Population Density: Some Facts and Some Predictions

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This article addresses the following point of contention: "In 40 years, the average person will live closer to her neighbors and farther from the ground than she does today."

When thinking about the typical American regarding density and building height, I predict—no way, and probably not. When thinking about people globally, I predict—no, and no.

How strong are my prior beliefs? Of the four predictions, on a scale of 1 to 10, where 1 is winning a lottery jackpot and 10 is the sun rising tomorrow, my subjective confidence on each of them, in turn, is United States: 9, 6; global: 7, 8.

In this article I explain why I am more confident about my density predictions than my predictions about building height in the United States, although the reverse is true for my global predictions.

Population Density: Some Basic Facts

Much of the discussion in this article is about cities and urbanization. The simplest definition of *urbanization* is the existence of above-average density. Densities vary across countries and within them. Divided evenly, every person in the world could have about 2 hectares of land.[1] The United States has an above-average endowment of raw land, by world standards: about 3.1 hectares per person (or about 0.3 people per hectare [pph]). Some other countries, however, have even larger areas relative to their population: Canada has about 30 hectares of raw land per person, Australia has 40 per person, and Russia has 12 per person. At the other extreme of the density scale, examples of higher densities include China, which has only 0.75 hectare per person (or about 1.35 pph); India and Japan have about 3.5 pph; Korea and the Netherlands have about 4.75 pph; Bangladesh has about 10 pph; the city states Singapore and Hong Kong have about 65 pph.

The figures presented in the previous paragraph, however, are extremely crude; densities vary even more *within* countries than *across* countries. Within the United States, most of the population lives within a few hundred miles of the major coasts (including the Great Lakes); with a few exceptions, such as Denver and Salt Lake City, most of the country is fairly empty between Minneapolis and the area 100 miles or so from the Pacific Ocean (Rappaport and Sachs, 2003). This pattern is not

[1] A hectare is 10,000 square meters, or 1/100 of a square kilometer. About 2.47 acres comprise a hectare.

atypical; many countries have some fairly dense areas and some (often large) "empty quarters." For example, almost 90 percent of Canada's population lives within 200 miles of the U.S. border, most of China's population lives within 100 miles of the coast, and very few Australians live very far from the coast.

The average densities of U.S. states ranges from about 4 pph in New Jersey (denser than India or Japan), 3 pph in Rhode Island (denser than Germany), and more than 2 pph in Connecticut and Massachusetts to less than 0.05 pph in Nevada and New Mexico and less than 0.02 pph in Alaska. To give some idea of the state density differences, if the entire United States, excluding Alaska, were settled at New Jersey's density, the country would contain more than 3 billion people.

Density Within Cities

So far, this article first examined data regarding density and now examines population as it relates to cities. The U.S. Census Bureau defines *urbanized* as census tracts and blocks that meet certain population density thresholds and that are part of or connected to some urban core of 2,500 or more people. During the past 40 years, the total U.S. population has grown about 1.1 percent per year, the urban population has grown about 1.3 percent per year, and the rural population has grown slightly more than 0.2 percent per year. Thus, the United States has been becoming more urban. In total, about 81 percent of the U.S. population is currently urbanized compared with 74 percent 40 years ago.[2] Over the very long run, the fraction of the U.S. population that is urbanized follows a logistic curve, sort of a stretched-out S, which is bounded between 0 and 100 percent. Given the recent slowing of the upward shift, it will be surprising if the overall U.S. rate of urbanization goes up more than a few percentage points over a 40-year time horizon.

Turning from the population of cities, the article now examines land as it relates to cities. U.S. Department of Agriculture (USDA) land use data show that urban areas comprise only about 3 percent of the U.S. land mass; another 2 percent is built-up rural areas, including highways (Nickerson et al., 2011).[3] Between 1969 and 2007 (USDA's closest available years to our benchmarks for population in the preceding paragraph), U.S. urban land grew from about 13 million hectares to 25 million hectares; at 1.6 percent growth per year, urban land grew 0.3 percent per year faster than urban population. That difference is more meaningful that it might first appear, given the effects of compounding over 40 years. On the other hand, urban population growth and urban land growth have

[2] The first census was undertaken shortly after the ratification of the U.S. Constitution in 1790. The definition of "urban" has changed, unsurprisingly, from time to time; the most recent significant changes were in 2000. We have made no adjustments for these changes to census data. Some U.S. data we will mention in the following section are based on metropolitan areas, rather than urbanized areas. Metropolitan areas are collections of counties containing one or more principal cities, but they can contain some nonurbanized area. The distinction between metropolitan and urban can be very important for many purposes, but it does not matter much for the discussion in this article, which focuses on urban, except as otherwise noted.

[3] Independent research by Shlomo Angel and associates using a different methodology (satellite imagery and statistical modeling) estimated a U.S. urbanized land share of 1.2 percent, which is less than one-half of the estimate from USDA's broader definition of urban (Angel et al., 2012). Overall, Angel et al. (2012) estimated the world's cities cover about 0.5 percent of the world's total land area, but, of course, large deserts, mountain ranges, and practically unusable places like Antarctica exist; Angel et al. (2012) estimated that cities cover about 4 percent of the world's *arable* land area. Angel et al.'s (2012) methodology estimated that 6.3 percent of arable U.S. land is urbanized.

been broadly slowing down in the United States. Between the end of World War II (WWII) and 1970, urban population grew at an annual rate of 2.7 percent and urban land grew at an annual rate of about 3.0 percent, or roughly double the more recent rate.

Next this article examines population and land together, relying on USDA's estimates of urbanized land. When considering only urbanized land and urbanized population, the average U.S. urban density is about 10 pph. This density is about 30 times the simple national average we calculated in the previous section. The density is calculated for urban and rural populations combined; compared with the simple average for the United State's densest state, the national *urban* average of 10 pph is more than double the *simple* average for New Jersey's urban and rural areas.

Although country averages are often cited and are of some interest, densities across and within cities vary remarkably, whether in U.S. cities or in cities around the world. Bertaud and Malpezzi (2013) recently updated their research on urban density in 54 cities around the world, including 8 major U.S. cities,[4] using a consistent methodology. They measured the average density of built-up census tracts, or their local equivalent, in each place; then they examined that pattern of these measures using several second-stage measures. (For a more detailed description of their method, see Bertaud and Malpezzi, 2013.) Exhibit 1 presents their overall average population density for the built-up areas of these cities. Exhibits 2 through 5 go beyond the overall city averages and present some simple density patterns within the cities of New York, Paris, Moscow, and Johannesburg. These exhibits present the average density of built-up areas in each 1-kilometer ring from the central business district (CBD).

