPP) in 2015. This relation mirrors the relation obtained for population density (Figure 8). Thus, if cities in poorer countries have higher population density levels, it is because the greater average building height in richer countries is dominated by the fact that poorer country cities have higher occupant densities and smaller space consumption per household.

When regressing occupant density on income, the coefficient is -0.84*** (R2 = 0.33; N = 1,010; see col. (1) of row 7 in Table 2). When using population weights, it is -1.24*** (R2 = 0.39; see col. (2)). Occupant density thus more than halves when income doubles. Alternatively, the giants of high-income countries have occupant densities 61 times higher than giants in low-income countries (16 times without weights). Indeed, cities in high-income countries have on average 71 times more interior space per capita than cities in low-income countries (18 times without weights).[23]

The population-income elasticity has decreased over time whereas the height-income elasticity increased over time. Logically, the occupant density-income elasticity should have decreased over

[23] We verify that these elasticities remain relatively similar if we implement the same robustness checks as described above for the population, building heights and income data (not shown). UN-Habitat (1993) also provides for 181 cities in 1993 floor area per person. Web Appx. Fig. A3 shows there is a strong relation between floor area per person and log per capita GDP (PPP). Residents of the agglomerations of high-income countries have about 29-30 sq m per capita vs. close to 7-8 sq m in the agglomerations of low-income countries. When using the log of this alternative measure, the income elasticity of occupant density is also high, at 0.47***-0.56*** (R2 = 0.56-0.50; not shown).

time, which is what we find. The unweighted elasticity decreased from 0.26* in 1960 to 0.02, -0.25, -0.52*** and -0.84*** in 1975, 1990, 2000 and 2015, respectively (see Panel F of Table 3). The weighted elasticity decreased from -0.26 in 1960 to -0.47**, -0.68***, -0.91*** and -1.24*** in 1975, 1990, 2000 and 2015, respectively (ibid.). Panel C of Appx. Table A5 shows that patterns hold for occupant density constructed using residential buildings only.

Plotting the relation over time (Fig. 5(f); using population weights), we find that these decreases were due to occupant densities increasing in poor country cities (for a given low income level) and occupant densities decreasing in rich country cities (for a given high income level). Behind these patterns, population increased in the former and heights increased in the latter.[24]

4.7. Summary of Elasticities and Decomposition of Population, 1960-2015

Decomposition, 2015. Table 2 summarizes the elasticities found for each component of city population size. In col. (1)-(2), where we do not control for city population size, the elasticities of land area, building heights and occupant density with respect to national per capita GDP are 0.52/0.58 (row 3), 0.34/0.71 (row 4) and -0.84/-1.24 (row 7), respectively. The sum of these elasticities should be close to the city population size-income elasticities that were estimated, -0.00/0.02 (row 1) for the full sample or 0.02/0.05 for the main sample (row 2). Row 8 shows that the sum of the elasticities is close to 0, so the estimated elasticities of city population size with respect to income and the elasticity constructed from its individual components are similar (row 9).

These results have several implications for today's city population sizes: (i) The elasticity of interior space with respect to income is close to 1 and can be decomposed into the elasticity of land area with respect to income and the elasticity of building heights with respect to income. Therefore, cities can grow their stock of space per capita by either building out or building up; (ii) Because the relation with income is positive for both land area and heights, cities in richer countries use both margins to do so. Thus, we are not in a world where poorer countries experience urban land expansion while cities in richer countries become more vertical. Instead, cities in richer countries both consume more land and become more vertical while cities in poorer countries are not expanding interior space per capita at the same rate and, relatively speaking, are packing in more inhabitants in existing structures. (iii) When focusing on the giants, these patterns are accentuated. In particular, the largest cities of richer countries disproportionately build up, whereas the structures of the largest cities in poorer countries disproportionately densify.

Decomposition, 1960-2015. Table 4 summarizes how the main elasticities have been changing

[24]Web Appx. Fig. 4(a) shows that patterns hold for occupant density constructed using residential buildings only.

over time for each component of city population size. In columns (1), (2), (3), (4) and (5), we report the absolute change in the elasticities for each period 2000-2015, 1990-2000, 1975-1990, 1960-1975, and 1960-2015 (the full period). Panel A then shows the unweighted elasticities whereas Panel B shows the elasticities when giving more weight to larger cities.[25]

As can be seen in row 1 of both panels, the lack of relation between city population sizes and income is a more recent phenomenon (-0.41 without weights for the full period 1960-2015, see col. (5); -0.28 with weights), and is due to the population of developing country cities growing faster. Row 2 shows that the area-income elasticity did not change during the full period (0.06 without weights, see col. (5); 0.13 with weights).[26] Next, row 3 shows that the height-income elasticity has increased in all periods, with the cumulative change in 1960-2015 being large (0.63 without weights, see col. (5); 0.56 with weights). Heights thus disproportionately increased over time in richer country cities. As a result (row 4), the interior space-income elasticity increased (0.69, see col. (5)).[27] The occupant density-income elasticity then decreased over time (-1.10*** without weights, see col. (5) of row 5; -0.98 with weights). Therefore, it disproportionately increased in poorer country cities over time. Lastly, we add the interior space- and occupant density-income elasticities in row 6. The combined elasticity is equal to the population-income elasticity.

To summarize, cities in richer countries have built up much more since 1960. If anything, this should have made rich country cities grow more. However, interior space per person has grown to absorb the additional supply of interior space. In contrast, the disproportionate increase in city population sizes in poorer countries has been accommodated by the densification of existing structures. Since the densification effect has been stronger in poorer country cities than the height effect in richer country cities, poorer country cities have outgrown richer country cities.

4.8. Decomposition of Population, 1890-1960.

For a limited sample of 38 large world cities, we know their population and tall buildings circa 1890 and 1960 (see data section 3.). We then know their land area circa 1890. For 25 of them, we know their land area circa 1960. The 38-25 cities belong to 27-23 countries. 28 of the 38 cities were among the 100 largest cities in the world circa 1900 (Chandler, 1987). The other 10 cities were

[25]In the weighted regressions, the elasticities are estimated using city population sizes in year t as weights. SEs cannot be computed using the Stata command 'suest' when using different weights across the different regressions.

[26]The European Commission (2018) does not report land areas in 1960. However, the Atlas of Urban Expansion (2016) reports land area for 25 large world cities circa 1960. We estimate how, for that sample, the land area-income elasticity changes between 1960 and 2015, which we report in column (5) of row 2 in Table 4. Knowing the change in 1960-2015 and the change in 1975-2015, we calculate the change between 1960 and 1975.

[27]We obtain the elasticity for the periods 1960-1975 and 1960-2015 by taking the simple difference between the interior space-income elasticity (row 4) and the area-income elasticity (row 2).

their country's largest city. The sample is geographically balanced as it includes 5 African cities, 11 Asian cities, 16 European cities, 4 Latin American cities, and 2 North American cities.

Col. (6) of Table 4 summarizes how the main elasticities have changed during the period 1890-1960. As seen in row 1 of Panel A, the unweighted population-income elasticity decreased by -0.41 (N = 38), implying that the relation between city population sizes and income was stronger in the past. The weighted elasticity only decreased by -0.12 (row 1 of Panel B). Ultimately, the elasticity decreased by -0.41/-0.12 during the period 1890-1960 vs. -0.41/-0.28 during the period 1960-2015 (col 5)). Graphically, we find that poorer country cities grew faster than richer country cities in 1890-1960 (see Web Appendix Figure 4(b), with population weights).

