Crowdedness, Centralized Employment, and Multifamily Home Construction

By Jordan Rappaport

After the 2007–08 financial crisis, both multifamily and single-family home construction collapsed. But multifamily home construction, unlike single-family construction, has since rebounded strongly. During the first half of 2016, multifamily home starts rose to their highest level since the late 1980s. However, this recent aggregate strength varied considerably across metropolitan areas. While multifamily construction boomed in several metros, such as Austin, TX; Charlotte, NC; Nashville, TN; and Des Moines, IA; it remained weak in many others, such as San Antonio, TX; Pittsburgh, PA; Memphis, TN; and Chicago, IL.

In this article, I examine potential drivers behind the recent variation in multifamily construction and find that factors related to population, population density, and centralized employment played important roles. More specifically, I find multifamily construction was stronger in metropolitan areas that had lower average population density, one or two neighborhoods with especially high population density relative to other neighborhoods, and relatively similar population density across remaining neighborhoods. I also find that multifamily construction was stronger in metropolitan areas with larger populations and in those with employment more concentrated in the city center. These relationships

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appear to primarily capture differences in metros' productivity, urban amenities, and availability of land for development.

Section I describes the variation in recent multifamily construction across metropolitan areas, including its relationship to the variation in single-family construction and population growth. Section II documents and interprets multifamily construction's correlations with metropolitan population, population density, and centralized employment. Section III highlights how multifamily construction's relationships with population, population density, and centralized employment differ in the city and suburban portions of metros.

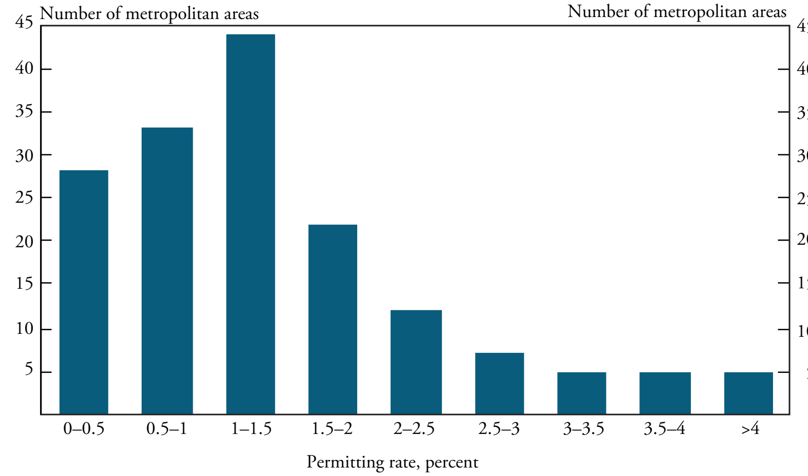
I. The Varying Strength of Multifamily Construction

To compare the strength of multifamily construction across metropolitan areas of different sizes and with different compositions of multifamily and single-family housing, I measure the rate of multifamily construction as the ratio of permits for new multifamily home units (specifically, individual apartments) to existing multifamily home units. Most places in the United States require a permit to construct a new house or apartment, and the Census Bureau conducts an annual census of the more than 20,000 local jurisdictions that issue such permits.[1] I calculate the number of multifamily permits issued in each metro during 2013–15 by summing the number of permits issued for home units in residential structures with five or more units. For each metro, I then divide average annual permits by the number of homes in structures with five or more units in 2010. The resulting multifamily permitting rate during 2013–15 can be interpreted as an average annual rate of gross investment.

To keep the analysis manageable, I limit the data set to metropolitan areas with a 2010 population of at least 250,000. I also exclude metros with a large number of college students relative to the total population, as college enrollment appears to drive especially strong multifamily permitting. The resulting data set includes 161 metros.[2]

Chart 1 shows that the multifamily permitting rate during 2013–15 varied considerably in strength across these metropolitan areas. In 28 metros, multifamily permitting plodded along at a less than 0.5 percent annual rate. But in 15 other metros, permitting boomed at an annual rate of more than 3 percent.[3]

Chart 1
Distribution of Multifamily Permitting Rates, 2013–15



Notes: The multifamily permitting rate is calculated as the average annual number of permits during 2013–15 for housing units in structures with five or more housing units divided by the number of such units in 2010. The distribution is over the 161 metro areas with populations over 250,000 in 2010 for which I could calculate the number of permits excluding metropolitan areas with less than 10,000 multifamily units in 2010 and excluding those with college student enrollment to population ratios in 2010 above 10 percent. The mean and standard deviation of the multifamily permitting rate for the included metros are 1.4 and 1.0 percent, respectively.
Sources: Census Bureau and author's calculations.

The similarities among the 15 booming metros are not obvious (Table 1). They are located throughout the country—in the South, Midwest, and West. They range in population from under 400,000 people to almost 6 million. And they specialize in a wide range of industries, including high tech (Austin, TX, and San Jose, CA), leisure (Charleston, SC, and Orlando, FL), financial services (Charlotte, NC, and Des Moines, IA), energy (Houston, TX), and manufacturing (Wilmington, NC, and Springfield, MO).

But these metros—and metros with strong multifamily construction more broadly—do share two features: strong single-family construction and fast population growth. Austin, for example, had the highest rate of multifamily permitting during 2013–15, the third highest rate of single-family permitting during 2013–15, and the fastest rate of population growth from 2010 to 2015 (see Table A-3). These positive relationships among multifamily construction, single-family construction, and population growth are perhaps unsurprising: multifamily and single-family construction are driven by many of the same factors, including population growth. In addition, strong population

Table 1
15 Metropolitan Areas with the Strongest 2013–15 Rate of Multifamily Permitting

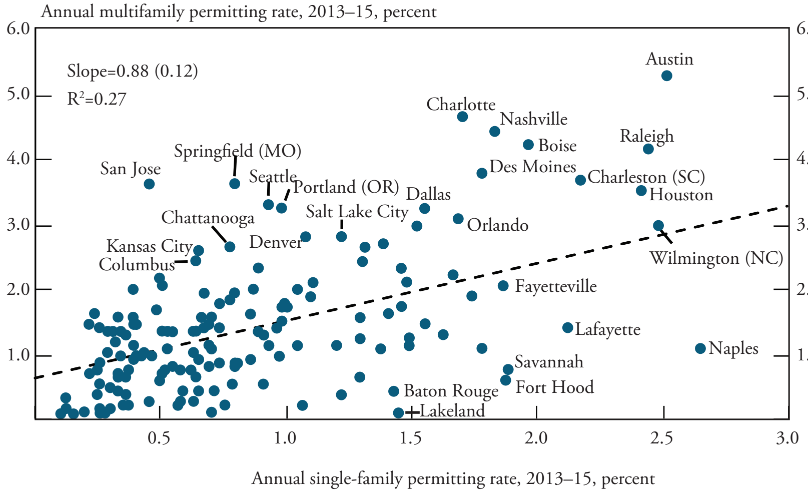
Rank	Metro	Multifamily permitting rate (percent)	Average annual multi-family permits (2013–15)	Multifamily housing units (2010)	Population (2010)
1	Austin-Round Rock, TX	5.3	9,900	186,000	1,716,000
2	Charlotte-Gastonia-Concord, NC-SC	4.7	6,200	134,000	1,758,000
3	Nashville-Davidson-Murfreesboro, TN	4.5	5,400	121,000	1,590,000
4	Boise City-Nampa, ID	4.2	1,000	23,000	617,000
5	Raleigh-Cary, NC	4.2	3,500	85,000	1,130,000
6	Des Moines, IA	3.8	1,600	44,000	570,000
7	Charleston-North Charleston, SC	3.7	1,900	50,000	665,000
8	San Jose-Sunnyvale-Santa Clara, CA	3.6	5,900	161,000	1,837,000
9	Springfield, MO	3.6	900	26,000	437,000
10	Houston-Baytown-Sugar Land, TX	3.5	20,500	584,000	5,947,000
11	Seattle-Tacoma-Bellevue, WA	3.3	12,600	379,000	3,440,000
12	Dallas-Fort Worth-Arlington, TX	3.3	20,800	636,000	6,372,000
13	Portland-Vancouver-Beaverton, OR-WA	3.3	6,400	195,000	2,226,000
14	Orlando, FL	3.1	6,700	215,000	2,134,000
15	Wilmington, NC	3.0	800	26,000	362,000

Notes: Multifamily permitting rate is constructed as average annual permits to construct new multifamily units during 2013–15 divided by total existing multifamily housing units in 2010. Permits to convert existing structures to multifamily use are not included. Permit and housing unit numbers are rounded. Housing units are classified as multifamily if they are in structures with five or more units. A full ranking is included in Table A-2.

growth requires vigorous home construction, typically both single-family and multifamily.

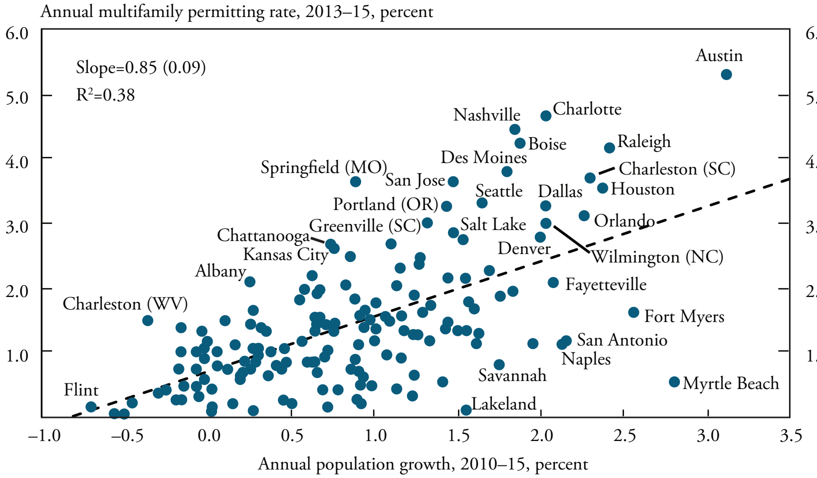
Chart 2 shows that multifamily construction tends to be strong where single-family construction is strong. The chart plots metros' multifamily permitting rate during 2013–15 against their single-family permitting rate during 2013–15.[4] The dotted line shows the best-fit linear relationship based on a simple regression. Its positive slope implies that a metro with a 1 percentage point higher single-family permitting rate than another metro is associated with a 0.88 percentage point higher multifamily permitting rate. The correlation is moderately tight, with the variation in metros' single-family permitting rates accounting for 27 percent of the variation in metros' multifamily permitting rates (as measured by the regression's R-squared).[5]

Chart 2
Multifamily Permitting versus Single-Family Permitting



Notes: Metros are labeled with the name of their largest city. Dashed line shows the best fit based on a linear regression. The corresponding coefficient, standard error, and fit are reported in the top left corner. The chart does not show Myrtle Beach, which had single-family and multifamily permitting rates of 3.5 percent and 0.6 percent, respectively.
Sources: Census Bureau and author's calculations.