Exhibit 1

Average Population Density of Selected World Cities (1 of 2)

City	Country	Year of Data	Average Number of People per Hectare in the Built-Up Area of the City
Mumbai	India	1991	389
Hong Kong	Hong Kong	1990	367
Guangzhou	China	1990	365
Seoul Municipality	Korea, Republic of	1990	322
Shanghai	China	1990	286
Seoul and New Towns	Korea, Republic of	1990	282
Tianjin	China	1988	228
Hyderabad	India	1991	223
Kabul	Afghanistan	2005	215
Hanoi	Vietnam	2009	209
Bangalore	India	1991	207
Moscow	Russia	1990	182
Addis Ababa	Ethiopia	2002	177
Barcelona	Spain	1990	171

[4] This article uses the term "city" in its generic sense; the units of observation, in general, are close to the U.S. definition of a metropolitan area. See Bertaud and Malpezzi (2013) for details. Many detailed country case studies are available at http://alainbertaud.com/.

Exhibit 1

Average Population Density of Selected World Cities (2 of 2)

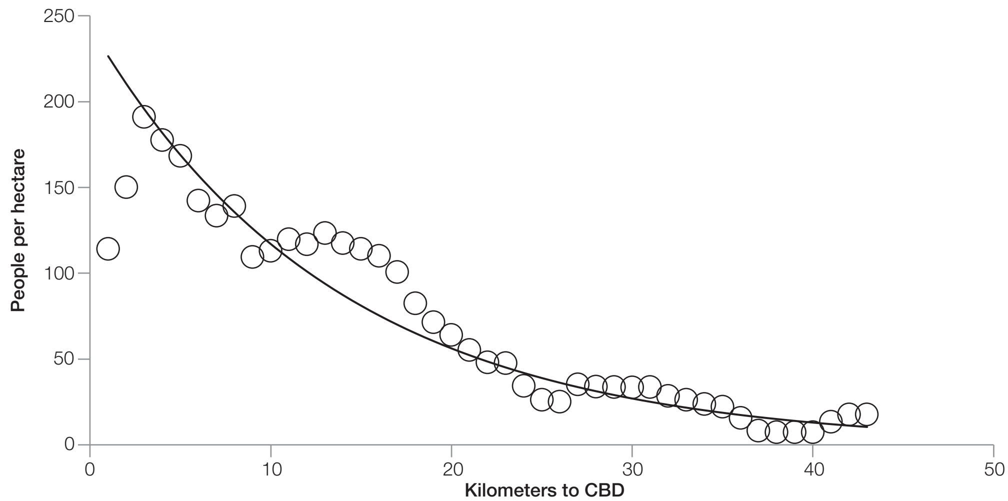
City	Country	Year of Data	Average Number of People per Hectare in the Built-Up Area of the City
Tianjin	China	2000	170
Yerivan	Armenia	1990	168
Ho Chi Minh City	Vietnam	2009	150
Tehran	Iran	1996	146
Beijing	China	1990	145
Abidjan	Cote d'Ivoire	1990	143
Ahmedabad	India	1991	134
Jakarta	Indonesia	1990	127
St. Petersburg	Russia	1990	121
Singapore	Singapore	1990	107
Tunis	Tunisia	1990	102
Rio de Janeiro	Brazil	1991	101
Mexico City	Mexico	2000	96
Sofia	Bulgaria	1999	94
Paris	France	1990	88
Danang	Vietnam	2009	88
New York City MSA	United States	1990	80
Prague	Czech Republic	1990	71
Warsaw	Poland	1993	70
Buenos Aires	Argentina	2000	66
Krakow	Poland	1988	65
Riga	Latvia	2000	64
Budapest	Hungary	1990	63
London	United Kingdom	1990	62
Bangkok	Thailand	1990	58
Brasilia	Brazil	1991	55
Curitiba	Brazil	1991	54
Marseille	France	1990	53
Johannesburg	South Africa	1991	53
Ljubjana	Slovenia	1990	46
New York CMSA	United States	1990	40
Toulouse	France	1990	36
Berlin	Germany	1990	36
Stockholm	Sweden	2000	36
Capetown	South Africa	1990	32
Los Angeles	United States	1990	22
Washington, DC	United States	1990	21
San Francisco MSA	United States	1990	19
Chicago	United States	1990	16
San Francisco Bay CMSA	United States	1990	16
Portland	United States	2000	14
Houston	United States	1990	11
Atlanta	United States	1990	6

CMSA = consolidated metropolitan statistical area. MSA = metropolitan statistical area.

Source: Bertaud and Malpezzi (2013)

Exhibit 2

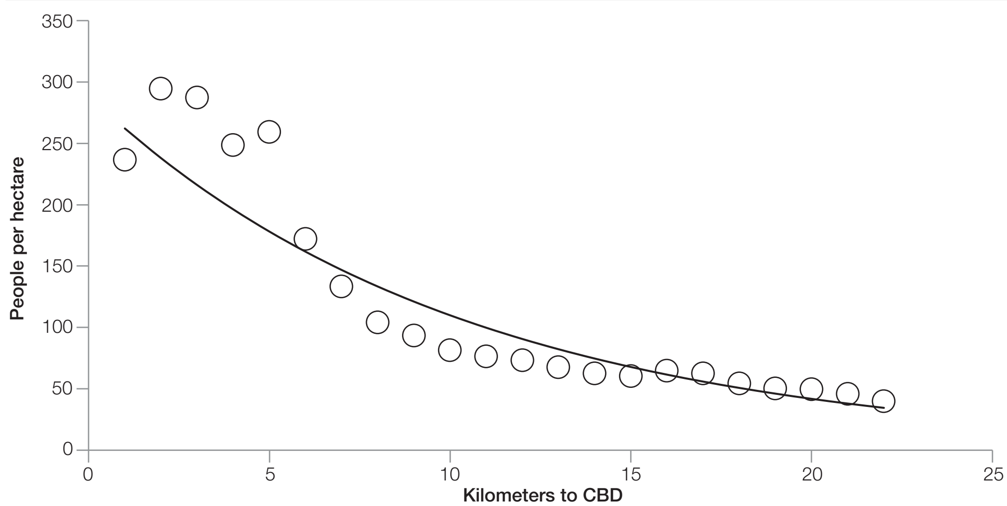
New York City MSA, 1990



CBD = central business district. MSA = metropolitan statistical area.