Row 4 of Panels A-B shows that the unweighted and weighted interior space-income elasticities increased during the period (+0.25/+0.51; N = 38), however not significantly so. Such changes were not driven by land expansion (row 2 of Panels A-B; -0.05/-0.03; N = 38-25) but by average building heights (row 3 of Panels A-B; +0.29/+0.54).[28] Interestingly, the interior space-income elasticity increased by +0.25/+0.54 in 1890-1960 vs. +0.69/+0.69 in 1960-2015. Therefore, the pattern in which rich country cities have become more vertical over time started pre-1960.

Despite the fact that rich country cites became more vertical in 1890-1960, we do not find that population density increased relatively more in rich country cities than in poor country cities during the period (see Web Appendix Figure 4(c), with population weights; N = 38-25). Logically, occupant density must have increased faster in poor country cities than in rich country cities, which is indeed what we find graphically (see Web Appendix Figure 4(d), with population weights; N = 38). Likewise, row 5 of Panels A-B and column (6) in Table 4 shows that the elasticity decreased by -0.66/-0.64, thus by a larger magnitude than the interior space-income elasticity (+0.25/+0.51). This explains why the population-income elasticity decreased. The change in the occupant density-income elasticity, although large, is lower than the corresponding change in the 1960-2015 period (-0.66/-0.64 vs. -1.10/-0.98, columns (5)-(6)).

Next, Lamson-Hall and Angel (2015) show how rich country cities such as New York de-densified over time, especially in the first half of the 20th century. While our evidence is limited to 38-25 cities, Web Appx. Fig. 4(c) suggests that the de-densification of rich country cities during the period 1890-1960 was possibly not due to a change in the population density-income relationship over time. Instead, if population density decreased, it must have been due to such countries

[28] The height-income elasticity is estimated as the difference between the interior space-elasticity (N = 38) and the land area-elasticity (N = 38-25). Land area not being available for all cities in both years introduces a possible compositional bias. We find that results are more consistent if the height-income elasticity is estimated residually rather than directly.

getting wealthier, and thus moving down along the population density-income line shown in the figure. Thus, area must have expanded faster than population as income increased, and this in spite of increased heights contributing to population growth. The factor most likely contributing to this sprawl is the rapid improvement in transportation technology between 1890 and 1960.

To conclude, poorer country cities outgrew richer country cities because occupant density increased faster in the former than average building heights in the latter. Therefore, the patterns highlighted for the period 1960-2015 might have started before 1960.

4.9. Land, Height and Density Relationships Across Development Status

The elasticities so far considered were estimated for all cities *on average*. However, the relations between city population size and each one of its components could be non-linear for groups of countries. We now document for the 1,010 agglomerations of the main sample how (unlogged) land area, building heights, interior space, occupant density and population density vary with log city population size depending on the development status of the country circa 2015.

First, we verify that low-income, lower-middle income, upper-middle income and high-income countries have the same distribution of city population sizes (see Figure 10(a)).

Next, for a given city population size, cities in richer countries use more land (Figure 10(b)) and have taller buildings (Figure 10(c)). These relations are convex for high- and middle-income countries, especially high-income countries, which explains the similar convex relations observed for total interior space (Figure 10(d)). Occupant density then also increases with city population size (Figure 10(e)), and the relation is particularly steep and convex for low-income countries.

Smaller cities are not particularly different across income levels. Most of the differences observed across groups of countries come from cities above 1 million inhabitants (≈ 7 when population is measured in thousands and logged). In this group of cities, richer country cities have far more space. Now, patterns observed for population density (Figure 10(f)) are not as convex (but still convex for poorer countries) because the occupant density effect in poorer countries and the height effect in richer countries offset each other. Overall, the density-population relation (i.e., the slope) is positive across all groups of countries, as has been shown in many studies in the literature, but the levels are very different, particularly so for the largest cities in poorer countries.

5. Concluding Discussion and Avenues for Future Research

5.1. Summary of the Decomposition Results

We have showed that cities in richer countries are large – i.e., contain large populations – because they build *up* – especially in their largest cities – and build *out*. Thus, even if residents use substantial space per capita, which should reduce city population size, the fact that richer country cities build more space also allows them to have more (or at least not fewer) residents. Conversely, cities in poorer countries are large because they crowd *in*, i.e. have more people per unit of space.

Logically, urban land expansion and the fact that cities became more vertical in developed countries should have made them grow faster than developing country cities, which should have accentuated the positive city population size-income relationship that was observed in 1960. However, these effects have been dominated by poor country cities becoming more crowded, which has, if anything, considerably weakened the city population size-income relation that was historically observed to the point that rich countries do not have larger cities today.

5.2. Nature of Crowding in Poorer Country Cities

One limitation of our main analysis is that our results on increased crowding over time in poorer country cities are based on tall buildings only. If poorer country city populations have grown so much faster than their stock of tall buildings, perhaps populations that were not accommodated by tall building construction were accommodated by slum expansion? Or was the non-tall non-slum sector (low-rises and non-slum houses) able to absorb the extra population growth?

Figure 11(a) shows for 58-126 countries with available data the relation between their slum share (%) – i.e., the share of their urban population that resides in slum areas – and national per capita GDP (defined as before) for the years 2015 (N = 126), 2000 (97) and 1990 (58).[29] As can be seen, the relation did not change over time.[30]

During the same 1990-2015 period, however, occupant density and population density dramatically increased in poorer countries. Given that the slum share did not simultaneously increase, it could be that the rising densities observed in the data came from the non-tall non-slum sector. Therefore, either structures of the non-tall non-slum sector became on average taller or existing structures in the same sector – and the units in these structures – became more crowded.

It is difficult to answer this question about the relative importance of slum expansion without global historical data on the evolution of the non-tall non-slum sector. However, we obtained from the *Minerals Yearbooks* of USGS (2020) and for 144 countries and each year from 1950 the total production of cement – the main ingredient of concrete – which we use as a proxy for cement

[29]The sources for the slum shares are United Nations (2015) and United Nations (2020). The slum share is available for few developed countries. When it is, the share is close to 0.1%. For country-years with a missing slum share, we thus assign a value of 0.1% to all countries that are classified as "high-income" in the same year by the World Bank.

[30]A similar result is obtained if we limit the analysis to the 58 countries for which the slum share is available in all years (not shown but available upon request). Slum shares do not exist for the pre-1990 period.

consumption.[31] After excluding countries for which cement use is missing in the early decades of the period, we obtain a consistent sample of 113 countries. For each year 1975, 1990, 2000 and 2015, we then construct a measure of how fast urban population is increasing relative to cement use (which does not just capture buildings but also infrastructure). More precisely, the measure is the change in urban population between 1960 and year t divided by total cement use between 1960 and year t. We then examine how the measure varies with income over time. In particular, the higher the measure the more likely it is that the overall non-slum sector is getting more crowded over time. As can be seen in Figure 11(b), evidence suggests that poor country urban areas are indeed getting possibly more crowded.

Therefore, the non-slum sector seems to have become more crowded over time in poor country cities. We believe this is a new fact that has not been established before.

5.3. Possible Determinants of Crowding in Poorer Country Cities

We now discuss what factors might explain why poorer country cities have seen their population grow so much without this being driven by physical urban development, at least the way we are able to measure it (either through land expansion or tall building construction).

First consider the possibility that the faster growth of larger cities in poorer countries could be due to a decline in the urban wage premium (UWP) there relative to richer countries? Indeed, a decline in the UWP would imply for a given country a disproportionate increase in the population of the largest cities holding city wage levels constant. Such a decline could be produced by a rise in amenity of larger cities that could be generated by public policy favoring larger cities. Alternatively, rising education could change preferences for consumption of product variety associated with larger agglomerations. However, there may be reasons to believe UWPs did not disproportionately change in poor countries relative to rich countries over time. In Web Appendix Section F2., we explain how we use population and economic development data for many cities to estimate for as many countries as possible their UWP circa 2000 and 2015. In the same section, we then discuss row 2 of Web Appendix Table A6 according to which there were no significant changes in the relation between countries' UWPs and countries' national per capita GDPs between 2000 and 2015. While we do not have the data to conduct the same analyses since 1960, we obtain for the period 2000-2015 average UWPs around 0.10. Other research suggests that the UWP did not change much across countries since the 1990s (Combes and Gobillon, 2015;

[31] Because cement is a low-value bulky item, the world trade of cement only accounts for 3% of world cement production (World Cement, 2013). Cement production is thus a very good proxy for cement consumption.