Chart 3
Multifamily Permitting versus Population Growth



Notes: Metros are labeled with the name of their largest city. Dashed line shows the best fit based on a linear regression. The corresponding coefficient, standard error, and fit are reported in the top left corner.
Sources: Census Bureau and author's calculations.

However, several metropolitan areas have multifamily permitting considerably above or below the rate their single-family permitting predicts. For example, actual multifamily permitting considerably exceeded its predicted rate in San Jose, CA; Springfield, MO; Charlotte, NC; and Austin, TX. In contrast, actual multifamily permitting fell considerably short of its predicted rate in Lakeland, FL; Fort Hood, TX; Savannah, GA; and Naples, FL. Both exceptions suggest that the factors driving multifamily permitting can sometimes differ significantly from those driving single-family permitting.

Chart 3 shows that multifamily construction tends to be strong where population growth is strong. The chart plots metros' multifamily permitting rate during 2013–15 against their annual rate of population growth from 2010 to 2015. The positive slope of the best-fit linear relationship implies that a metro with population growth that is 1 percentage point higher than another metro is expected to have a multifamily permitting rate that is 0.85 percentage point higher. The correlation is moderately tight, with the variation in population growth across metros accounting for almost 40 percent of the variation in the multifamily permitting rate.[6]

However, much like the correlation with single-family permitting, several metros have actual multifamily permitting considerably above or below the rate their population growth predicts. For example, actual multifamily permitting considerably exceeded the permitting rate predicted by population growth in Charlotte, NC; Nashville, TN; and Springfield, MO. In contrast, actual multifamily permitting fell considerably short of predicted multifamily permitting in Myrtle Beach, SC, and Lakeland, FL. Rapid population growth in these metros was made possible by strong single-family construction and, possibly, the re-occupancy of previously vacant single-family and multifamily housing units.

II. The Types of Metropolitan Areas Where Multifamily Construction Has Been Strongest

Multifamily construction's positive relationships with single-family construction and population growth give only limited insight into what drove the recent boom. While the relationships suggest the boom was driven by more than just a shift in preferences toward living in apartments rather than houses, they fail to identify more fundamental similarities among metros with strong multifamily construction as well as the underlying forces behind them.

To get a better sense of the types of metros where multifamily construction has boomed, I examine multifamily construction's relationships with several measures of population density, population, and centralized employment. These characteristics evolve slowly over time, making it easier to identify the forces driving their relationships with multifamily construction. In addition, I show that several of these relationships are also shared by single-family construction and population growth, suggesting similar forces are driving them.

Metropolitan population density

Population density, a measure of crowdedness, varies considerably within metropolitan areas. In metros with a population of at least 500,000 in 2010, the most-crowded census tract had, on average, a population density 60 times that of the least-crowded census tract within the non-rural portion of the metro.[7] In the New York City, Chicago, and San Francisco metros, this ratio exceeded 300. When the rural portions of metropolitan areas are included, this ratio is multiplied manyfold. Consequently, raw measures of average population density that divide total metro population by total land area can be highly misleading. For example, measured this way, the average population density of the Las Vegas metro in 2010 was just 250 persons per square mile. But this masks the fact that 90 percent of the Las Vegas metro's population lived in a census tract with a density of at least 1,500 persons per square mile.

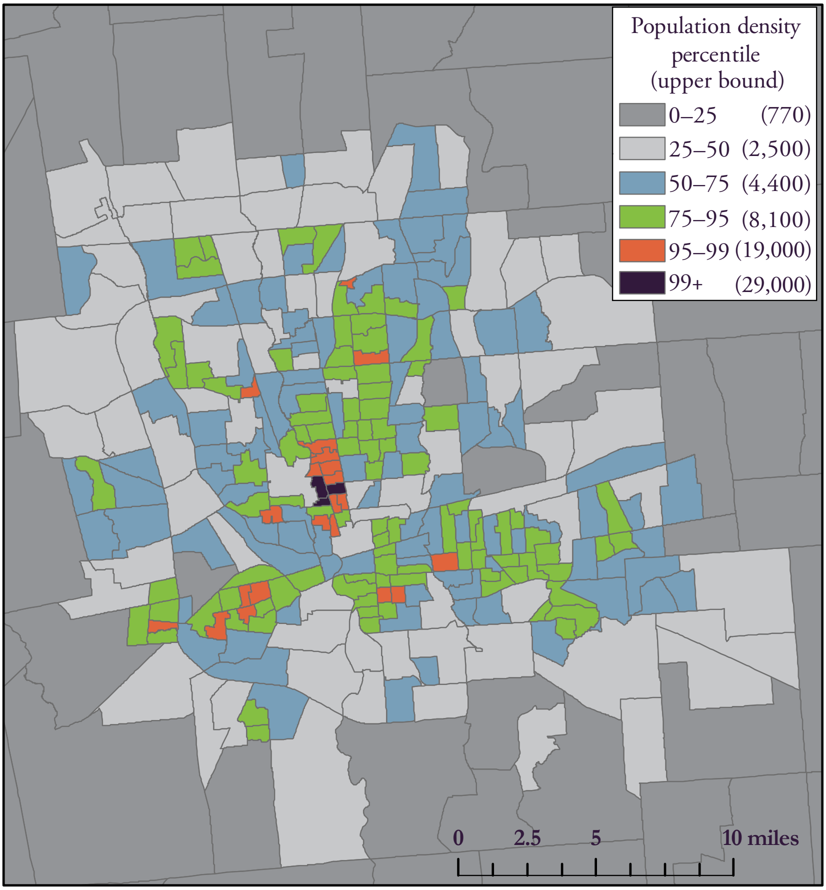
A more meaningful measure of average metropolitan population density is its median or 50th percentile density—that is, the tract density at or below which at least 50 percent of a metro's population lives.[8] For example, Las Vegas's median density in 2010 was 6,200 persons per square mile: half of its population lived in census tracts at or below this density, and half lived in census tracts at or above this density.

Multifamily construction's relationship with population density, however, is not just with median density but rather with the entire distribution of population density within metropolitan areas.[9] I jointly measure this internal distribution by three characteristics: median (50th percentile) population density, the increase from the log of 50th percentile density to the log of 95th percentile density, and the increase from the log of 95th percentile density to the log of 99th percentile density. The increase from the 50th percentile to the 95th percentile, or 95th/50th percentile density, captures how steeply population density increases across the more crowded tracts within a metropolitan area. This change in log density is proportional to the ratio of 95th percentile to 50th percentile density, which ranged from an average of 2 (among the 10 metros in which it was lowest in 2010) to an average of 15 (among the 10 metros in which it was highest). Analogously, 99th/95th percentile density captures how steeply population density increases across the *most* crowded tracts within a metropolitan area. The ratio of 99th percentile to 95th percentile density ranged from an average only slightly above 1 (almost no increase) to an average of almost 3.[10]

To give a sense of variation in density within a metro area, Map 1 shows the spatial distribution of population density in and around the settled portion of the Columbus metropolitan area in 2010. Census tracts with population density at or below the 25th percentile, shaded in dark gray, surround the settled portion, extending out to the border of the metro approximately 10 miles in each direction beyond what is shown. Most tracts in this range are made up primarily of agricultural land. Tracts with population density from the 25th to 50th percentiles, shaded light gray, are primarily located at the periphery of the settled portion, with a number of tracts near the center of Columbus also having low density in this range. Tracts with population density from the 50th to 75th percentiles and from the 75th to 95th percentiles, respectively shaded blue and green, make up most of the interior of the settled portion. Tracts with density from the 95th to 99th percentiles, shaded orange, are primarily located near the center of Columbus, with some also scattered among medium density tracts five to 10 miles from the center. Finally, the three tracts with the highest density, shaded purple, are located in the center, adjacent to each other and to tracts with population density nearly as high.

The measures I use to describe the internal distribution of population density can be thought of as taking place moving from the periphery of Columbus' settled portion to its center. The 95th/50th percentile density corresponds to the increase in density moving inward from the least-crowded blue tracts to the least-crowded orange tracts. The 99th/95th percentile density corresponds to the increase in den-

Map 1
Distribution of Population Density in Columbus, OH, 2010



Notes: Map shows the distribution of population density across census tracts in the Columbus, OH, metropolitan area. Values in parentheses are the upper-bound population densities of each percentile range (measured as persons per square mile). The Columbus metropolitan area as delineated by the OMB during the 2000s extends about 15 miles east and west of the displayed area and about 20 miles north and south. Almost all of the area not shown has a population density below the 25th percentile. Tracts with population density at the 25th percentile or higher account for 13 percent of the Columbus metro's total land area.
Sources: Census Bureau and author's calculations.

sity moving inward from the least-crowded orange tracts to the least-crowded purple tract.