Exhibit 3

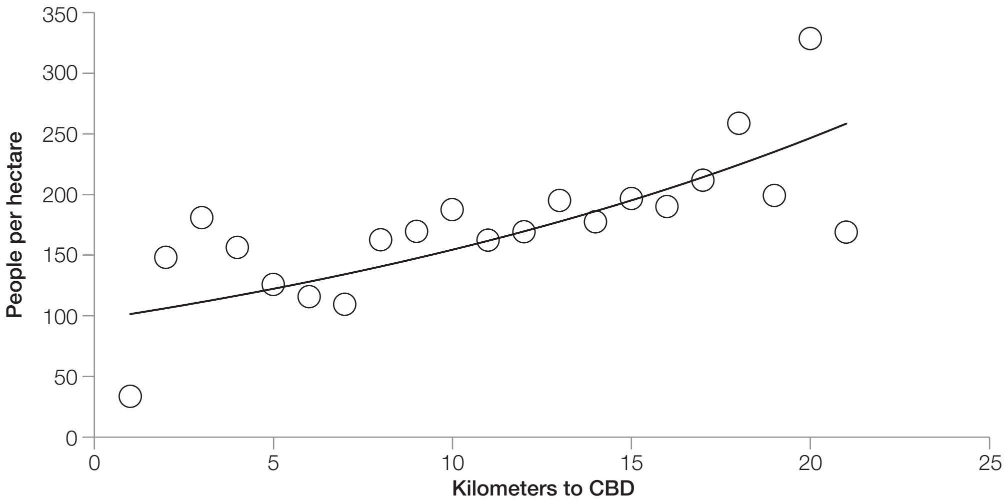
Paris, 1990



CBD = central business district.

Exhibit 4

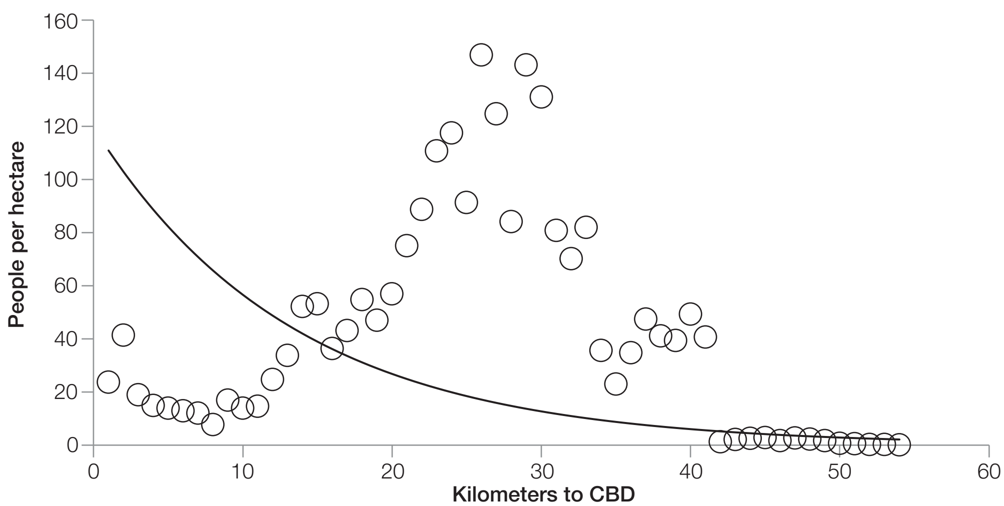
Moscow, 1990



CBD = central business district.

Exhibit 5

Johannesburg, 1990



CBD = central business district.

Enormous variation in the average density of cities is immediately apparent in exhibit 1; these population densities range from 6 pph in Atlanta to 389 pph in Mumbai. According to these averages, the densest cities in our sample are mainly in Asia, but Africa has some fairly dense cities (Addis Ababa and Abidjan), and Europe has a few very dense cities in our sample (Barcelona and Moscow). Moscow is a particularly unusual and instructive case, as Bertaud and Renaud (1997) have carefully documented, and we note briefly in the following section.

The eight U.S. cities examined in Bertaud and Malpezzi (2013) and in this article—New York; Chicago; Los Angeles; Washington, DC; San Francisco; Houston; Portland; and Atlanta—are at or near the bottom of our global comparisons of average density. Among large cities in the United States, New York is the densest, with an average density of 50 pph and a central density approaching 200 pph, falling off rapidly to 50 pph or fewer about 20 kilometers from midtown Manhattan. Chicago and Los Angeles have central densities of 50 to 70 pph and average densities of around 20 pph; Chicago's central density is higher, but Los Angeles' average density, 22 pph, is greater than Chicago's 16 pph. At the other extreme, Atlanta's central density is only 25 pph, although it exhibits an even faster dropoff with distance from the center, from a lower base, and an average density of 6 pph.

What Can Urban Economics Teach About Density?

Urban economists have developed and tested a family of models, deriving from the closely related models of Alonso (1964), Mills (1972), and Muth (1969), which we will refer to simply as the AMM model.[5] The AMM model demonstrates that this pattern of a high central population density followed by a rapid initial dropoff that slows as we move out from the center of the city is a consequence of qualitatively similar patterns, first in land rents, and then in real estate rents and asset prices. These land rents, in turn, are derived from the value of access to a central location; in particular, the increase in value of a location a kilometer closer to the center of the city depends on savings in transportation cost. In the higher land value locations, developers and landlords have incentives to apply more capital (structures) to a unit of land, leading density to roughly correlate with these land values.[6] Simple, but broadly defensible, versions of the AMM model characterize the dropoff in land rents, and therefore in population density, as a "negative exponential" function; that is, measured density follows the form—

$$D(\mu) = D_0 e^{-\gamma\mu\varepsilon},$$

[5] In addition to consulting the original works of Alonso (1964), Muth (1969), and Mills (1972), see Turnbull (1995), McMillen (2004), and Glaeser and Kahn (2004) for elaboration and variations on the simplest models.