Ahlfeldt and Pietrostefani, 2019). There are too few studies before 1990.

Assuming the UWP's of low-and high-income countries did not change significantly, then why do poorer countries today have on average the same total distribution of city population sizes as rich countries? In Web Appendix Section F2. we discuss how all cities of poorer countries have expanded at about the same rate (if the UWP also remained stable) without their incomes rising. UWPs capture wage (and non-wage) differences across cities, not urban-rural gaps. It could be that, in poorer countries, productivity and earnings growth associated with agglomeration economies occurred simultaneously with declining productivity and earnings growth in rural areas, thus generating widening urban-rural earnings gaps that are being closed down by rural-to-urban migration (Gollin et al., 2013, 2017; Lagakos et al., 2018). Urban-rural earnings gaps were also historically caused by urban-biased policies favoring productivity in larger cities – hence urban primacy – in poor countries (see Ades and Glaeser (1995) but also Lipton (1977), Bates (1981), Davis and Henderson (2003) and Castells-Quintana and Royuela (2015)).

Alternatively, non-wage factors might have changed differentially across rural and urban areas in poorer countries relative to rich countries. One possibility is that housing and commuting costs decreased relatively faster in poor country urban systems than in rich country urban systems. However, this would have differentially caused land expansion and a vertical expansion of cities, patterns we do not observe. Food prices might have then differentially decreased in poor country cities relative to rich country cities, a fact highlighted by (Glaeser, 2014a). Next, amenities, for example related to increased life expectancy, could have then differentially improved in the urban areas of poor countries relative to rich countries, making city life more attractive (e.g., Ades and Glaeser, 1995; Jedwab et al., 2015; Gollin et al., 2017; Jedwab and Vollrath, 2019).

To conclude, the urban areas of poor countries have disproportionately grown in size without this being driven by the same physical development forces as the urban areas of richer countries. Various factors might explain why the urban systems of poor countries have been able to grow *despite* the possible crowding, for example rural-urban wage gaps and/or declining food prices and/or better amenities in urban areas. How much each factor has contributed to our patterns is difficult to say and we believe benchmarking the contributions of these various factors constitutes an important research agenda. Our study is to our knowledge the first study to have ever studied patterns of physical urban development across all countries and over time. Yet, we are aware of the limitations of our analysis and we think that confirming these results with better measured historical and global data on construction constitutes another important research agenda.

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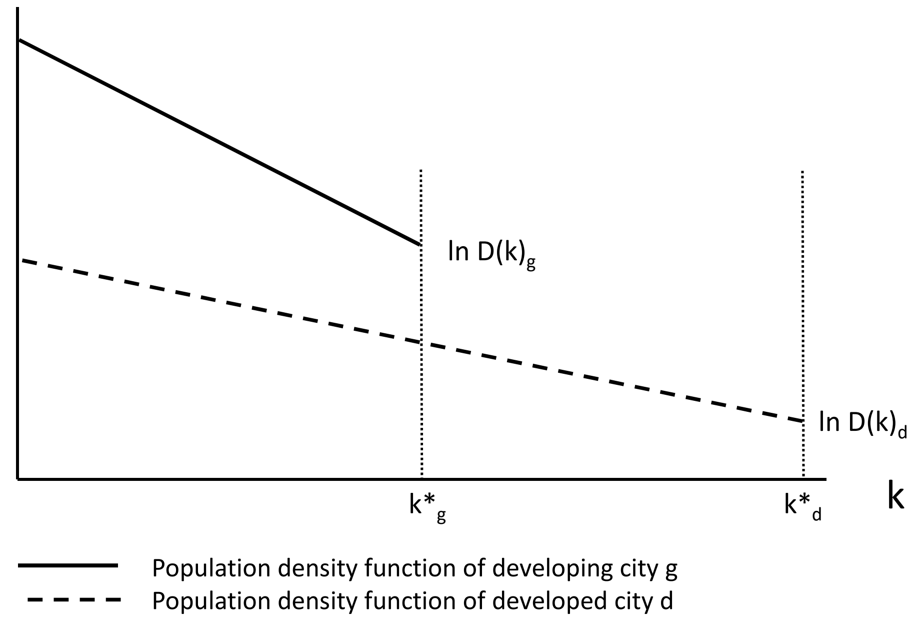
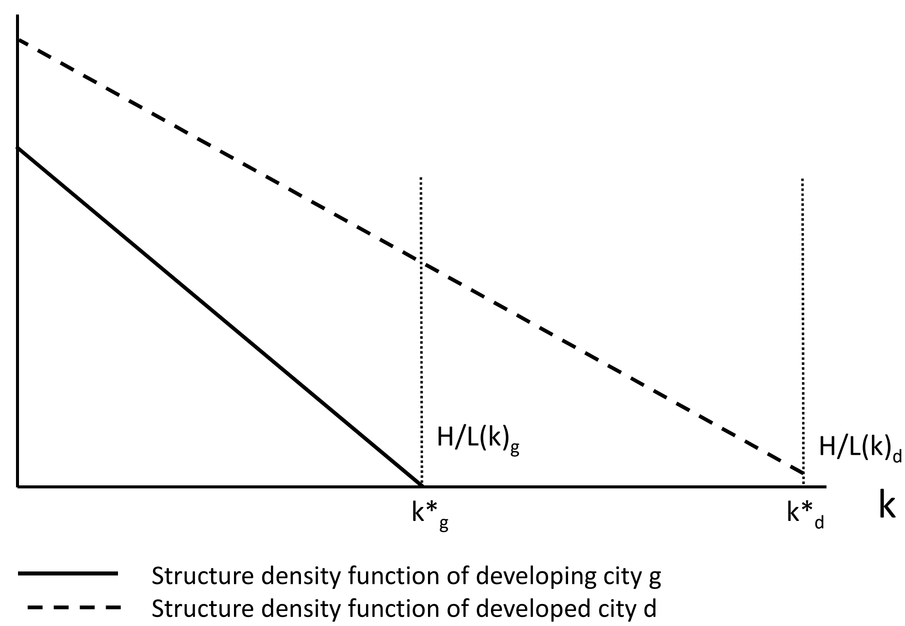
Figure 1: **POPULATION DENSITY FUNCTIONS IN DEVELOPED & DEVELOPING CITIES**