Table 2 reports the partial correlations of multifamily permitting with each of these three population density variables and with metro population. In other words, the table reports the correlation between

Table 2
Multifamily Permitting, Population, and Population Density

Explanatory variable	All metros (1)	Smaller metros (2)	Larger metros (3)
ln(population)	0.27**	0.69	0.29
	(0.11)	(0.43)	(0.18)
ln(median density)	−0.29*	−0.11	−0.41*
	(0.16)	(0.16)	(0.24)
ln(95th percentile density)− ln(50th percentile density)	−0.69***	−0.33*	−0.90***
	(0.16)	(0.18)	(0.24)
ln(99th percentile density)− ln(95th percentile density)	1.42***	1.58***	1.36***
	(0.33)	(0.38)	(0.47)
Observations	161	62	99
R^2	0.23	0.27	0.20
Adjusted R^2	0.21	0.22	0.17

* Significant at the 10 percent level
** Significant at the 5 percent level
*** Significant at the 1 percent level
Notes: The dependant variable is the average annual rate of multifamily permitting during 2013–15. Population and population density are measured in 2010. Smaller metros are those with populations from 250,000 to 500,000. Larger metros are those with populations of at least 500,000. Regressions also include a constant. Standard errors are in parentheses.

multifamily permitting and each variable while controlling for variations in the other three variables. In addition to results using the full sample of 161 metropolitan areas, I include results from separate regressions that use only the smaller metros (those with populations from 250,000 to 500,000) and only the larger metros (those with populations above 500,000). Doing so allows me to capture underlying forces that may affect smaller and larger metros differently.

Multifamily permitting is positively correlated with metro population, especially among smaller metropolitan areas. The estimated coefficient from the regression using the full sample implies that a metro with population 1 log point higher than another, equivalent to a 2.7 times larger population, is expected to have a 0.27 percentage point higher multifamily permitting rate. This difference is economically significant, representing just over one-quarter of the standard deviation of the multifamily permitting rate across all metros. The correlation is more than twice as strong for small metros, as measured by the estimated coefficient.[11]

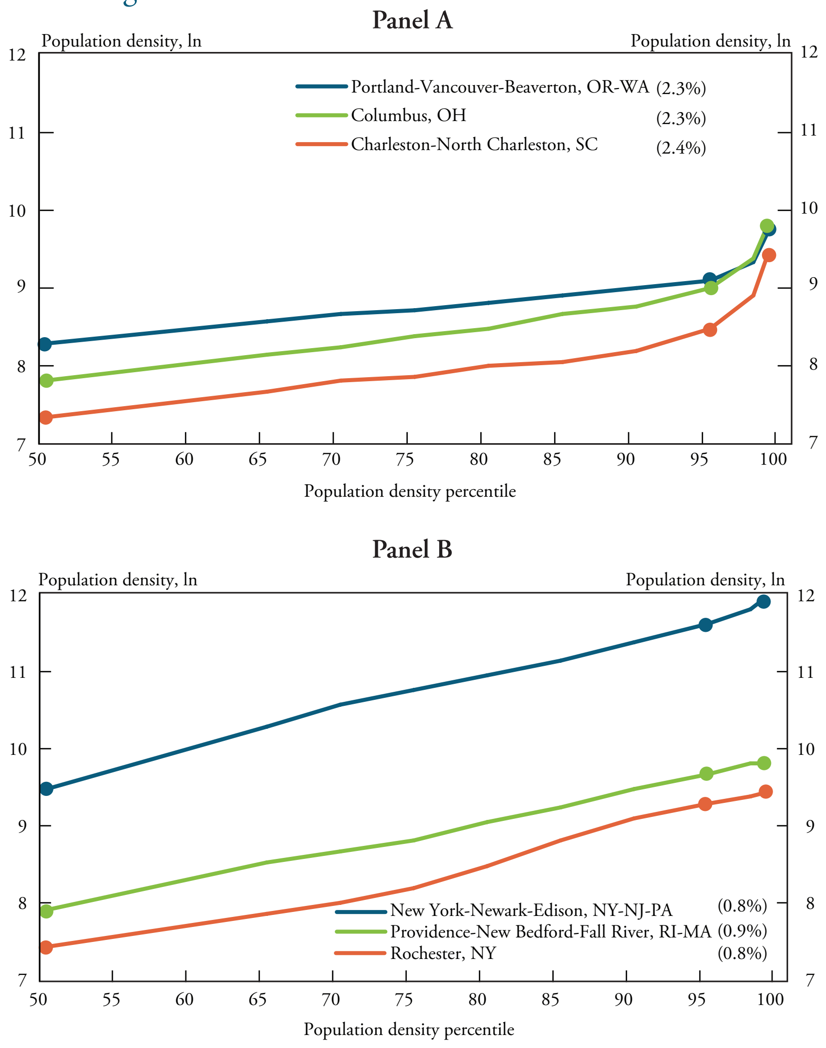
Taking account of its positive relationship with size, multifamily permitting is negatively correlated with median population density. This correlation is primarily driven by the larger metros in the sample. The negative coefficient on median density for larger metros is statistically and economically significant, implying that a metro with 1 log point higher median density than another is expected to have a 0.41 percentage point lower rate of multifamily permitting. This difference represents one-third of the standard deviation among the larger metros. In contrast, the coefficient for smaller metros is close to zero, suggesting that multifamily permitting and median population density are uncorrelated among metros with populations from 250,000 to 500,000. Importantly, multifamily permitting's negative partial correlation with median density holds only when controlling for population. Otherwise, the positive relationship with population masks the negative relationship with median density.

For both smaller and larger metros, multifamily permitting is negatively correlated with the increase in population density from the 50th to 95th percentiles and positively correlated with the increase in density from the 95th to 99th percentiles. In each of the three regressions, the negative coefficients on 95th/50th percentile density and positive coefficients on 99th/95th are statistically and economically significant. The negative partial correlation with 95th/50th percentile density is considerably stronger for the larger metros. A large metro with a 1 log point larger increase in density from the 50th to 95th percentile is expected to have a 0.90 percentage point lower multifamily permitting rate.

To illustrate these relationships, Panel A of Chart 4 shows distributions of population density associated with relatively strong multifamily permitting. Specifically, it shows the density profiles of Portland, OR; Columbus, OH; and Charleston, SC. Each metro has a relatively modest increase in population density from the 50th to 95th percentiles and a relatively steep increase in population density from the 95th to 99th percentiles. Based on the coefficients from the regression using the larger metros, a small 95th/50th percentile density and large 99th/95th percentile density contribute to relatively high rates of multifamily permitting. In addition, the higher median population densities of Portland and Columbus compared with Charleston (indicated by the height of their 50th percentile density markers) are associated with weaker multifamily permitting. However, this negative contribution from median population density is mostly offset by a positive contribution from the larger populations of Portland and Columbus, leaving the predicted multifamily permitting rates for all three metros a few tenths above 2 percent.

Chart 4

Distribution of Population Density and Predicted Multifamily Permitting



Notes: Numbers in parentheses are the predicted mulitfamily permitting rates based on each metro's population and population density multiplied by the corresponding coefficients for the regression using only larger metros reported in column 3 of Table 2. Markers indicate log population density at the 50th, 95th, and 99th percentiles.
Sources: Census Bureau and author's calculations.

Panel B of Chart 4 shows density profiles associated with relatively weak multifamily permitting. In the New York City, NY; Providence, RI; and Rochester, NY, metros, population density increases rather steeply from the 50th to 95th percentiles and increases moderately relative to other metros from the 95th to 99th percentiles. Based on the coefficients from the regression using the larger metros, a large 95th/50th percentile density and small 99th/95th percentile density contribute to relatively weak multifamily permitting. The negative contribution to permitting from New York City's higher median population density relative to Providence and Rochester is mostly offset by a positive contribution from its larger population, leaving the predicted multifamily permitting rate for all three metros a few tenths below 1 percent. Overall, differences in the internal distributions of population density predict 1.5 percentage points lower multifamily permitting rates for the New York City, Providence, and Rochester metros than for the Portland, Columbus, and Charleston metros.

Centralized employment

Another characteristic that varies considerably across metropolitan areas is the extent to which jobs are concentrated in a central location rather than spread more diffusely across the metro. More centralized employment may boost demand for nearby home construction among workers seeking shorter commute times. Recent research shows that more centralized employment may also increase firms' productivity, thereby boosting population growth and construction throughout a metropolitan area (Brinkman, Coen-Pirani, and Sieg).

I measure the centralization of employment by the share of employment in 2000 that took place in each metro's central business district (CBD), defined to encompass the traditional "downtown" of the largest city within a metropolitan area as well as nearby neighborhoods with dense employment.[12] For the larger metros in my sample, the CBD share of employment ranged from an average of less than 2 percent (among the 10 metros where it was lowest) to an average of 25 percent (among the 10 metros where it was highest).