[6] Construction costs do not vary much by location within a city and are usually assumed to not vary at all in the models (Davis and Palumbo, 2008). Land rents and corresponding asset prices vary a lot, both in reality and in the models. Real estate developers combine land and structure to obtain houses and other real estate, so real estate rents and asset prices vary more than the structures but vary less than the land. Further, if technology and regulations permit the production of different kinds of housing (single family, duplexes, multifamily, all of varying sizes), developers will build most densely where land costs the most; in the simpler models, this land is located at or near the city center. The population density data observed directly and discussed in this article correlate with the development of more or less dense housing. The models formalize this perfectly intuitive process. See Follain, Renaud, and Lim (1979) for representative empirical evidence on the relationship between land rents and density patterns.

where D is population density at distance u from the center of a city, usually called the central business district (CBD) by urban economists; D_0 is the density at the center; e is the base of natural logarithms; γ is "the gradient," or the rate at which density falls from the center.

Thus, urban economists concern themselves with more than just the average density of a city. Malpezzi and Guo (2001) and Galster et al. (2001), for example, discussed a wide variety of measures. For most urban economists, the second top density measure, after the average, is the aforementioned density gradient. Economists also find it very useful to measure how well the simple model fits the data; that is, to use the simple model as a benchmark. The simple measure of fit used in this paper is the R-squared from the regression equation that estimates the parameters of the simple exponential model written above. To an urban economist, a "sprawling" city, in general, will have some combination of low density, a flat gradient (the city spreads out), and, quite possibly, a poor fit to any version of the standard model.

In the large literature devoted to variants of this model, urban economists also consider taxes, regulations, local governance, fiscal arrangements, other public policies, as well as amenities and natural features of the landscape.[7] The authors also relax initially strong assumptions about a single center or CBD, and incorporate the effects of infrastructure and physical geography in their analyses. This article defers those for now and focuses on city size, income, and transport costs—the most fundamental determinants of density and urban form across the majority of this rich literature.

Three central predictions of the standard model, for purposes of this article, are (1) cities will decentralize as incomes rise, because richer households will demand more living space, on average, which generally translates into higher demand for land;[8] (2) cities will decentralize as (if) transport costs fall, because lowering transport costs flattens the tradeoff between a more central location and those farther out; and (3) cities will decentralize (sprawl)[9] as they grow in population, in no small part because the jobs and other features that attract people to the CBD are in turn decentralized in larger cities. The standard model ironically is often (mis)labeled the monocentric model because it begins with highly centralized employment, dense cores, and steep gradients. Over time, however, fundamental forces revealed by the model cause the city to decentralize, or sprawl. Put melodramatically, the initial monocentric version of the model contains the seeds of its own destruction.

Models Versus Reality

No real-world city mirrors the simple AMM model exactly, but this "negative exponential" density pattern *roughly* corresponds to reality, not only in most U.S. cities, but also in most cities in market-oriented economies, as many studies, including Bertaud and Malpezzi (2013), have documented.

[7] The works listed in previous footnotes and the references contained in those papers provide an introduction to this rich literature.

[8] The mapping of increased demand for living space into demand for land is not one for one because of the aforementioned ability to substitute capital (structure) and land to produce houses of different types. Given increased demand for floor space, however, demand for land would increase in the end.

[9] Many studies emphasize this built-in entropy; see, for example, McMillen (2004) and Wheaton (2004).

A comparison of Paris (exhibit 3) with New York (exhibit 2) shows that, in both cities, the very center of the city is not the densest spot, because the CBD devotes substantial space to office and public uses; it shows, instead, that the densest annuli in the city are a few kilometers out. The exhibits show that density then tends to decrease at a decreasing rate moving out from the center. The estimated density gradients for New York and Paris are -0.07 and -0.10, respectively. The R-squared values for the two regressions that estimate these gradients are about 0.9 in both cities. In other words, for every 1-kilometer move from the center of New York, density falls about 7 percent; in Paris, the decline is about 10 percent. This very simple descriptive regression captures about 90 percent of the variation in the average density of the two cities' concentric 1-km rings. Within Bertaud and Malpezzi's sample, examples of other cities that very broadly follow this pattern, albeit with steeper or flatter gradients and reasonable but usually somewhat lower R-squared values, include almost all U.S. cities, most western European cities, many (not all) Asian cities, and many Latin American cities (Bertaud and Malpezzi, 2013).

Some cities, however, show very different patterns. The density gradient of Moscow (exhibit 4), for example, goes beyond "flat" and "poor fit": density patterns are actually *inverted* from the standard urban model's prediction, a legacy of a particular central planning system, as discussed in detail by Bertaud and Renaud (1997). The gradient is a positive 0.05, with an R-squared of about 0.44. Johannesburg (exhibit 5) under apartheid shows a less dense central White city, with very dense Black townships some kilometers distant from the CBD. Although the overall estimated gradient, -0.04, does not look outrageously out of line with other cities, the R-squared is only 0.18, and the equation completely misses the density of the Black townships. In addition to apartheid's other deleterious effects, it created a commuting nightmare for many Black South Africans, whose 2-hour one-way commutes were, and still are, surprisingly common.

Bertaud and Malpezzi (2013) examined other cities, which are more or less similar to standard model predictions, but also point out a number of other anomalies.[10] For example, Curitiba and Brasilia are cities designed by architects and planners with relatively little reference to land-price signals and other market indicators. The cities' density patterns are also very much at odds with the model's predictions; most of their low-income residents live far out from the central core in very dense settlements.

Bertaud and Malpezzi (2013) analyzed these cross-city differences in density patterns more systematically and found, *inter alia*, that cities become less dense and more decentralized as incomes rise and as transport costs fall. Larger cities become more decentralized but also denser on average, ceteris paribus, as economists would expect. Although the Bertaud and Malpezzi (2013) study documented these results across countries in a unique way, urban economists are not surprised by these qualitative results, because they have been foreshadowed in the standard models and documented repeatedly in both case studies and comparisons of cities within countries.[11] As incomes

[10] Only a few cities are addressed in this article for lack of space; see the full paper and data appendix for figures and detailed data for each city. The data for the four cities discussed in this article are based on 1990 data; the full sample includes data ranging from 1990 to 2009.

[11] In addition to consulting papers cited elsewhere in this article, see McDonald (1989), Paulsen (2013), and Jordan, Ross, and Usowksi (1998) for good examples of U.S. comparisons.

rise and transport costs fall, households consume more housing. Although the ability to substitute structure for land breaks the one-to-one link between the consumption of housing floor space and the consumption of land, space and land consumption are still positively correlated. As incomes rise and transport costs fall, people consume more land.