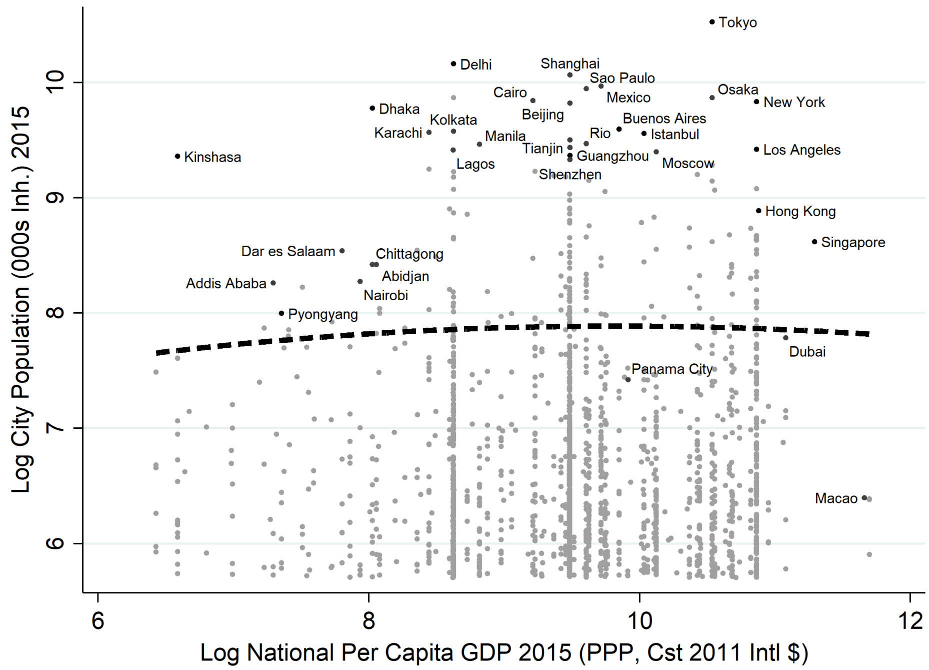
Notes: This figure plots the population density functions ($D(k)$) of a developed city (d) and a developing city (g) of similar sizes. k* is the edge of the city. Total population density is overall higher in the developing city (g).

Figure 2: **STRUCTURE DENSITY FUNCTIONS IN DEVELOPED & DEVELOPING CITIES**



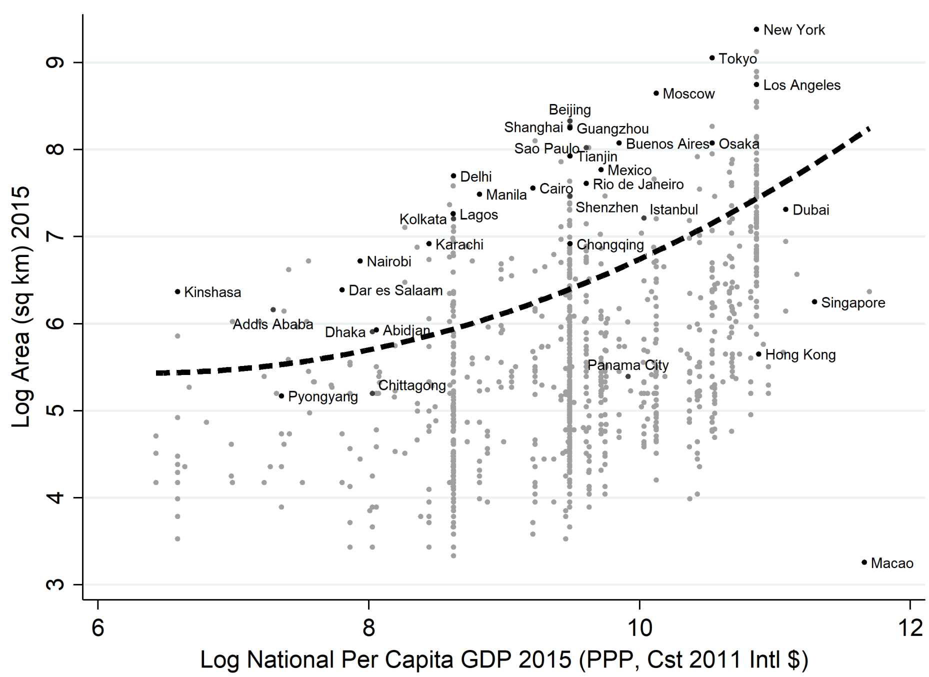
Notes: This figure plots the structure density functions ($H/L(k)$) of a developed city (d) and a developing city (g) of similar sizes. k* is the edge of the city. Total structure density is overall higher in the developed city (d).

Figure 3: **ECONOMIC DEVELOPMENT AND CITY POPULATION SIZES, 2015**



Notes: This figure shows for the 1,773 urban agglomerations of more than 300,000 inhabitants in 2015 the relation between their log pop. size (000s inh.) in 2015 and log mean national per capita GDP (PPP, constant 2011 international $) for all available years in 2013-2017. The quadratic fit is estimated using as weights the pop. of each city in 2015.

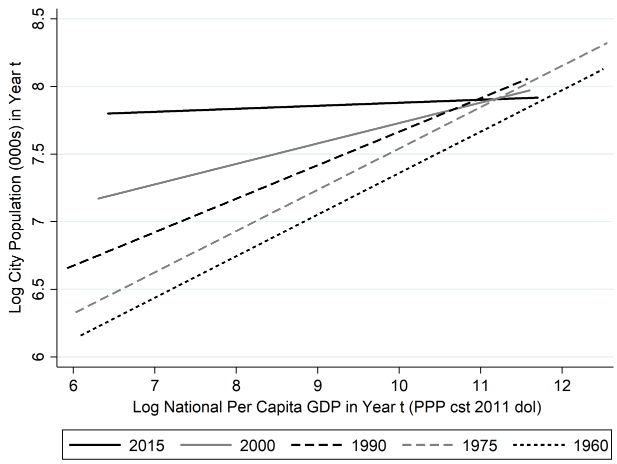
Figure 4: **ECONOMIC DEVELOPMENT AND CITY LAND AREAS, 2015**



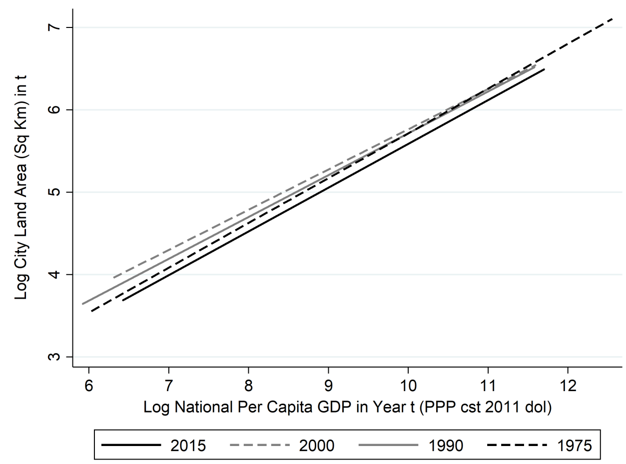
Notes: This figure shows for 1,010 urban agglomerations of more than 500,000 inhabitants in 2015 the relation between log land area (sq km) in 2017 and log mean national per capita GDP (PPP, constant 2011 international $) for all available years in 2013-2017. The quadratic fit is estimated using as weights the pop. of each city in 2015.