Table 3 reports results from regressions of multifamily permitting, single-family permitting, and population growth on population, population density, and the CBD employment share. I limit the analysis

Table 3

Multifamily Permitting, Single-Family Permitting, and Population Growth

Explanatory variable	Multifamily permitting rate, 2013–15 average (1)	Single-family permitting rate, 2013–15 average (2)	Population growth rate, 2010–15 average (3)	Multifamily permitting rate, 2013–15 average (4)
ln(population)	0.25 (0.17)	0.09 (0.08)	0.16 (0.11)	0.08 (0.13)
ln(median density)	−0.56** (0.24)	−0.50*** (0.11)	−0.24* (0.15)	−0.30* (0.19)
ln(95th percentile density)–ln(50th percentile density)	−1.08*** (0.24)	−0.71*** (0.11)	−0.86*** (0.15)	−0.19 (0.22)
ln(99th percentile density)–ln(95th percentile density)	1.17** (0.46)	0.25 (0.21)	0.45 (0.28)	0.71** (0.36)
CBD share of employment	4.22*** (1.36)	1.38** (0.62)	1.71** (0.85)	2.46** (1.07)
Population growth rate (2010–15 average)				1.03*** (0.13)
Observations	99	99	99	99
R^2	0.27	0.34	0.31	0.57
Adjusted R^2	0.24	0.31	0.27	0.54

* Significant at the 10 percent level
** Significant at the 5 percent level
*** Significant at the 1 percent level
Notes: Regressions are for metropolitan areas with a population of at least 500,000. The dependent variable for each regression is listed in the top row. Permitting is the average annual rate during 2013–15. Population growth is the average annual rate during 2010–15. Regresssions also include a constant. Standard errors are in parentheses.

to the larger metros, as multifamily construction is uncorrelated with centralized employment among the smaller metros.[13]

The results from the baseline specification in column 1 show that multifamily permitting has a strong positive correlation with centralized employment. The estimated coefficient on the CBD employment share implies that a metro with a CBD employment share 10 percentage points higher than another metro, representing less than one standard deviation, is expected to have 0.4 percentage point higher multifamily permitting. For example, Las Vegas, NV; New York City, NY; and Des Moines, IA—which have CBD shares close to 30 percent—are expected to have 1 percentage point higher multifamily permitting rates than Los Angeles, CA; Oklahoma City, OK; and Tucson, AZ—which have CBD shares close to 7 percent. Controlling for the CBD share leaves multifamily permitting's partial correlations with population and density largely unaffected.

The baseline specification of centralized employment, together with population and the three measures of population density, does a fairly good job predicting the rate of multifamily construction in the larger metropolitan areas. Variation in the baseline variables accounts for more than one-quarter of the variation in multifamily permitting, as measured by the R-squared statistic.[14] Chart 5 plots each metro's actual 2013–15 multifamily permitting rate against its predicted value based on the baseline coefficients. Differences in actual versus predicted permitting, measured by the vertical distance of each dot to the dashed line, were driven by forces unrelated to the baseline characteristics. Austin, TX; Charlotte, NC; Nashville, TN; and Boise, ID, stand out as metros with actual multifamily permitting considerably above the rate the baseline variables predict. In a similar vein, Sacramento, CA, and New Orleans, LA, stand out as metros with actual multifamily permitting considerably below their predicted rates.

Importantly, the predictive power of population, population density, and centralized employment does not mean that their variations across metropolitan areas *caused* the variations in multifamily construction. A better interpretation is that underlying forces interacted with the varying characteristics to drive varying multifamily construction.

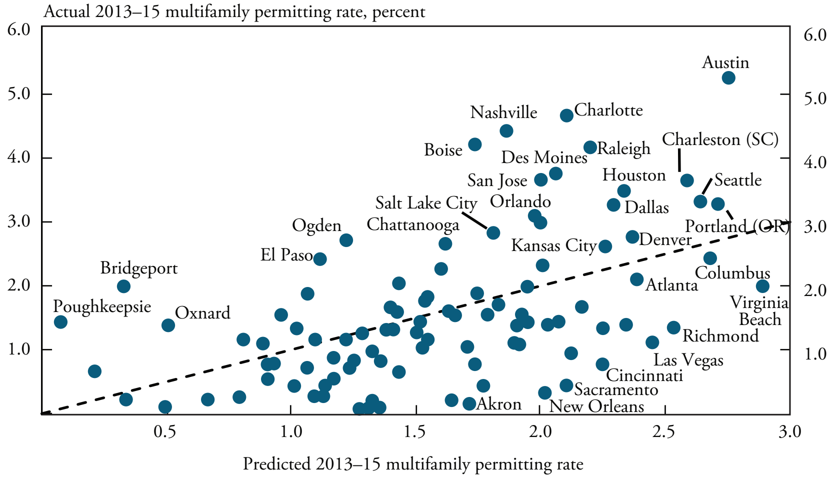
Underlying forces

Designing policies to shape, prepare for, and respond to multifamily housing development critically depends on identifying the forces driving multifamily construction's relationships with population, population density, and centralized employment. Single-family construction and population growth largely parallel multifamily construction's relationships with the baseline characteristic (Table 3, columns 2 and 3), suggesting that the forces driving the multifamily relationships also drive the single-family and population growth relationships. Most obviously, such forces may directly affect population growth, thereby indirectly affecting multifamily construction and single-family construction.

Multifamily permitting's positive relationship with population was likely driven indirectly (through the channel of population growth) by the higher productivity and greater amenities of many larger metros.[15] Considerable research has documented a positive relationship between productivity and metro size. Larger size, as measured by either

Chart 5

Actual versus Predicted Multifamily Permitting in Larger Metropolitan Areas



Notes: Metros are labeled with the name of their largest city. The horizontal axis measures the multifamily permitting rate predicted by the regression reported in column 1 of Table 3. Dashed line shows where the actual permitting rate equals the rate predicted by the regression.
Sources: Census Bureau and author's calculations.

employment or population, can increase firms' productivity as well as the wages they pay by allowing for better matching between workers and firms, more specialized professional support services, more innovation from collaboration among firms that sell to each other, and greater competition among firms in the same industry (Duranton and Puga; Combes and Gobillion). Larger size also increases a metro's amenities—for example, by allowing for a greater variety of restaurants, live entertainment, outdoor activities, education opportunities, and places of worship (Glaeser, Kolko, and Saiz; Diamond).[16] Conversely, many metros became large due to exogenous sources of high productivity and amenities, such as a central location and nice weather (Rappaport 2008b).

Multifamily permitting's positive relationship with centralized employment was also likely driven in part (through the channel of population growth) by higher firm productivity and the accompanying higher wages. Much of the productivity benefit of size is thought to occur by firms interacting with each other in close proximity, and a considerable portion of the higher average productivity of firms located in larger metros reflects the higher productivity of firms located in the CBD itself (Rosenthal and Strange; Brinkman, Coen-Pirani, and Sieg). Firms located elsewhere in the metro may also benefit from interactions with high-productivity firms in the CBD—for example, by working with CBD firms that offer specialized professional services (Brinkman). Notably, single-family construction, which typically takes place away from CBDs, is also positively related to centralized employment. While this relationship may seem less intuitive, it is consistent with the conclusion that permitting's positive relationship with centralized employment works through the channel of population growth; specifically, by attracting residents from other metros rather than from elsewhere in the same metro.

At the same time, some of the forces driving multifamily permitting's positive relationship with centralized employment appear to be doing so by attracting residents who live elsewhere in the same metro to move near the CBD, possibly to cut commute times.[17] In particular, multifamily permitting remains positively related with CBD employment even after taking account of its strong positive relationship with population growth (Table 3, column 4). Adding population growth to the baseline regression is meant to capture any forces that operate by attracting people from other metros, and the estimated coefficient on it, which is close to 1, implies that multifamily permitting responds approximately proportionally to population inflows. The estimated coefficients on the baseline characteristics in this regression should thus primarily capture forces that shift demand between single-family and multifamily housing as well as among different neighborhoods within the same metro.

Multifamily permitting's negative partial correlation with median population density was likely driven by the supply of land suitable for new residential development. Metros with higher average population density typically have higher average land prices, requiring developers to charge higher average rents and sales prices for newly constructed units. Controlling for other metropolitan characteristics, higher rents and prices dissuade people from moving into more crowded metros, depressing population growth and thereby multifamily construction. Bolstering this interpretation, single-family permitting is also negatively related to median density. Higher average land prices make newly constructed homes less affordable for existing residents, which may explain the portions of multifamily and single-family constructions' negative correlations with median density that remain after controlling for population growth.[18]

Multifamily permitting's negative relationship with 95th/50th percentile density was likely driven by a similar supply consideration. A steeper increase in density from the 50th to 90th percentile is associated with a steeper increase in land prices; this in turn likely boosts rents for newly constructed multifamily units in high-density neighborhoods relative to moderate-density neighborhoods. The resulting negative effect on multifamily permitting appears to arise solely from discouraging population inflows (multifamily permitting is uncorrelated with 95th/50th percentile density when controlling for population growth). To the extent that individuals considering moving to a metro prefer to live in denser neighborhoods, higher relative rents in these neighborhoods may push down population growth for the entire metro area. Consistent with this interpretation, multifamily permitting and population growth across larger metros were also negatively related to the increase in density from the 25th to the 50th percentile (not shown).

Conversely, a smaller increase in density from the 50th to the 95th percentiles may make it possible to construct less expensive multifamily units close to high-density neighborhoods. A smaller increase in 95th/50th percentile density partly reflects pockets of lightly used land in census tracts that otherwise have relatively high population density. Land in these pockets—typically occupied by small businesses, surface parking, vacant buildings, and undeveloped lots—is likely to cost less than land elsewhere within the same census tract.[19]

Lastly, multifamily permitting's positive relationship with the increase in density from the 95th to the 99th percentiles was likely driven by the urban amenities often found near spikes in population density. Urban amenities—such as pedestrian access to varied restaurants, cafes, bars, and small retailers—increase housing demand nearby. Consistent with this interpretation, recent research finds that young professionals have been increasingly choosing to live near CBDs with high levels of urban amenities (Couture and Handbury; Baum-Snow and Hartley). This attraction to urban amenities appears to primarily draw residents from elsewhere in the same metro. Specifically, the coefficient on 99th/95th percentile density is only moderately smaller when controlling for population growth (column 4 versus column 1). However, urban amenities are also likely to attract population inflows from other metros. The coefficient on 99th/95th percentile density in the population regression is relatively large and differs from zero at the 12 percent level, only slightly above the 10 percent benchmark for rejecting that population growth is uncorrelated with 99th/95th percentile density.