The Future of U.S. Cities

What does the AMM model tell us about the point of contention at hand? If incomes continue to rise and transport costs continue to fall, powerful forces will fundamentally continue to decentralize cities and reduce average densities. On the other hand, increasing the size of cities will tend to increase average density, although it will lessen the importance and the density of one or a few central locations in each city.

Despite the well-known recent stagnation in U.S. household income growth, especially for those households with modest incomes, real income growth is expected to resume in due course, although debate continues regarding whether that growth will return to the same patterns of growth and distribution that were present during much of the post-WWII period. Over the long run, rising incomes and the resultant demand for land will cause cities to spread out.

Regarding post-WWII transport costs, there is little trend in the real cost of transportation as measured by the Consumer Price Index (CPI), although these costs rise and fall quite a bit over shorter time horizons, driven partly by the volatility of fuel costs. The transportation CPI, however, leaves out one of the largest costs of commuting and other intracity transport: the cost of time. As incomes rise, the opportunity cost of time also rises, providing at least a partial offset to the demand for housing effect discussed in the preceding paragraph. In addition to these increases in per-hour costs, traffic congestion seems to be increasing in U.S. cities in recent decades. The average one-way commute in metropolitan areas was stable at about 21 or 22 minutes for several decades (the data were first collected in the 1980 census), but that same commute now averages up to 25 minutes, according the American Community Survey.[12] Some trends could push back against these recent increases, including technological innovations (increased telecommuting, "smart cars") and improved transportation policies (for example, if we adopted congestion pricing of roads and carbon taxes). Although improved transportation policies face serious political roadblocks, improvements in automobiles and road designs are proceeding. Transport costs are likely to increase, on balance, for a while, but it is hard to see that the densifying effects of increases in transportation costs would be so great that they would offset the effects of increasing incomes and demand for housing.

As noted previously, the U.S. population continues to grow at a rate that is a bit less than 1 percent per year. Average metropolitan population growth is just slightly higher than the overall national average. Nonmetropolitan population growth rates are lower than national averages, sometimes substantially so, and are also more volatile year to year. Some tendency exists for the relative popu-

[12] Commutes are actually a modest fraction of urban trips, but the increase in commute time generally will be correlated with congestion. In fact, overall congestion often increases faster than commutes, because one of the "safety valves" in a growing city is the fact that decentralization of jobs can improve commutes (see Gordon, Richardson, and Jun, 1991). As an alternative, one could simply imagine Chicago's commute if all 4 million metropolitan area workers headed to the Willis Tower each day.

lation growth of the largest metropolitan areas to slow down in recent decades, and, unsurprisingly, much more variation exists in the growth rates of small metropolitan areas than of large areas (Ehrlich and Gyourko 2000). In the end, the population of most metropolitan areas will continue to grow, even in areas such as Cleveland, Detroit, or Harrisburg, where the area's central city populations are declining. Overall population growth will contribute to further sprawl, even if some cities could see increases in average density from this population growth.

Future Patterns of Global Settlements

The outlook for density is similar, if not exactly the same, for cities globally as it is for cities in the United States. Rising incomes are driving demand for increased housing consumption (Malpezzi and Wachter 2012). Long-run average growth rates of gross domestic product per capita are slightly less than 2 percent, which is close to the U.S. average; of course, these averages mask large variations between star performers, like China and Botswana, and countries that have underperformed just as dramatically. The IMF (2013) abstracted from Europe's current stagnation; and Eichengreen, Park, and Shin (2012) expressed concerns about slowdowns in China and elsewhere; and Banerjee and Duflo (2008), Kharas (2010), and Pinkovskiy and Sala-i-Martin (2009) described their expectations for long-run global incomes to continue to rise, extreme poverty to decline, and a much larger global middle class to emerge.

If you consider the minimum floor space consumption worldwide to be represented by 1 square meter of Kolkata pavement, much of the density decrease will signify a wonderful improvement in many lives. We have already seen an extreme case of this improvement in China, where urban floor space per capita *doubled* in less than 20 years.[13] Furthermore, although big cities like Shanghai have built a large number of tower blocks, the pre-reform housing was so crowded that, on balance, land consumption per capita is probably increasing.

When turning our attention from the United States to the global picture, we need to consider the urban transition that is still under way in many countries, including some of the largest countries. The U.S. population is about 80 percent urbanized; most developed countries and a number of emerging markets are also highly urbanized; Latin America's population as a whole is also about 80 percent urbanized. On the other hand, China's population is about 50 percent urbanized, and India's is about 30 percent urbanized. The populations of many African countries and poorer Asian countries are also around 30 to 50 percent urbanized, which analysis of World Bank World Development Indicators data shows is roughly the point of inflection at which urbanization takes off and begins to increase relatively rapidly until the growth of urbanization slows down again at around 60 to 70 percent.

United Nations (U.N.) population projections suggest that global population growth, already slowing down, will stabilize later in this century.[14] Between overall population growth and increases in

[13] In 1987, urban residential floor space per capita was 12.7 square meters; by 2005, it was 26.1. See Chow and Niu (2010).

[14] See United Nations (2012) for a more detailed discussion. All such projections obviously are subject to error. The U.N.'s country-by-country analysis uses each country's own definition of urban.

the percentage of people living in the cities of developing countries, however, during the 40-year time horizon of our charge, substantial increases are expected in the number of people living in cities, globally. U.N. population projections roughly suggest an increase of 2.2 billion in cities during the next 40 years, of which 0.5 billion might be in China alone. Although such projections may sound scary (they have given rise to a number of alarmist news items), it is worth noting that in the previous 40 years we added 2.6 billion to the world's cities (340 million in China alone), and that increase was over a much smaller base, with less in the way of resources, knowledge, and infrastructure. I would be the last to minimize the challenges ahead, especially for poorer countries, but we have faced these challenges before, and urbanization presents tremendous opportunities. A huge amount of literature exists on agglomeration and other benefits of urbanization. World Bank (1991) and Henderson (1997) are examples of policy-oriented reviews; Glaeser's (2011) review is a recent and extremely readable introduction to these benefits.[15]

What effect does moving from the countryside to the city have on population density? It is hard to put a number on the effect. We have some data on floor space per capita of many international cities, but we have little on the rural areas of many countries. Still, it is surely the case that on first moving from rural areas to cities, density increases. Will this effect be enough to offset the increases in space per urban resident as incomes grow? It is worth noting that often half or more of the growth of developing countries' cities comprises natural increase (number of births divided by number of deaths) of pre-existing residents, with the other half coming from rural-urban migration (and sometimes immigration from other countries). So what we might call the urbanization effect will increase population density, but rising incomes work in the other direction.