Figure 5: **EVOLUTION OF CITY RELATIONS, POP.-WEIGHTED, 1960-2015**

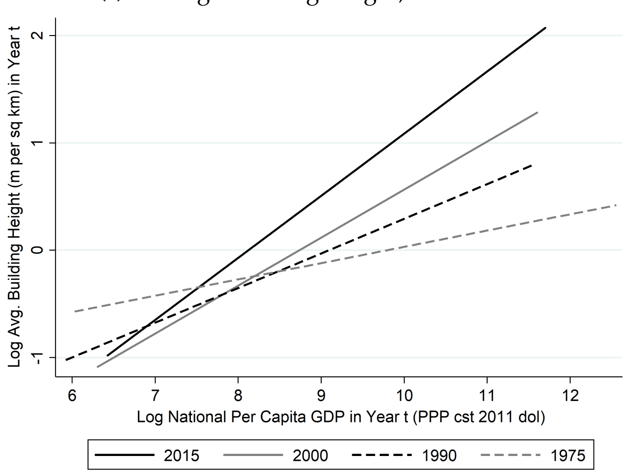
(a) Population Size, 1960-2015



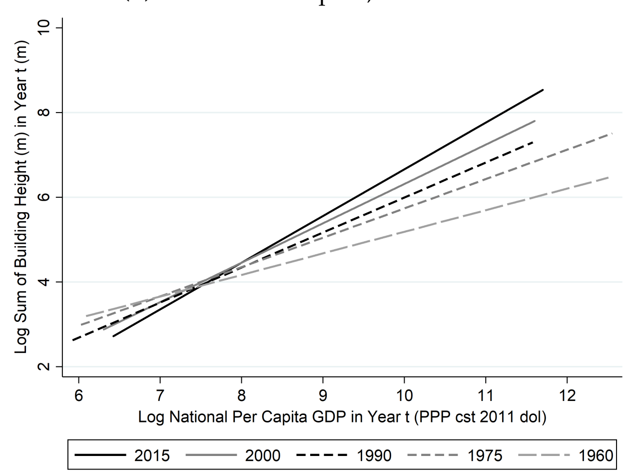
(b) Land Area, 1975-2015



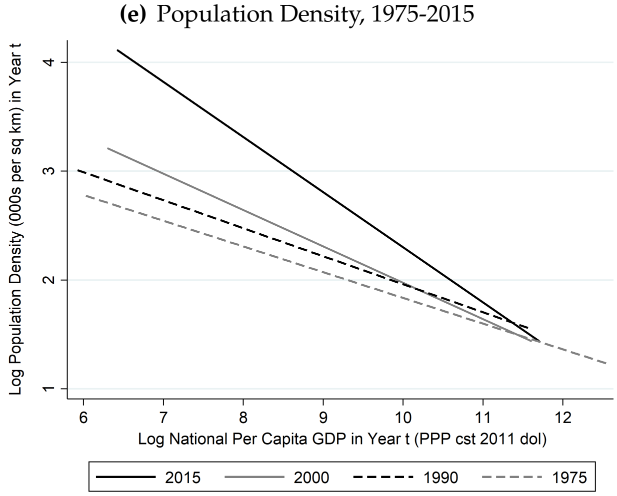
(c) Average Building Height, 1975-2015



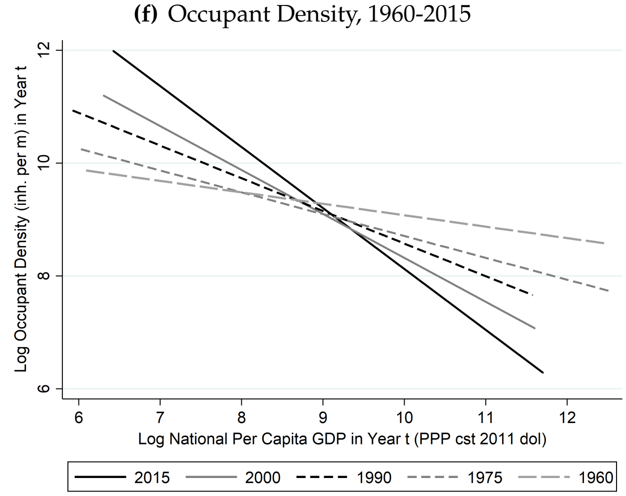
(d) Total Interior Space, 1960-2015



(e) Population Density, 1975-2015

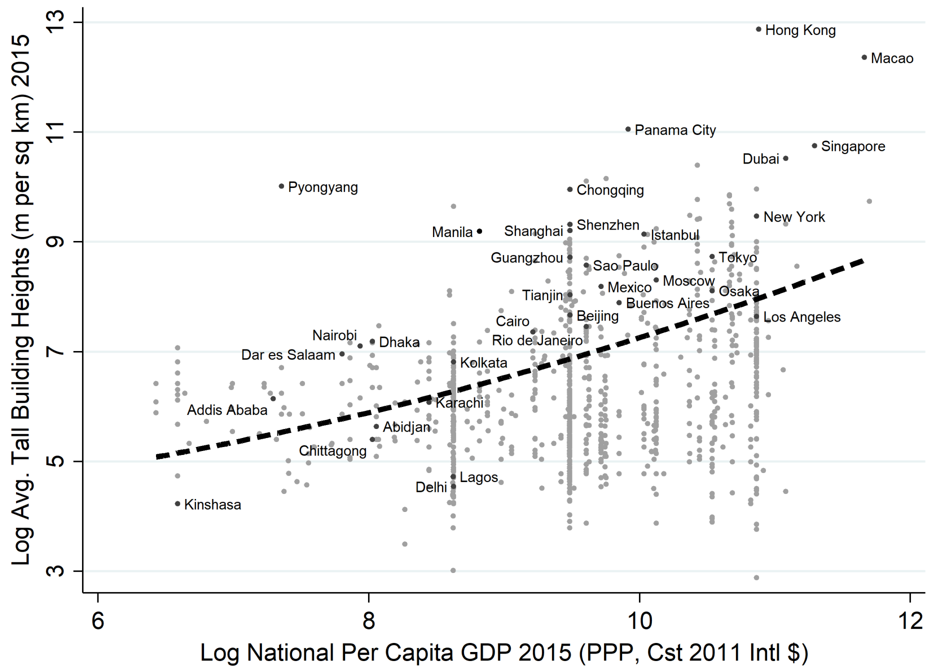


(f) Occupant Density, 1960-2015



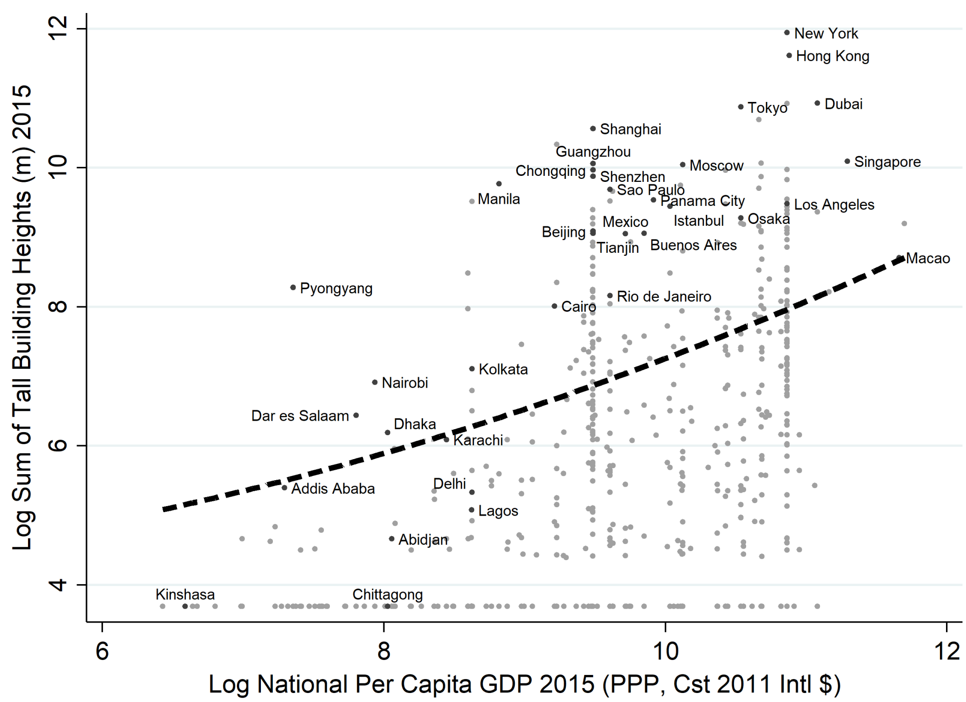
Notes: These figures show for selected years and using population weights the relation between log city population size, and its various components, and log national per capita GDP (PPP, constant 2011 international $).