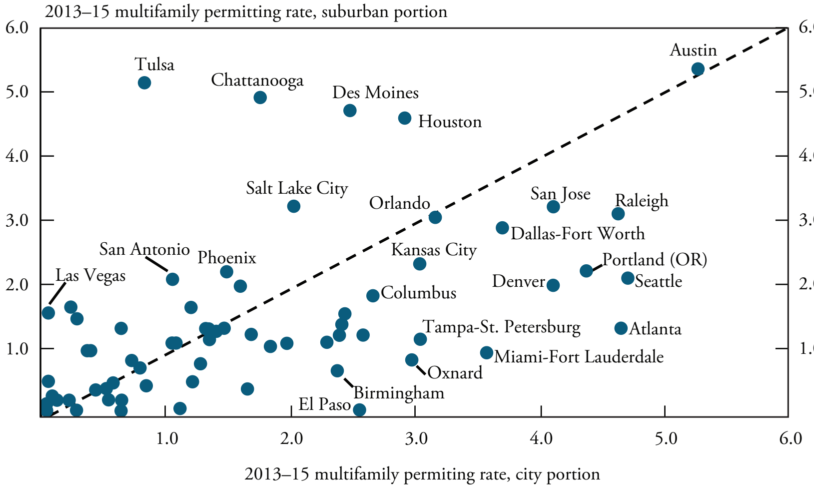
III. Multifamily Construction in Cities and Suburbs

The increasing popularity of living near CBDs with high amenities suggests that the forces driving construction in the city and suburban portions of metropolitan areas may differ. Indeed, separate regressions for each of these portions show that city and suburban multifamily permitting's relationships with 99th/95th percentile density differ significantly. However, city and suburban multifamily permitting have relatively similar relationships with three of the four other baseline characteristics: population density, 95th/50th percentile density, and the CBD employment share. Furthermore, their apparent difference with respect to the final baseline characteristic, population, may be misleading.

To capture potential differences between city and suburban construction, I calculate separate permitting rates for the city and suburban portions of 67 of the larger metropolitan areas (those whose largest municipality had a population of at least 150,000 in 2000 and for which I am able to distinguish the location of permits). The city portion of each metro includes its largest municipality and, in a few cases, its second- and third-largest ones. For example, I include St. Paul in the city portion of the Minneapolis metro and Tacoma and Bellevue in the city portion of the Seattle metro. The remainder of each metro constitutes its suburban portion.[20]

Recent multifamily permitting was, on average, equally strong in the city and suburban portions of these metros. Chart 6 plots the 2013–15 rates of multifamily permitting in the suburbs against their rates in the cities. The dashed line delineates where the suburban and city permitting rates are equal. Metros above the line had stronger suburban permitting; those below the line had stronger city permitting. In almost two-thirds of the 67 metros, the city and suburban rates were within 1 percentage point of each other. Among the remaining metros, slightly more experienced stronger multifamily permitting in the city. Atlanta had especially strong multifamily permitting in the city relative to the

Chart 6
Suburban versus City Multifamily Permitting



Notes: Metros are labeled with the name of their largest city. Dashed line shows where the multifamily permitting rates in the city portion and suburban portion of the metro are equal. Below the dashed line, the city permitting rate exceeds the suburban permitting rate. Chart does not show Boise, ID, which had respective permitting rates of 2.5 percent and 8.7 percent in the city and suburban portions.
Sources: Census Bureau and author's calculations.

suburbs; Tulsa and Chattanooga had especially strong multifamily permitting in the suburbs relative to the city.[21]

Table 4 reports results from regressions of multifamily and single-family permitting in the city and suburban portions of metros on metropolitan population, metropolitan population density, and metropolitan centralized employment.[22] As with the analysis of underlying forces in the previous section, the single-family partial correlations help interpret the multifamily ones.

The most important difference between the city and suburban multifamily regressions is that city permitting's positive relationship with 99th/95th percentile density is large and statistically significant whereas suburban permitting's positive relationship with 99th/95th percentile density is small and not statistically significant. This contrast bolsters the interpretation that spikes in 99th/95th density reflect urban amenities that attract people to live nearby.

Another difference between the two multifamily regressions is that city permitting has a positive, statistically significant relationship with metro population, while suburban permitting appears largely unrelated

Table 4
Multifamily and Single-Family Permitting in Cities and Suburbs

Explanatory variable	Multifamily permitting rate, 2013–15 average		Single-family permitting rate, 2013–15 average	
	City portion (1)	Suburban portion (2)	Primary city portion (3)	Suburban portion (4)
ln(population)	0.51** (0.26)	0.15 (0.32)	0.06 (0.09)	0.14 (0.14)
ln(median density)	−0.53 (0.36)	−0.97** (0.44)	−0.24* (0.13)	−0.65*** (0.19)
ln(95th percentile density)− ln(50th percentile density)	−1.19*** (0.43)	−1.51*** (0.53)	−0.60*** (0.15)	−0.97*** (0.23)
ln(99th percentile density)− ln(95th percentile density)	1.53** (0.62)	0.39 (0.76)	0.08 (0.22)	0.08 (0.33)
CBD share of employment	4.63** (2.10)	7.54*** (2.60)	0.38 (0.75)	2.82** (1.12)
Observations	67	67	67	67
R^2	0.33	0.21	0.21	0.29
Adjusted R^2	0.27	0.15	0.15	0.23

* Significant at the 10 percent level
** Significant at the 5 percent level
*** Significant at the 1 percent level
Notes: The dependant variable for each column is listed in the top row. Endnote 24 describes the sensitivity of the suburban mulitfamily partial correlations with population and CBD employment and the suburban single-family partial correlation with CBD employment. Regressions also include a constant. Standard errors are in parentheses.

to population. However, the suburban estimate may be misleading, as it reflects permitting rates in just a handful of metros. An alternative methodology that is less sensitive to the exact sample of metros included in a regression finds a strong, positive relationship between suburban multifamily permitting and metro population.[23]

The remaining relationships of city and suburban multifamily permitting with 50th percentile density, 95th/50th percentile density, and CBD employment differ only moderately. For each of the three pairs, the magnitude of city permitting's partial correlation is moderately smaller than suburban permitting's partial correlation, but the difference is not statistically significant. More importantly, the large, positive partial correlations of suburban multifamily and single-family permitting with the CBD employment share bolster the interpretation that centralized employment boosts construction because of the higher productivity associated with it. Further bolstering this productivity interpretation, suburban population growth also has a strong positive relationship with CBD employment (not shown).[24]

IV. Conclusions

Multifamily home construction has rebounded strongly since the financial crisis, but some metropolitan areas have experienced stronger construction than others. I identify five characteristics that account for much of the variation in the recent strength of multifamily construction and discuss some underlying forces that may be driving the relationships. Specifically, I find that multifamily construction during 2013–15 was stronger in larger metropolitan areas, less crowded metropolitan areas, and in metropolitan areas with more centralized employment. Additionally, I find that multifamily construction was stronger in metropolitan areas where population density increased less steeply across the more crowded tracts and more steeply across the most crowded tracts.

Several underlying forces are likely driving these relationships. Productivity and amenities tend to be higher in larger metropolitan areas, attracting population inflows that boost multifamily construction. Productivity also tends to be higher in metropolitan areas with more centralized employment, attracting population inflows that boost multifamily home construction. More centralized employment may also allow nearby multifamily construction to better meet demand for shorter commute times. Urban amenities are likely to be high near spikes in population density, attracting residents from other parts of the metro as well as other metros, thereby boosting multifamily home construction. And lower average crowdedness and a less steep increase in population density across the more crowded tracts of a metro likely reflect more land available for development and lower land prices, boosting multifamily construction both directly and by attracting population inflows.

Understanding the forces driving multifamily construction is important in designing effective policies for metropolitan development. For example, policies that support centralized employment may boost productivity, attracting firms and residents from elsewhere in the country and thereby increasing residential construction throughout a metropolitan area. The resulting increase in metropolitan population may itself reinforce high productivity and amenities. Similarly, policies that promote urban amenities, whether in the city or suburbs, may attract young adults from elsewhere in the metro and from other metros, accelerating nearby multifamily development. In contrast, policies that seek to encourage multifamily development by cutting commute time without taking into account nearby urban amenities may prove unsuccessful.

Of course, the forces driving multifamily construction in the future may differ. Young adults primarily drove the recent rebound in multifamily construction, but members of the baby boom generation are increasingly likely to affect demand as they age (Rappaport 2015). In 2021, the leading edge of the baby boom turns 75, the age at which downsizing to multifamily homes typically picks up. For seniors who are retired, amenities are likely to be a more important consideration than productivity and wages in choosing where to live. Some amenities—such as nice weather and adjacency to the ocean and mountains—are clearly beyond the scope of public policy. But public policy may be able to help shape other amenities—for example, through zoning policies that support the development of neighborhoods that mix multifamily housing, urban amenities, assisted-living arrangements, and proximity to where seniors' children and grandchildren live.

In the longer term, technological innovation is also likely to affect multifamily home construction. The pace at which self-driving cars are adopted will be especially important. Self-driving cars are likely to ameliorate long commutes, potentially supporting single-family construction in peripheral suburbs. However, reduced parking needs due to self-driving cars may considerably benefit both multifamily construction in dense urban areas and centralized employment. While it is unclear which of these competing forces will dominate, both lower the broadly construed costs of living in larger metropolitan areas and will thus favor residential construction in larger metros over residential construction in smaller ones.