Worldwide, a number of forces could cause transportation costs to decline, primarily in developing and emerging markets, as more people shift from slow transport modes (walking, bicycling) to faster modes. How this transformation takes place, and its exact effect on urban form, will be determined in part by public policies including energy pricing. But in the end, both developed and developing countries are expected to see overall declines in density, through this channel, and also after all channels are accounted for. A careful and very rich analysis by Angel et al. (2012) came to the same conclusion. Angel et al. (2012) provided a summary, and they also provided country-by-country forecasts of urban land under alternative scenarios at their website, http://www.lincolninst.edu/subcenters/atlas-urban-expansion/.

What Does Density Tell Us About Height?

In addition to asking about density, our charge asked about the population becoming "farther from the ground," or about a building's height. Although much of the press coverage of the U.S. housing market focuses on single-family homes, at the end of World War II about 11 percent of the housing stock was multifamily (5 or more units in a structure); by 1980 the multifamily portion of the

[15] Some of Glaeser's (2011) reported density figures are very different from our own, especially for Chinese cities. This disparity is almost certainly because of the unusual ways that China legally defines cities, which can be more like a city and its surrounding state in other countries. The Bertaud and Malpezzi (2013) method gives a better view of density in the presence of such administrative definitions. None of these differences detract from the main messages of Glaeser's fine review.

housing stock had grown to about 18 percent, and, despite lots of annual volatility in multifamily construction, that is about where it remains today. Within the category of multifamily housing, in recent years we have been building a somewhat larger share of larger (50 or more units) buildings, but, overall, the size distribution of multifamily buildings changes rather slowly. We have been suburbanizing, but the multifamily stock has largely retained its national market share.

Although a correlation exists between building height and population density, this correlation is modest. For example, New York has a number of residential buildings 50 stories or higher; although dense by U.S. standards, New York's central density is only two-thirds the density of central Paris, where heights have been limited to 7 stories.[16] By all accounts, the densest settlement in modern times has been the so-called walled city in Kowloon; at the time of its demolition about 20 years ago, this 2.6-hectare political and urban anomaly reportedly contained an estimated 33,000 people, a density of more than 12,000 pph; the buildings were about 12 stories high (Basler 1992).

As of the writing of this article, the tallest residential building is Dubai's 101-story Princess Tower.[17] It reportedly comprises 763 units on about 0.5 hectares of land. At present we do not have the data that would permit us to analyze Dubai using the same methodology that we use in the analysis of the other cities discussed in this article. Some rough calculations, however, can still be instructive. A reasonable guess is that the Princess Tower building might house 1,500 residents. If the plot is equivalent to a census tract, 3,000 pph would be denser than any other tract in our 54-city sample. If applied, our method would average this pph out over other buildings and intervening land (including roads), yielding a lower estimate than this crude back-of-the-envelope estimate.[18]

One back of the envelope deserves another. Compare Princess Tower to another, older, large building—New York's London Terrace. Principal construction was completed in 1928, and it comprises 1,665 units, which probably house 3,000 residents. Its maximum height of 19 stories is about one-fifth the height of the Princess Tower, and London Terrace covers most of a city block, or roughly 2 hectares. This back-of-the-envelope estimate would yield something similar to the densest census tract equivalents in our 54-city sample, or about 1,500 pph. One-fifth of the height of the Princess Tower might, we guess, yield one-half of the density.

Princess Tower and London Terrace are instructive but obviously exceptional. In the end, the United States builds lots of "semi-tall" apartments that are dense by U.S. standards, but not by global standards. U.S. neighborhoods that comprise many 10- to 12-story apartment buildings are often less dense than Parisian neighborhoods with 4-story buildings, much less the denser lowrise neighborhoods of Mumbai or Shanghai.

[16] The outstanding exception (and we mean outstanding in the sense of standing out, not in the sense of excellent) is Tour Montparnasse. This 59-story anomaly in the 15th arrondissement is mainly office space, so it does not directly affect any density calculations. As of this writing, proposals have been written to relax the height restrictions currently in place in central Paris.

[17] Taller office and mixed-use buildings exist; a notable example, also in Dubai, is the 163-story Burj Khalifa building, which happens to have a large number of residential units. To my knowledge, Princess Tower is the tallest primarily *residential* building currently extant.

[18] Certainly Dubai would be a very welcome addition to the Bertaud and Malpezzi (2013) sample, were the data made available.

In fact, Mumbai provides some of the most compelling evidence of low correlation between building height and density. Mumbai is the densest city in our sample, on average, but it also has some of the most stringent restrictions on building height, as Bertaud (2004) pointed out. Mumbai's Floor Area Ratio (FAR), locally called the Floor Space Index (FSI), is particularly problematic.

FAR regulations directly limit the amount of floor space per unit of land. If the FAR is one, and we have a 1-hectare plot, then we are permitted to build up to a hectare of floor space. If FAR were the only binding regulation, we could theoretically build a one-story structure out to the lot line, or we could build a two-story structure on one-half of the plot, or three stories on one-third of the plot, and so on. Other regulations are usually in place, such as setback requirements, so we rarely see a structure extending out to the lot line all around. (Even in the absence of setback requirements, such a strange building would rarely pass market tests.)

Despite its large population and high overall density, Mumbai has a maximum FAR of, in general, 1.3, even in some of the most central locations. A very few small areas have recently permitted an FAR of 4. For comparison, the maximum FAR in much less dense New York is about 15. Bertaud and Brueckner (2005) undertake a simulation analysis of Bangalore (another city with very low FARs, although not as binding as Mumbai's). Bertaud and Brueckner's (2005) model makes clear that in Bangalore, and surely more so in Mumbai, India's extremely stringent FARs have the effect of depressing development at the center, pushing population out to the periphery. Secondary effects abound; these FARs increase the size of informal (technically illegal) settlements such as Dharavi (made superficially familiar to American viewers of the film *Slumdog Millionaire*) and make bad commutes worse. In terms of our measures, in Mumbai the density gradient is very flat, -0.01, and the R-squared is a paltry 0.19. The problems created by this badly designed FAR are compounded by low incomes, challenging physical geography, other inappropriate regulations on land use and rental markets, and inadequate infrastructure.[19]

These few crude examples are only suggestive, but I think they are sufficient to make the point that, although a relationship exists between building height and density, that relationship is not fixed. We have much to learn about the empirics of height and density on any systematic basis, despite some interesting simulation studies, such as Chau et al. (2007). As of the writing of this article, I am not as confident of statements about height as I am about density, because comparatively little research has focused on height per se. More careful research on this subject could be beneficial.