Figure 6: **ECONOMIC DEVELOPMENT AND CITY AVERAGE HEIGHTS, 2015**



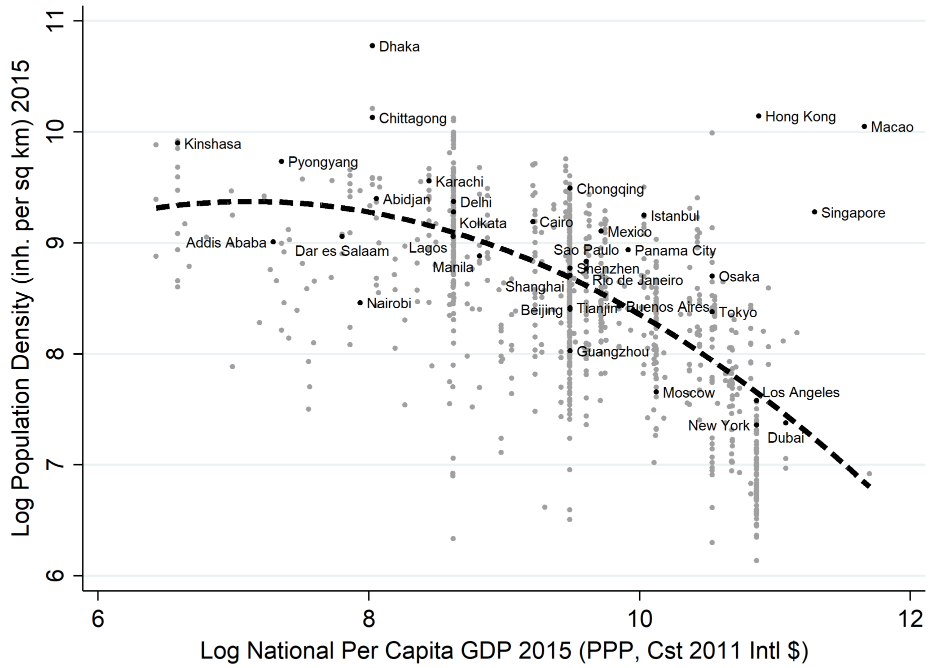
Notes: This figure shows for 1,010 urban agglomerations of more than 500,000 inh. the relation between log average building height in 2017 and log mean national per capita GDP (PPP, cst 2011 intl $) for all available years in 2013-2017. Average height is calculated as the sum of tall building heights (m) divided by land area (000s sq km). The quadratic fit is estimated using as weights the pop. of each city in 2015.

Figure 7: **ECONOMIC DEVELOPMENT AND CITY TOTAL INTERIOR SPACE, 2015**



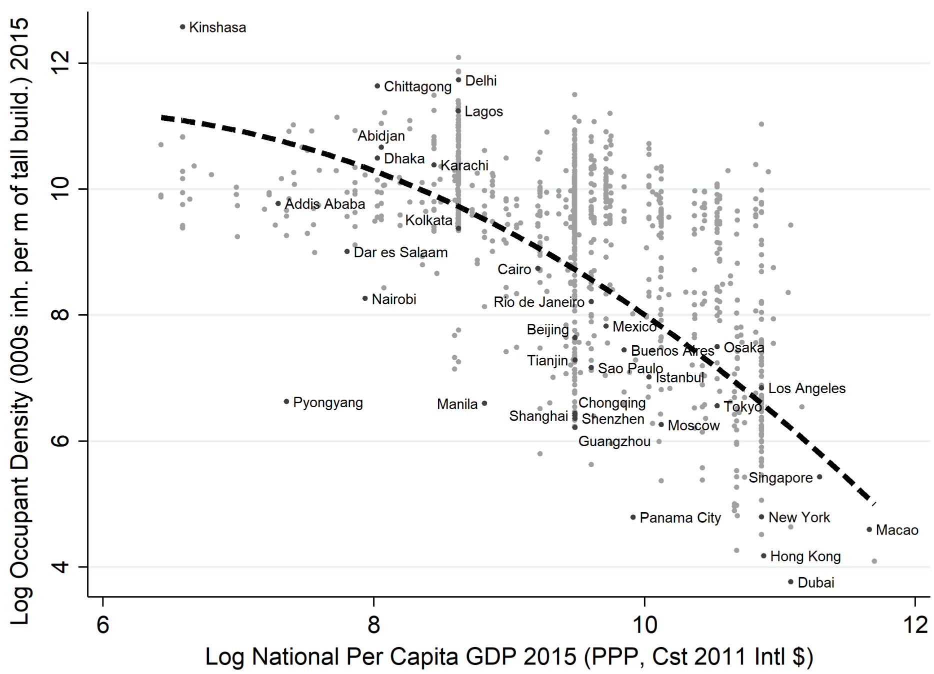
Notes: This figure shows for 1,010 agglomerations of more than 500,000 inh. the relation between their log interior space (m) in 2015 and log mean national per capita GDP (PPP, cst 2011 intl $) for all available years in 2013-2017. Interior space is proxied by the sum of tall building heights. The quadratic fit is estimated using as weights the pop. of each city in 2015.

Figure 8: **ECONOMIC DEVELOPMENT AND CITY POPULATION DENSITIES, 2015**



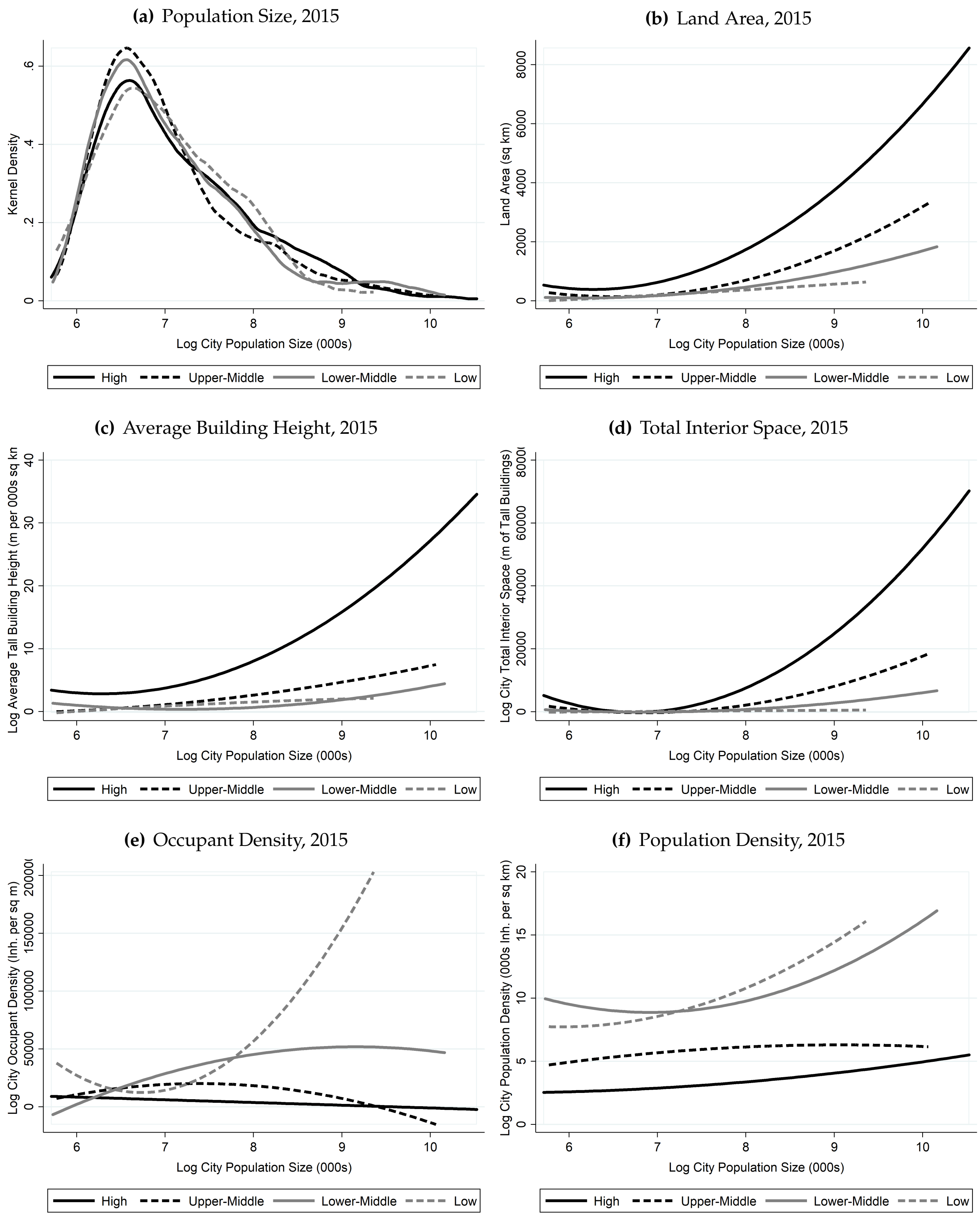
Notes: This figure shows for 1,010 urban agglomerations of more than 500,000 inhabitants the relation between log pop. density (inh. per sq km) in 2017 and log mean national per capita GDP (PPP, cst 2011 intl $) for all available years in 2013-2017. Population density is calculated as the number of residents divided by land area. The quadratic fit is estimated using as weights the pop. of each city in 2015.