Appendix
Additional Tables

Table A-1
Metropolitan Summary Statistics

Explanatory variable	All metropolitan areas (161 metros with population of at least 250,000)			
	Mean	Standard deviation	Minimum	Maximum
Multifamily permitting rate (2013–15)	1.42	1.02	0	5.29
Single-family permitting rate (2013–15)	0.87	0.60	0.10	3.51
Population growth rate (2010–15)	0.85	0.74	–0.71	3.12
ln(population)	13.60	0.92	12.43	16.75
ln(median density)	7.51	0.70	5.62	9.49
ln(95th percentile density)–ln(50th percentile density)	1.39	0.52	0.60	3.03
ln(99th percentile density)–ln(95th percentile density)	0.38	0.23	0.05	1.77
CBD share of employment (percent)	0.14	0.09	0	0.50
Population (2010)	1,391,040	2,202,287	251,133	18,897,109
50th percentile density (persons/square mile)	2,333	1,806	275	13,196
95th percentile density (persons/square mile)	9,426	10,561	1,737	113,988
99th percentile density (persons/square mile)	14,519	16,630	2,883	159,209
95th/50th percentile density	4.71	3.34	1.82	20.62
99th/95th percentile density	1.51	0.49	1.05	5.87
Multfamily permits (2013–15 average)	2,107	4,879	0	44,231
Single-family permits (2013–15 average)	3,045	4,358	88	36,611
Multifamily housing units (2010)	124,439	282,938	10,479	2,811,815
Single-family housing units (2010)	375,899	477,087	63,482	3,223,449
College and graduate enrollment	79,043	140,181	6,692	1,184,677
College and graduate enrollment to population (ratio)	0.059	0.013	0.027	0.096

Note: CBD share of employment is not available for three of the smaller metros.

Table A-1(continued)

Explanatory variable	Smaller metropolitan areas (62 metros with population 250,000–500,000)			
	Mean	Standard deviation	Minimum	Maximum
Multifamily permitting rate (2013–15)	1.15	0.71	0	3.62
Single-family permitting rate (2013–15)	0.86	0.68	0.10	3.51
Population growth rate (2010–15)	0.68	0.73	–0.71	2.80
ln(population)	12.78	0.20	12.43	13.11
ln(median density)	7.12	0.62	5.62	8.52
ln(95th percentile density)–ln(50th percentile density)	1.52	0.54	0.60	2.90
ln(99th percentile density)–ln(95th percentile density)	0.34	0.22	0.05	1.08
CBD share of employment (percent)	0.13	0.10	0	0.50
Population (2010)	362,816	70,288	251,133	494,593
50th percentile density (persons/square mile)	1,481	942	275	5,016
95th percentile density (persons/square mile)	6,680	4,777	1,737	27,611
99th percentile density (persons/square mile)	9,597	7,357	2,883	37,702
95th/50th percentile density	5.40	3.74	1.82	18.23
99th/95th percentile density	1.44	0.38	1.05	2.93
Multfamily permits (2013–15 average)	275	222	0	928
Single-family permits (2013–15 average)	953	719	88	3,433
Multifamily housing units (2010)	23,050	11,261	10,479	73,723
Single-family housing units (2010)	112,799	25,044	63,482	177,537
College and graduate enrollment	18,636	6,654	6,692	39,258
College and graduate enrollment to population (ratio)	0.06	0.014	0.027	0.096

Note: CBD share of employment is not available for three of the smaller metros.

Table A-1 (continued)

Explanatory variable	Larger metropolitan areas (99 metros with population of at least 500,000)			
	Mean	Standard deviation	Minimum	Maximum
Multifamily permitting rate (2013–15)	1.59	1.15	0.03	5.29
Single-family permitting rate (2013–15)	0.88	0.55	0.16	2.52
Population growth rate (2010–15)	0.96	0.73	−0.57	3.12
ln(population)	14.11	0.82	13.15	16.75
ln(median density)	7.76	0.63	5.76	9.49
ln(95th percentile density)–ln(50th percentile density)	1.30	0.50	0.63	3.03
ln(99th percentile density)–ln(95th percentile density)	0.41	0.24	0.10	1.77
CBD share of employment (percent)	0.14	0.08	0	0.48
Population (2010)	2,034,978	2,612,977	514,098	18,897,109
50th percentile density (persons/square mile)	2,867	2,006	316	13,196
95th percentile density (persons/square mile)	11,146	12,654	2,800	113,988
99th percentile density (persons/square mile)	17,601	19,822	3,250	159,209
95th/50th percentile density	4.28	3.00	1.87	20.62
99th/95th percentile density	1.56	0.54	1.10	5.87
Multfamily permits (2013–15 average)	3,254	5,948	8	44,231
Single-family permits (2013–15 average)	4,356	5,117	316	36,611
Multifamily housing units (2010)	187,934	346,475	15,874	2,811,815
Single-family housing units (2010)	540,668	547,725	143,141	3,223,449
College and graduate enrollment	116,874	168,229	12,539	1,184,677
College and graduate enrollment to population (ratio)	0.061	0.012	0.028	0.094

Note: CBD share of employment is not available for three of the smaller metros.

Table A-2
City and Suburban Summary Statistics

Explanatory variable	Mean	Standard deviation	Minimum	Maximum
Primary city portion of metropolitan area				
Multifamily permitting rate (2013–15)	1.75	1.37	0	5.26
Single-family permitting rate (2013–15)	0.47	0.45	0.01	1.84
Population growth rate (2010–15)	0.88	0.83	–0.97	2.69
Multfamily permits (2013–15 average)	1,719	2,462	0	11,144
Single-family permits (2013–15 average)	747	1,019	13	5,236
Multifamily housing units (2010)	76,504	84,377	9,018	466,872
Single-family housing units (2010)	139,727	104,759	17,989	455,631
Population (2010)	579,638	495,767	142,308	2,697,650
Suburban portion of metropolitan area				
Multifamily permitting rate (2013–15)	1.60	1.56	0	8.70
Single-family permitting rate (2013–15)	1.02	0.71	0.26	3.18
Population growth rate (2010–15)	1.01	0.73	–0.08	3.24
Multfamily permits (2013–15 average)	1,639	2,205	0	9,816
Single-family permits (2013–15 average)	4,329	5,082	272	31,375
Multifamily housing units (2010)	111,513	141,697	1,754	812,370
Single-family housing units (2010)	460,942	411,079	28,163	1,909,513
Population (2010)	1,583,919	1,477,705	151,953	6,773,707
Primary city share of metropolitan total				
Multfamily permits (2013–15 average)	0.50	0.26	0	1.00
Single-family permits (2013–15 average)	0.16	0.17	0.01	0.89
Multifamily housing units (2010)	0.48	0.21	0.13	0.96
Single-family housing units (2010)	0.28	0.16	0.05	0.85
Population (2010)	0.31	0.16	0.08	0.81
Metropolitan area characteristics				
ln(population)	14.29	0.76	13.15	16.06
ln(median density)	7.89	0.56	6.61	9.00
ln(95th percentile density)–ln(50th percentile density)	1.21	0.40	0.63	2.43
ln(99th percentile density)–ln(95th percentile density)	0.41	0.26	0.10	1.77
CBD share of employment (percent)*	0.15	0.07	0	0.31

Note: Sample comprises 67 metropolitan areas with populations of at least 500,000 that meet additional criteria described in the text.

Table A-2 (continued)

Explanatory variable	Mean	Standard deviation	Minimum	Maximum
Population	2,158,023	1,827,596	514,453	9,461,105
50th percentile density (person/square mile)	3,067	1,589	740	8,133
95th percentile density (person/square mile)	10,386	6,493	3,115	35,537
99th percentile density (person/square mile)	16,695	13,196	3,635	79,072
95th/50th percentile density	3.67	1.77	1.87	11.35
99th/95th percentile density	1.57	0.62	1.10	5.87

Note: Sample comprises 67 metropolitan areas with populations of at least 500,000 that meet additional criteria described in the text.

Table A-3

Multifamily Permitting by Metropolitan Area

	Multifamily housing				Single-family housing		Population growth	
Metropolitan area	Rank	Permit rate	Average annual permits	Housing units (2010)	Rank	Permit rate	Rank	Growth rate
Austin, TX	1	5.3	9,850	186,000	3	2.5	1	3.1
Charlotte, NC	2	4.7	6,220	134,000	17	1.7	12	2.0
Nashville, TN	3	4.5	5,380	121,000	13	1.8	17	1.9
Boise City, ID	4	4.2	960	23,000	9	2.0	16	1.9
Raleigh, NC	5	4.2	3,540	85,000	5	2.4	4	2.4
Des Moines, IA	6	3.8	1,650	44,000	14	1.8	19	1.8
Charleston, SC	7	3.7	1,850	50,000	7	2.2	6	2.3
San Jose, CA	8	3.6	5,850	161,000	116	0.5	34	1.5
Springfield, MO	9	3.6	930	26,000	70	0.8	77	0.9
Houston, TX	10	3.5	20,500	584,000	6	2.4	5	2.4
Seattle, WA	11	3.3	12,620	379,000	55	0.9	23	1.7
Dallas, TX	12	3.3	20,790	636,000	21	1.6	13	2.0
Portland, OR	13	3.3	6,370	195,000	52	1.0	38	1.4
Orlando, FL	14	3.1	6,690	215,000	18	1.7	7	2.3
Wilmington, NC	15	3.0	800	26,000	4	2.5	11	2.0
Greenville, SC	16	3.0	1,180	39,000	23	1.5	42	1.3
Salt Lake City, UT	17	2.8	2,270	80,000	39	1.2	33	1.5
Denver, CO	18	2.8	8,760	313,000	44	1.1	14	2.0
Ogden, UT	19	2.7	540	20,000	32	1.4	31	1.5
Chattanooga, TN-GA	20	2.7	760	28,000	72	0.8	87	0.7
Corpus Christi, TX	21	2.7	820	31,000	34	1.3	57	1.1
Kansas City, MO-KS	22	2.6	3,560	136,000	90	0.6	84	0.8
El Paso, TX	23	2.5	1,120	45,000	35	1.3	78	0.9
Columbus, OH	24	2.4	3,790	155,000	92	0.6	44	1.3
Huntsville, AL	25	2.4	570	24,000	28	1.5	45	1.3
Indianapolis, IN	26	2.3	3,010	130,000	61	0.9	54	1.1
McAllen, TX	27	2.3	460	20,000	19	1.7	22	1.7
Eugene, OR	28	2.2	500	23,000	111	0.5	101	0.6
Atlanta, GA	29	2.1	9,620	454,000	42	1.1	29	1.6
Clarksville, TN-KY	30	2.1	240	12,000	26	1.5	35	1.4
Fayetteville, AR	31	2.1	640	31,000	12	1.9	10	2.1

Notes: Metropolitan area column lists the largest city in each metro area. Permit rates and average annual permits are calculated during 2013–15. Population growth rates are calculated over 2010–15.