What is my bottom line on whether the average person will live higher up? In the United States, I expect height will decrease along with the general decentralization of population that we will see over the next four decades, even if some individual tall buildings are successfully developed. But I do not have as much data or strong models to stand behind this prior belief. In much of the rest of the world, I expect height to increase somewhat, largely by effects we will probably fail to measure very well: relatively smaller fractions of our world's population will live in rural areas, at whatever density, and a higher fraction in cities. I have not seen too many tower blocks in rural India.

[19] In addition to higher FARs existing on some older grandfathered buildings, developers can build above the legal FAR on some parcels by reducing already low FARs on other parcels; that is, they can implement a form of transferable development rights. Presumably this transfer of rights was the way Mukesh Ambani obtained approvals for his controversial, recently completed, 27-story house in Mumbai, described in Reginato (2012).

Flies in the Ointment?

Famous urban thinker Yogi Berra warned, “It is difficult to make predictions, especially about the future.” Incomes could collapse, transportation costs could skyrocket, and the growth of U.S. urban population could shudder to a halt. Such shocks would clearly sabotage my predictions, but I consider those events unlikely. On the other hand, it is well known that economists are good at working through marginal changes of things in front of them, but occasionally, rather like the dinosaurs, are blissfully unaware of an impending asteroid. What are some of the blue-sky developments that could counter my views?

Some analysts think that cultural and generational shifts are taking place; that some combination of downsizing among the baby boom generation and being environmentally aware among the millennial generation will exhibit radically different preferences for housing and modes of commuting. Nelson (2009) is an interesting example of this view. Although anecdotal conversations with my students over the years suggest less interest in buying a home right out of college than a decade ago, I am skeptical that such changes will be strong enough to drive declines in density. Economists often point to Stigler and Becker (1977), who argued that tastes are more stable than is commonly realized and showed how easy it is to confuse changes in prices and budget constraints with changes in tastes. More recent research by psychologists, without much stake in economists’ desire to reclaim the high ground of unchanging preferences, finds substantial (if not complete) stability in tastes (Kahneman and Snell 1992). My claim is not that underlying preferences cannot change, or will not change at all, but rather that I will be surprised if tastes change enough to drive a reversal in long-run trends in population density over the next several decades.

Many broad technological changes have affected real estate development and density in recent years, and they will continue to do so. The effects of new technology, however, including the Internet, are complex and difficult to sort out completely. The view that telecommuting and other uses will generally lead to a much more spread-out form of development is well represented by Cairncross (2001), but, as others such as Kolko (2000) have pointed out, many new technologies complement urbanization and substitute for it; centripetal and centrifugal forces are at work. It is worth pondering that some of the industries that know and have access to the best telecommuting and other Internet technologies exhibit some of the greatest clustering effects—Silicon Valley and Wall Street immediately come to mind. Many industries do both simultaneously; for example, moving back-office jobs to suburban locations, or even other states or countries, while concentrating on other kinds of jobs.

Both manmade and natural disasters can affect urban form. We noted in the introduction that much of the world’s densest settlements—parts of New York, Florida and the Gulf Coast, the Netherlands, and Bangladesh—may be at risk of sea level changes and future storm surges (Nicholls 2011; Rosenzweig, et al., 2011). Some knowledgeable observers worry about entropy in the control of the world’s thermonuclear devices and other weapons of mass destruction. For most of the history of cities, urbanization has improved personal security, but the 20th century’s military technology has complicated matters. Density may no longer be much of a defense, and the prospect of terrorism may have some effects on density (Blomberg and Sheppard 2007). I have not tried to factor such possibilities of natural and manmade disasters into my simple scenarios, although, taken together, they could have powerful, if uncertain, effects on urban form in the future.

What about public policy? Policies like the mortgage interest deduction have been shown to increase demand for larger homes, albeit with negligible effect on homeownership rates, the oft-cited rationale for these subsidies. On tax policy, see Green and Vandell (1999) and Gyourko and Siani (2003), for example; Brueckner (2001) analyzed a wide variety of public policies and their effects on urban form. Other research, some already mentioned, suggested that sufficiently high energy costs could change household behavior enough to measure (Larson, Lui, and Yezer 2012). Granted, fundamental tax reform that included about a $50 per ton tax on carbon, reduction in marginal income tax rates, and elimination of the deductions for property taxes and mortgage interest could, over several decades, measurably affect urban form. Such reforms, however, are politically unlikely in the foreseeable future.

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References

Alonso, William. 1964. *Location and Land Use: Toward a General Theory of Land Rent*. Cambridge, MA: Harvard University Press.

Angel, Shlomo, Jason Parent, Daniel L. Civco, and Alejandro M. Blei. 2012. *Atlas of Urban Expansion*. Cambridge, MA: Lincoln Institute of Land Policy.

Banerjee, Abhijit V., and Esther Duflo. 2008. "What Is Middle Class About the Middle Classes Around the World?" *Journal of Economic Perspectives* 22 (2): 3.

Basler, Barbara. 1992. "Hong Kong Journal: The Walled City, Home to Huddled Masses, Falls," *New York Times*, June 16.

Bertaud, Alain. 2004. Mumbai FSI Conundrum: The Perfect Storm; the Four Factors Restricting the Construction of New Floor Space in Mumbai. Working paper. Washington, DC: World Bank.

Bertaud, Alain, and Jan K. Brueckner. 2005. "Analyzing Building-Height Restrictions: Predicted Impacts and Welfare Costs," *Regional Science and Urban Economics* 35 (2): 109–125.

Bertaud, Alain, and Stephen Malpezzi. 2013. *The Spatial Distribution of Population in 54 World Cities*. Madison, WI: University of Wisconsin, School of Business, James A. Graaskamp Center for Real Estate.

Bertaud, Alain, and Bertrand Renaud. 1997. "Socialist Cities Without Land Markets," *Journal of Urban Economics* 41 (1): 137–151.

Blomberg, S. Brock, and Stephen Sheppard. 2007. "The Impacts of Terrorism on Urban Form," *Brookings-Wharton Papers on Urban Affairs* 2007: 257–294.