Figure 9: **ECONOMIC DEVELOPMENT AND CITY OCCUPANT DENSITIES, 2015**



Notes: This figure shows for 1,010 urban agglomerations of more than 500,000 inh. the relation between log occupant densities and log mean national per capita GDP (PPP, cst 2011 intl $) for all available years in 2013-2017. Occupant density is calculated as the number of residents divided by the sum of tall building heights in 2015. The quadratic fit is estimated using as weights the pop. of each city in 2015.

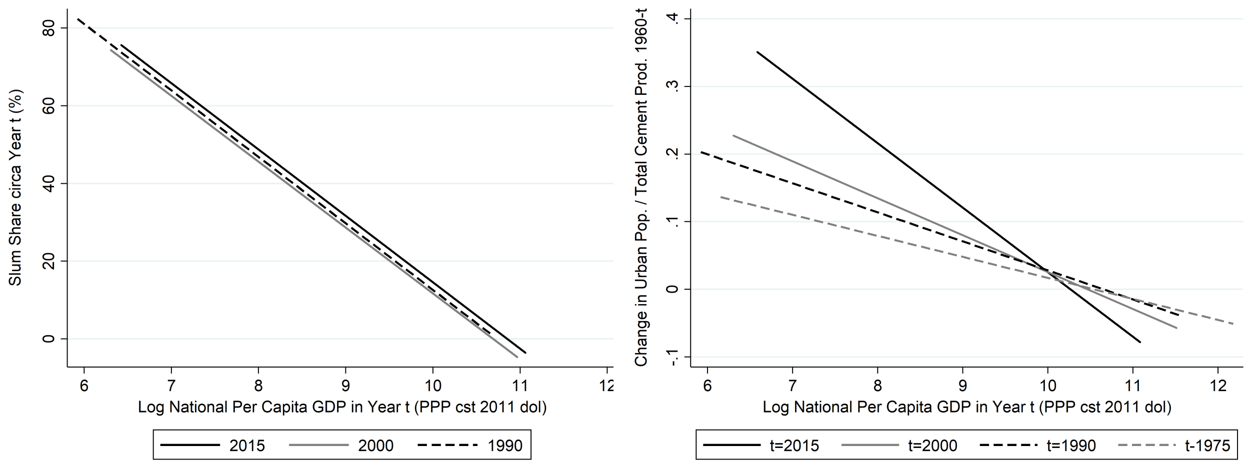
Figure 10: **RELATION BETWEEN LAND, HEIGHT & INCOME BY DEVELOPMENT STATUS**



Notes: Figure 10(a) shows the Kernel distribution of log city population size by country development status circa 2015 (for the main sample of 1,010 cities). Figures 10(b), 10(c), 10(d), 10(e) and 10(f) show, by country development status, the relationship between log city population size and city land area, average tall building height, total interior space, occupant density and population density circa 2015, respectively (for the main sample of 1,010 cities).

Figure 11: **RELATION BETWEEN SLUM SHARE, CEMENT USE & INCOME 1990-2015**

(a) Slum Share, 1990-2015 **(b)** ∆Upop/Cement Prod. (Relative to 1960), 1975-2015



Notes: Subfig. 11(a) shows the relation between the country's slum share and national per capita GDP (PPP, cst 2011 intl $) ca. 2015 (N = 126), 2000 (97) and 1990 (58). Subfig. 11(b) shows for the years 1975, 1990, 2000 and 2015 the relation between the country's absolute change in urban population (inh.) between 1960 and year t divided by the country's total cement production (000 tons.) between 1960 and year t and national per capita GDP (ibid.) ca. 2015 , 2000 and 1990 (N = 111-113). The linear fit is estimated using as weights the urban population of each country in the same year.

Table 1: **RELATIVE SIZE OF SELECTED URBAN AGGLOMERATIONS, CIRCA 2015**

	(1) National Per Capita GDP ($, PPP)	(2) City Population (000s)	(3) City GDP (millions $)	(4) City Sum of Night Lights	(5) City Land Area (sq km)	(6) City Avg. Tall Building Height (m)	(7) City Sum of Tall Building Heights (km)
New York	52,354	18,648	1,489,896	5,077,941	11,875	13	154
		Columns (2)-(7): Percentage Difference (%) Relative to New York City					
Mexico	16,750	14	-81	-79	-80	-72	-94
Sao Paulo	14,873	12	-71	-79	-74	-59	-89
Beijing	13,170	-1	-77	-81	-65	-83	-94
Cairo	10,027	1	-94	-85	-84	-88	-98
Mumbai	5,578	4	-92	-95	-63	-76	-91
Dhaka	3,065	-6	-97	-99	-97	-90	-100

Notes: This table shows the percentage differences in population, measures of economic activity, and measures of land area and building heights, between the agglomeration of New York City and six selected urban agglomerations of similar population sizes. National per capita GDP (PPP and constant 2011 international $) comes from World Bank (2018). City population comes from United Nations (2018). Estimates of city GDP (cst 2012 million $) comes from Oxford Economics (2019). The sum of radiance calibrated night lights comes from NGDC (2015). City land area comes from Demographia (2017). Data on tall building heights comes from CTBUH (2018). Average tall building height in column (6) comes from dividing the city sum of tall building heights by city land area.