Table A-3 (continued)

	Multifamily housing				Single-family housing		Population growth	
Metropolitan area	Rank	Permit rate	Average annual permits	Housing units (2010)	Rank	Permit rate	Rank	Growth rate
Albany, NY	32	2.1	1,220	59,000	110	0.5	123	0.3
Omaha, NE	33	2.0	1,360	67,000	46	1.0	56	1.1
Spokane, WA	34	2.0	720	36,000	62	0.9	80	0.8
Bridgeport, CT	35	2.0	1,370	69,000	125	0.4	94	0.7
Virginia Beach, VA	36	2.0	2,560	129,000	67	0.8	104	0.6
Green Bay, WI	37	1.9	390	20,000	86	0.7	95	0.7
Sarasota, FL	38	1.9	1,520	80,000	16	1.7	18	1.8
Phoenix, AZ	39	1.9	6,460	343,000	43	1.1	20	1.8
Columbus, GA	40	1.9	370	20,000	73	0.8	47	1.2
Fayetteville, NC	41	1.8	400	22,000	49	1.0	106	0.5
Little Rock, AR	42	1.8	790	44,000	76	0.7	74	0.9
Colorado Springs, CO	43	1.8	770	43,000	27	1.5	27	1.6
Asheville, NC	44	1.8	330	18,000	48	1.0	61	1.0
Tampa, FL	45	1.7	5,060	292,000	51	1.0	40	1.3
Boston, MA-NH	46	1.7	7,480	447,000	113	0.5	66	1.0
Washington, DC	47	1.7	11,010	664,000	63	0.9	26	1.6
Trenton, NJ	48	1.6	480	30,000	154	0.2	122	0.3
Cape Coral, FL	49	1.6	1,340	83,000	31	1.4	3	2.6
San Diego, CA	50	1.6	5,280	328,000	123	0.4	43	1.3
New York, NY	51	1.6	44,230	2,812,000	138	0.3	99	0.6
Minneapolis, MN	52	1.6	4,720	300,000	79	0.7	60	1.1
Reno, NV	53	1.6	640	41,000	37	1.3	52	1.2
Louisville, KY-IN	54	1.6	1,340	86,000	87	0.7	93	0.7
Tulsa, OK	55	1.5	900	58,000	50	1.0	71	0.9
Charleston, WV	56	1.5	180	12,000	156	0.2	157	–0.4
Salem, OR	57	1.5	330	22,000	84	0.7	65	1.0
Columbia, SC	58	1.5	710	48,000	22	1.5	58	1.1
Poughkeepsie, NY	59	1.5	540	37,000	120	0.4	133	0.1
San Francisco, CA	60	1.5	7,170	494,000	121	0.4	36	1.4
Shreveport, LA	61	1.4	320	22,000	54	1.0	124	0.3
Greensboro, NC	62	1.4	780	54,000	85	0.7	83	0.8
Winston-Salem, NC	63	1.4	500	35,000	75	0.7	91	0.7
Lafayette, LA	64	1.4	220	16,000	8	2.1	37	1.4
Oxnard, CA	65	1.4	620	44,000	147	0.3	97	0.7

Notes: Metropolitan area column lists the largest city in each metro area. Permit rates and average annual permits are calculated during 2013–15. Population growth rates are calculated over 2010–15.

Table A-3 (continued)

	Multifamily housing				Single-family housing		Population growth	
Metropolitan area	Rank	Permit rate	Average annual permits	Housing units (2010)	Rank	Permit rate	Rank	Growth rate
Honolulu, HI	66	1.4	1,680	121,000	105	0.5	67	0.9
Birmingham, AL	67	1.4	990	72,000	97	0.6	116	0.3
Knoxville, TN	68	1.4	600	44,000	59	0.9	85	0.7
Norwich, CT	69	1.4	210	16,000	134	0.3	151	–0.2
Los Angeles, CA	70	1.4	19,570	1,439,000	140	0.3	81	0.8
Richmond, VA	71	1.4	1,180	86,000	60	0.9	62	1.0
Baltimore, MD	72	1.4	3,070	226,000	104	0.6	100	0.6
Montgomery, AL	73	1.4	270	20,000	93	0.6	144	0.0
Miami, FL	74	1.3	12,900	956,000	109	0.5	28	1.6
Santa Rosa, CA	75	1.3	320	24,000	144	0.3	86	0.7
Lexington, KY	76	1.3	510	38,000	57	0.9	51	1.2
Philadelphia, PA	77	1.3	5,270	399,000	131	0.4	115	0.3
Jacksonville, FL	78	1.3	1,520	116,000	20	1.6	32	1.5
Oklahoma City, OK	79	1.3	1,000	77,000	25	1.5	24	1.6
Riverside, CA	80	1.3	2,370	188,000	91	0.6	50	1.2
Pensacola, FL	81	1.3	340	27,000	38	1.3	46	1.3
Buffalo, NY	82	1.2	740	63,000	139	0.3	139	0.0
San Antonio, TX	83	1.2	1,750	149,000	47	1.0	8	2.2
Bakersfield, CA	84	1.2	290	25,000	56	0.9	63	1.0
Duluth, MN-WI	85	1.2	200	17,000	126	0.4	140	0.0
Olympia, WA	86	1.2	180	16,000	41	1.2	41	1.3
Harrisburg, PA	87	1.1	370	33,000	82	0.7	105	0.6
Augusta, GA	88	1.1	260	23,000	24	1.5	72	0.9
Naples, FL	89	1.1	820	74,000	2	2.7	9	2.1
Las Vegas, NV	90	1.1	2,380	214,000	33	1.4	25	1.6
St. Louis, MO-IL	91	1.1	1,840	167,000	106	0.5	130	0.2
Kennewick, WA	92	1.1	150	13,000	15	1.8	15	2.0
Allentown, PA-NJ	93	1.1	430	40,000	122	0.4	121	0.3
Albuquerque, NM	94	1.1	540	50,000	81	0.7	110	0.5
Atlantic City, NJ	95	1.1	240	22,000	117	0.4	142	0.0
Memphis, TN-MS-AR	96	1.1	1,000	94,000	96	0.6	117	0.3
South Bend, IN-MI	97	1.0	180	17,000	143	0.3	134	0.1
Hickory, NC	98	1.0	120	12,000	118	0.4	152	–0.2
Syracuse, NY	99	1.0	440	43,000	133	0.3	146	–0.1

Notes: Metropolitan area column lists the largest city in each metro area. Permit rates and average annual permits are calculated during 2013–15. Population growth rates are calculated over 2010–15.

Table A-3 (continued)

Metropolitan area	Multifamily housing				Single-family housing		Population growth	
	Rank	Permit rate	Average annual permits	Housing units (2010)	Rank	Permit rate	Rank	Growth rate
Hagerstown, MD	100	1.0	120	12,000	53	1.0	88	0.7
Roanoke, VA	101	1.0	210	21,000	119	0.4	113	0.4
Manchester, NH	102	1.0	300	30,000	114	0.5	118	0.3
Vallejo, CA	103	0.9	210	22,000	88	0.6	59	1.1
Bremerton, WA	104	0.9	130	14,000	64	0.9	90	0.7
Pittsburgh, PA	105	0.9	1,300	141,000	124	0.4	143	0.0
Stockton, CA	106	0.9	260	29,000	77	0.7	53	1.2
Beaumont, TX	107	0.9	180	21,000	65	0.8	119	0.3
Salinas, CA	108	0.9	210	24,000	148	0.3	76	0.9
Portland, ME	109	0.9	260	30,000	66	0.8	108	0.5
Cedar Rapids, IA	110	0.9	150	18,000	69	0.8	102	0.6
Tucson, AZ	111	0.8	650	76,000	68	0.8	103	0.6
Evansville, IN-KY	112	0.8	170	20,000	103	0.6	126	0.2
Fort Wayne, IN	113	0.8	220	26,000	83	0.7	98	0.6
Rochester, NY	114	0.8	550	68,000	127	0.4	135	0.0
Savannah, GA	115	0.8	200	25,000	10	1.9	21	1.8
Cincinnati, OH	116	0.8	1,250	158,000	107	0.5	112	0.4
Wichita, KS	117	0.8	250	32,000	101	0.6	111	0.4
Grand Rapids, MI	118	0.8	350	46,000	98	0.6	79	0.9
Erie, PA	119	0.8	110	15,000	152	0.3	153	–0.2
New Haven, CT	120	0.7	530	71,000	155	0.2	147	–0.1
Mobile, AL	121	0.7	160	22,000	108	0.5	132	0.1
Milwaukee, WI	122	0.7	1,070	145,000	136	0.3	125	0.3
Davenport, IA	123	0.7	160	23,000	129	0.4	127	0.2
Spartanburg, SC	124	0.7	80	12,000	36	1.3	73	0.9
Lancaster, PA	125	0.7	160	24,000	94	0.6	96	0.7
Chicago, IL	126	0.7	6,190	939,000	135	0.3	128	0.2
York, PA	127	0.6	90	14,000	112	0.5	114	0.4
Killeen, TX	128	0.6	110	18,000	11	1.9	48	1.2
Reading, PA	129	0.6	100	17,000	146	0.3	129	0.2
Fresno, CA	130	0.6	290	52,000	58	0.9	68	0.9
Hartford, CT	131	0.6	560	98,000	151	0.3	141	0.0
Port St. Lucie, FL	132	0.5	210	39,000	71	0.8	39	1.4

Notes: Metropolitan area column lists the largest city in each metro area. Permit rates and average annual permits are calculated during 2013–15. Population growth rates are calculated over 2010–15.