Cairncross, Frances. 2001. *The Death of Distance: How the Communications Revolution Is Changing Our Lives*. Cambridge, MA: Harvard Business Press.

Chau, Kwong-Wing, S.K. Wong, Y. Yau, and A.K.C. Yeung. 2007. "Determining Optimal Building Height," *Urban Studies* 44 (3): 591–607.

Chow, Gregory C., and Linlin Niu. 2010. "Demand and Supply for Residential Housing in Urban China," *Journal of Financial Research* 44 (1): 1–11.

Davis, Morris A., and Michael G. Palumbo. 2008. "The Price of Residential Land in Large U.S. Cities," *Journal of Urban Economics* 63 (1): 352–384.

Ehrlich, Steven, and Joseph Gyourko. 2000. "Changes in the Scale and Size Distribution of U.S. Metropolitan Areas During the Twentieth Century," *Urban Studies* 37 (7): 1063–1077.

Follain, James R., Bertrand Renaud, and Gill-Chin Lim. 1979. "Economic Forces Underlying Urban Decentralization Trends: A Structural Model for Density Gradients Applied to Korea," *Environment and Planning* 1 (1): 541–551.

Galster, George, Royce Hanson, Michael R. Ratcliffe, Harold Wolman, Stephen Coleman, and Jason Freihage. 2001. "Wrestling Sprawl to the Ground: Defining and Measuring an Elusive Concept," *Housing Policy Debate* 12 (4): 681–717.

Glaeser, Edward. 2011. *Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier*. New York: Penguin.

Glaeser, Edward L., and Matthew E. Kahn. 2010. "The Greenness of Cities: Carbon Dioxide Emissions and Urban Development," *Journal of Urban Economics* 67 (3): 404–418.

———. 2004. "Sprawl and Urban Growth," *Handbook of Regional and Urban Economics* (4): 2481–2527.

Gordon, Peter, Harry W. Richardson, and Myung-Jin Jun. 1991. "The Commuting Paradox Evidence From the Top Twenty," *Journal of the American Planning Association* 57 (4): 416–420.

Green, Richard K., and Kerry D. Vandell. 1999. "Giving Households Credit: How Changes in the U.S. Tax Code Could Promote Homeownership," *Regional Science and Urban Economics* 29 (4): 419–444.

Gyourko, Joseph, and Todd Sinai. 2003. "The Spatial Distribution of Housing-Related Ordinary Income Tax Benefits," *Real Estate Economics* 31 (4): 527–575.

Henderson, J. Vernon. 1997. *Urban Development: Theory, Fact and Illusion.* Cambridge, MA: Oxford University Press.

Jordan, Stacy, John P. Ross, and Kurt G. Usowski. 1998. "U.S. Suburbanization in the 1980s," *Regional Science and Urban Economics* 28 (5): 611–627.

Kahneman, Daniel, and Jackie Snell. 1992. "Predicting a Changing Taste: Do People Know What They Will Like?" *Journal of Behavioral Decision Making* 5 (3): 187–200.

Kharas, Homi. 2010. *The Emerging Middle Class in Developing Countries*. Paris, France: OECD Development Centre.

Kolko, Jed. 2000. "The Death of Cities? The Death of Distance? Evidence From the Geography of Commercial Internet Usage." In *The Internet Upheaval: Raising Questions, Seeking Answers*, edited by Ingo Vogelsang and Benjamin M. Compaine. Selected papers from the Telecommunications Policy Research Conference. Cambridge, MA: MIT Press.

Larson, William, Feng Liu, and Anthony Yezer. 2012. "Energy Footprint of the City: Effects of Urban Land Use and Transportation Policies," *Journal of Urban Economics* 72 (2): 147–159.

Malpezzi, Stephen, and Wen Kai Guo. 2001. *Measuring "Sprawl": Alternative Measures of Urban Form in U.S. Metropolitan Areas.* Madison, WI: University of Wisconsin, School of Business, Center for Urban Land Economics Research.

Malpezzi, Stephen, and Susan M. Wachter. 2012. "Housing Demand." In *Encyclopedia of Housing and Home,* edited by Susan J. Smith. Philadelphia: Elsevier.

McDonald, John F. 1989. "Econometric Studies of Urban Population Density: A Survey," *Journal of Urban Economics* 26: 361.

McMillen, Daniel P. 2004. "Employment Densities, Spatial Autocorrelation, and Subcenters in Large Metropolitan Areas," *Journal of Regional Science* 44 (2): 225–244.

Mills, Edwin S. 1972. *Studies in the Structure of the Urban Economy*. Baltimore, MD: Johns Hopkins University Press.

Muth, Richard F. 1969. *Cities and Housing: The Spatial Pattern of Urban Residential Land Use*. Chicago: University of Chicago Press.

Nelson, Arthur C. 2009. "The New Urbanity: The Rise of a New America," *The ANNALS of the American Academy of Political and Social Science* 626 (1): 192–208.

Nicholls, Robert J. 2011. "Planning for the Impacts of Sea Level Rise," *Oceanography* 24 (2): 144.

Nickerson, Cynthia, Robert Ebel, Allison Borchers, and Fernando Carriazo. 2011. *Major Uses of Land in the United States, 2007*. Washington, DC: U.S. Department of Agriculture, Economic Research Service.

Pinkovskiy, Maxim, and Xavier Sala-i-Martin. 2009. *Parametric Estimations of the World Distribution of Income*. New York: National Bureau of Economic Research.

Rappaport, Jordan, and Jeffrey D. Sachs. 2003. "The United States As a Coastal Nation," *Journal of Economic Growth* 8 (1): 5–46.

Rosenzweig, Cynthia, William D. Solecki, Stephen A. Hammer, and Shagun Mehrotra, eds. 2011. *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network*. Cambridge, United Kingdom: Cambridge University Press.

Stigler, George J., and Gary S. Becker. 1977. "De Gustibus Non Est Disputandum," *The American Economic Review* 67 (2): 76–90.

Turnbull, Geoffrey K. 1995. *Urban Consumer Theory*. Washington, DC: Urban Institute; Urban Economics Association.

United Nations. 2012. *World Urbanization Prospects: The 2011 Revision*. New York: United Nations, Department of Economic and Social Affairs, Population Division.

Wheaton, William C. 2004. "Commuting, Congestion, and Employment Dispersal in Cities With Mixed Land Use," *Journal of Urban Economics* 55 (3): 417–438.

World Bank. 1991. *Urban Policy and Economic Development*. Washington, DC: World Bank.