Table 2: **SUMMARY OF ELASTICITIES AND DECOMPOSITION OF POPULATION, 2015**

	Elasticity of ... wrt National Per Capita GDP (PPP)			
	(1)	(2)	(3)	(4)
1. Population Size (Full Sample; N = 1,773)	-0.00	0.02	-0.00	0.04
	[0.02]	[0.09]	[0.02]	[0.08]
2. Population Size (Main Sample; 1,010)	0.02	0.05	0.02	0.06
	[0.03]	[0.09]	[0.03]	[0.09]
3. Total Land Area (Main Sample; 1,010)	0.52***	0.58***	0.50***	0.54***
	[0.13]	[0.12]	[0.11]	[0.12]
4. Avg. Build. Heights (Main Sample; 1,010)	0.34***	0.71***	0.33***	0.68***
	[0.06]	[0.10]	[0.06]	[0.11]
5. Interior Space (Main Sample; 1,010)	0.86***	1.28***	0.83***	1.22***
	[0.15]	[0.13]	[0.12]	[0.14]
6. Population Density (Main Sample; 1,010)	-0.50***	-0.53***	-0.50***	-0.54***
	[0.11]	[0.12]	[0.11]	[0.12]
7. Occupant Density (Main Sample; 1,010)	-0.84***	-1.24***	-0.83***	-1.22***
	[0.13]	[0.12]	[0.12]	[0.14]
8. Sum of Rows 3, 4 and 7	0.02	0.05	0.00	0.00
	[0.03]	[0.09]	[0.00]	[0.00]
9. Diff. btw Row 8 and Row 2	0.00	0.00	-0.02	-0.06
	[0.00]	[0.00]	[0.03]	[0.09]
City Population in Year *t* as Weights	N	Y	N	Y
Control for Log City Population in Year *t*	N	N	Y	Y

Notes: This table summarizes the main elasticities found for each component of city population size. The full sample consists of 1,773 urban agglomerations of at least 300,000 inhabitants in 2015 according to United Nations (2018). The main sample consists of 1,010 urban agglomerations of at least 300,000 inhabitants in 2015 according to United Nations (2018) and for which land area is available in Demographia (2017). We control for the log total population of the city's country in rows 1-2 and col. (3)-(4). In rows 3-7 and col. (3)-(4), we control for the log city population. Standard errors are clustered at the country level.

Table 3: **ESTIMATED ELASTICITIES OVER TIME**

	(1)	(2)	(3)	(4)	(5)
Panel A:	Elasticity of City Population Size wrt National Per Capita GDP (PPP)				
	2015	2000	1990	1975	1960
1. No Pop. Weights	0.02	0.13***	0.25***	0.33***	0.43***
	[0.03]	[0.03]	[0.06]	[0.07]	[0.08]
2. Pop. Weights	0.05	0.17*	0.27**	0.32***	0.33***
	[0.09]	[0.10]	[0.11]	[0.09]	[0.06]
Panel B:	Elasticity of City Land Area wrt National Per Capita GDP (PPP)				
	2015	GHS Built 2015	GHS Built 2000	GHS Built 1990	GHS Built 1975
1. No Pop. Weights	0.52***	0.46***	0.43***	0.44***	0.50***
	[0.13]	[0.10]	[0.08]	[0.09]	[0.09]
2. Pop. Weights	0.58***	0.53***	0.48***	0.51***	0.55***
	[0.12]	[0.11]	[0.10]	[0.11]	[0.12]
Panel C:	Elasticity of City Building Heights wrt National Per Capita GDP (PPP)				
	2015	GHS Built 2015	GHS Built 2000	GHS Built 1990	GHS Built 1975
1. No Pop. Weights	0.34***	0.40***	0.22**	0.06	-0.19***
	[0.06]	[0.07]	[0.09]	[0.10]	[0.07]
2. Pop. Weights	0.71***	0.75***	0.59***	0.44***	0.24
	[0.10]	[0.09]	[0.07]	[0.14]	[0.17]
Panel D:	Elasticity of City Interior Space wrt National Per Capita GDP (PPP)				
	2015	2000	1990	1975	1960
1. No Pop. Weights	0.86***	0.65***	0.50***	0.31***	0.17*
	[0.15]	[0.15]	[0.16]	[0.12]	[0.09]
2. Pop. Weights	1.28***	1.08***	0.95***	0.79***	0.59**
	[0.13]	[0.15]	[0.19]	[0.21]	[0.28]
Panel E:	Elasticity of City Population Density wrt National Per Capita GDP (PPP)				
	2015	2015	2000	1990	1975
1. No Pop. Weights	-0.50***	-0.24***	-0.16***	-0.02	0.09
	[0.11]	[0.06]	[0.05]	[0.09]	[0.09]
2. Pop. Weights	-0.53***	-0.29***	-0.17**	-0.08	-0.03
	[0.12]	[0.08]	[0.08]	[0.08]	[0.06]
Panel F:	Elasticity of City Occupant Density wrt National Per Capita GDP (PPP)				
	2015	2000	1990	1975	1960
1. No Pop. Weights	-0.84***	-0.52***	-0.25	0.02	0.26**
	[0.13]	[0.14]	[0.17]	[0.13]	[0.11]
2. Pop. Weights	-1.24***	-0.91***	-0.68***	-0.47**	-0.26
	[0.12]	[0.16]	[0.22]	[0.23]	[0.25]
Observations	1,010	1,006	1,005	1,005	1,004

Notes: This table shows the evolution of the elasticities of city population size, city land area (or built-up land area), city average building heights, city total interior space, city population density and city occupant density with respect to national per capita GDP (see text for details). The specifications in row 1 and row 2 are the same as in columns (1) and (2) of Table 2, respectively. In row 2, city population sizes in the same year are used as regression weights. Standard errors are clustered at the country level.

Table 4: **DECOMPOSITION OF POPULATION, EVOLUTION, 1890-2015**

△ Elasticity wrt Nat. PCGDP	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Unweighted	2000-2015	1990-2000	1975-1990	1960-1975	1960-2015	1890-1960
1. Population Size	-0.10***	-0.12***	-0.08***	-0.10***	-0.41***	-0.41
	[0.02]	[0.04]	[0.02]	[0.03]	[0.08]	[0.26]
2. Total Land Area	0.03	-0.01	-0.06***	0.10	0.06	-0.05
	[0.02]	[0.04]	[0.02]	[0.23]	[0.25]	[0.20]
3. Avg. Build. Heights	0.18***	0.16***	0.25***	0.04	0.63**	0.29
	[0.06]	[0.03]	[0.04]	[0.24]	[0.26]	[0.34]
4. Interior Space	0.22***	0.15***	0.19***	0.14***	0.69***	0.25
	[0.06]	[0.04]	[0.05]	[0.04]	[0.09]	[0.32]
5. Occupant Density	-0.32***	-0.27***	-0.28***	-0.24***	-1.10***	-0.66*
	[0.06]	[0.07]	[0.06]	[0.05]	[0.11]	[0.43]
6. Sum of Rows 4 and 5	-0.10***	-0.12***	-0.08***	-0.10***	-0.41***	-0.41
	[0.02]	[0.04]	[0.02]	[0.03]	[0.08]	[0.26]
7. Diff. btw Rows 6 and 1	0.00	0.00	0.00	0.00	0.00	0.00
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Panel B: Weighted	2000-2015	1990-2000	1975-1990	1960-1975	1960-2015	1890-1960
1. Population Size	-0.12	-0.10	-0.05	-0.01	-0.28	-0.12
2. Total Land Area	0.05	-0.03	-0.04	0.15	0.13	-0.03
3. Avg. Build. Heights	0.16	0.15	0.20	0.05	0.56	0.54
4. Interior Space	0.20	0.18	0.16	0.20	0.69	0.51
5. Occupant Density	-0.33	-0.23	-0.21	-0.21	-0.98	-0.64
6. Sum of Rows 4 and 5	-0.13	-0.05	-0.05	-0.01	-0.29	-0.13
7. Diff. btw Rows 6 and 1	0.01	0.00	0.00	0.00	0.01	0.01

Notes: Columns (1)-(5) show for the 1,010 cities of the main sample changes in the main elasticities of Table 2 during each period 1960-1975, 1975-1990, 1990-2000, 2000-2015 and 1960-2015. For the period 1890-1960 (column (6)), we use similar data for 25-38 large world cities (see text for details). Panel A: SEs clustered at the country level. Panel B: The elasticities in each year t are estimated using city pop. sizes in year t as weights. However, SEs cannot be computed using the Stata command 'suest' when using different weights across the different regressions. We thus do not test if changes in the main elasticities are significant.