Table A-3 (continued)

Metropolitan area	Multifamily housing				Single-family housing		Population growth	
	Rank	Permit rate	Average annual permits	Housing units (2010)	Rank	Permit rate	Rank	Growth rate
Myrtle Beach, SC	133	0.5	310	59,000	1	3.5	2	2.8
Canton, OH	134	0.5	60	13,000	142	0.3	148	–0.1
Anchorage, AK	135	0.5	110	24,000	99	0.6	64	1.0
Toledo, OH	136	0.5	220	47,000	137	0.3	149	–0.1
Deltona, FL	137	0.5	200	44,000	78	0.7	69	0.9
Sacramento, CA	138	0.4	640	145,000	89	0.6	55	1.1
Baton Rouge, LA	139	0.4	190	43,000	30	1.4	92	0.7
Detroit, MI	140	0.4	1,240	291,000	130	0.4	137	0.0
Brownsville, TX	141	0.4	90	21,000	40	1.2	82	0.8
Utica, NY	142	0.4	60	14,000	153	0.2	155	–0.3
Huntington, WV	143	0.4	40	11,000	159	0.1	156	–0.3
New Orleans, LA	144	0.3	240	77,000	95	0.6	49	1.2
Peoria, IL	145	0.3	60	18,000	115	0.5	145	–0.1
Scranton, PA	146	0.3	50	19,000	100	0.6	154	–0.2
Jackson, MS	147	0.3	80	30,000	45	1.1	109	0.5
Palm Bay, FL	148	0.3	120	48,000	74	0.8	75	0.9
Cleveland, OH	149	0.3	440	173,000	132	0.4	150	–0.2
Providence, RI	150	0.2	260	117,000	128	0.4	131	0.2
Worcester, MA	151	0.2	120	54,000	102	0.6	107	0.5
Binghamton, NY	152	0.2	20	12,000	160	0.1	158	–0.5
Modesto, CA	153	0.2	30	16,000	150	0.3	70	0.9
Akron, OH	154	0.2	80	46,000	141	0.3	136	0.0
Flint, MI	155	0.1	40	27,000	157	0.2	161	–0.7
Ocala, FL	156	0.1	10	10,000	80	0.7	89	0.7
Springfield, MA	157	0.1	50	51,000	149	0.3	120	0.3
Lakeland, FL	158	0.1	20	25,000	29	1.4	30	1.5
Dayton, OH	159	0.1	40	52,000	145	0.3	138	0.0
Youngstown, OH	160	0.0	10	27,000	158	0.2	160	–0.6
Rockford, IL	161	0.0	0	18,000	161	0.1	159	–0.5

Notes: Metropolitan area column lists the largest city in each metro area. Permit rates and average annual permits are calculated during 2013–15. Population growth rates are calculated over 2010–15.

Table A-4

Multifamily Permitting in City and Suburban Portions of Metro Areas

Primary city	City portion				Suburban portion			
	Rank	Permitting rate (2013–15)	Average annual permits (2013–15)	Housing units (2010)	Rank	Permitting rate (2013–15)	Average annual permits (2013–15)	Housing units (2010)
Austin, TX	1	5.3	7,370	140,000	2	5.4	2,490	46,000
Seattle-Tacoma-Bellevue, WA	2	4.7	8,230	174,000	13	2.1	4,390	205,000
Atlanta. GA	3	4.7	4,970	107,000	32	1.3	4,650	347,000
Raleigh, NC	4	4.6	2,720	59,000	8	3.1	820	26,000
Portland-Vancouver, OR-WA	5	4.4	4,110	94,000	12	2.2	2,260	102,000
San Jose, CA	6	4.1	3,040	74,000	6	3.3	2,810	86,000
Miami-Fort Lauderdale, FL	7	3.6	5,140	144,000	46	1.0	7,760	812,000
Orlando, FL	8	3.2	1,780	56,000	9	3.1	4,920	159,000
Kansas City, MO	9	3.0	1,600	53,000	10	2.4	1,950	83,000
Tampa-St. Petersburg, FL	10	3.0	2,610	86,000	37	1.2	2,450	206,000
Oxnard, CA	11	3.0	350	12,000	48	0.8	270	32,000
Houston, TX	12	2.9	11,140	383,000	5	4.6	9,350	201,000
Columbus, OH	13	2.7	3,030	114,000	21	1.8	760	41,000
Boston-Cambridge, MA	14	2.6	3,800	147,000	36	1.2	3,690	300,000
El Paso, TX	15	2.6	1,120	44,000	66	0.0	0	2,000
Boise City, ID	21	2.5	420	17,000	1	8.7	540	6,000
Virginia Beach-Norfolk-Newport News, VA	22	2.4	1,450	60,000	25	1.6	1,100	70,000

Table A-4 (continued)

Primary city	City portion				Suburban portion			
	Rank	Permitting rate (2013–15)	Average annual permits (2013–15)	Housing units (2010)	Rank	Permitting rate (2013–15)	Average annual permits (2013–15)	Housing units (2010)
Washington, DC	23	2.4	3,750	155,000	27	1.4	7,260	509,000
Omaha, NE	24	2.4	1,090	45,000	34	1.3	270	22,000
Birmingham, AL	25	2.4	700	30,000	51	0.7	290	42,000
Minneapolis-St. Paul, MN	26	2.3	2,540	111,000	39	1.1	2,170	189,000
Salt Lake City, UT	27	2.0	530	26,000	7	3.2	1,740	54,000
San Diego, CA	28	2.0	3,640	185,000	41	1.1	1,640	143,000
Philadelphia, PA	29	1.8	2,230	122,000	43	1.1	3,040	278,000
Chattanooga, TN	30	1.7	350	20,000	4	4.9	410	8,000
San Francisco-Oakland, CA	31	1.7	3,920	231,000	35	1.2	3,250	262,000
Bakersfield, CA	32	1.7	250	15,000	57	0.4	40	10,000
Little Rock, AR	33	1.6	360	22,000	15	2.0	430	21,000
Phoenix, AZ	34	1.5	2,340	158,000	11	2.2	4,120	184,000
Greensboro, NC	35	1.5	580	40,000	31	1.3	190	14,000
Knoxville, TN	36	1.4	410	29,000	33	1.3	190	14,000
Oklahoma City, OK	37	1.3	670	50,000	38	1.2	330	28,000
Richmond, VA	38	1.3	430	32,000	29	1.4	750	55,000
Baltimore, MD	39	1.3	870	66,000	28	1.4	2,200	160,000
Pittsburgh, PA	40	1.3	460	36,000	49	0.8	840	105,000
Grand Rapids, MI	41	1.2	180	15,000	52	0.5	170	31,000

Table A-4 (continued)

Primary city	City portion				Suburban portion			
	Rank	Permitting rate (2013–15)	Average annual permits (2013–15)	Housing units (2010)	Rank	Permitting rate (2013–15)	Average annual permits (2013–15)	Housing units (2010)
Jacksonville, FL	42	1.2	1,040	87,000	23	1.7	480	29,000
Tucson, AZ	43	1.1	650	58,000	67	0.0	0	18,000
Albuquerque, NM	44	1.1	500	46,000	40	1.1	40	3,000
San Antonio, TX	45	1.0	1,370	132,000	14	2.1	370	17,000
St. Louis, MO-IL	46	1.0	430	41,000	42	1.1	1,400	125,000
Chicago, IL	47	0.9	3,990	467,000	55	0.5	2,210	472,000
Tulsa, OK	48	0.8	400	48,000	3	5.2	490	10,000
Wichita, KS	49	0.8	220	28,000	50	0.7	30	4,000
Rochester, NY	50	0.7	170	23,000	47	0.8	380	45,000
Toledo, OH	51	0.6	160	25,000	59	0.3	60	22,000
Stockton, CA	52	0.6	110	18,000	30	1.4	150	11,000
New Orleans, LA	53	0.6	210	34,000	64	0.1	30	43,000
Fresno, CA	54	0.6	220	37,000	53	0.5	80	14,000
Baton Rouge, LA	55	0.5	150	28,000	60	0.3	40	15,000
Sacramento, CA	56	0.5	220	44,000	56	0.4	420	101,000
Cincinnati, OH	57	0.4	210	54,000	45	1.0	1,040	105,000
Milwaukee, WI	58	0.4	230	62,000	44	1.0	840	83,000
Riverside-San Bernardino, CA	59	0.3	110	38,000	26	1.5	2,250	150,000
Modesto, CA	60	0.3	30	9,000	65	0.0	0	7,000

Table A-4 (continued)

Primary city	City portion				Suburban portion			
	Rank	Permitting rate (2013–15)	Average annual permits (2013–15)	Housing units (2010)	Rank	Permitting rate (2013–15)	Average annual permits (2013–15)	Housing units (2010)
Buffalo, NY	61	0.2	50	21,000	22	1.7	690	41,000
Worcester, MA	62	0.2	50	21,000	62	0.2	70	33,000
Providence, RI	63	0.1	20	16,000	61	0.2	240	102,000
Cleveland, OH	64	0.1	30	40,000	58	0.3	410	133,000
Las Vegas, NV	66	0.0	0	65,000	24	1.6	2,380	149,000
Jackson, MS	65	0.0	0	14,000	54	0.5	80	16,000
Springfield, MA	67	0.0	0	15,000	63	0.1	50	36,000

Endnotes

[1]The Census Bureau survey excludes permits to renovate a residential structure or to convert a structure from commercial to residential use, which may understate multifamily construction in older and more crowded metropolitan areas as well as in the city portion of metropolitan areas relative to the suburban portion.

[2]I use the 2003 delineation of Core-Based Statistical Areas (CBSAs) from the Office of Management and Budget (OMB), which is based on the 2000 decennial census. In addition, I combine the Denver and Boulder CBSAs to keep the delineation unchanged over time. The threshold of 250,000 as the cutoff population for inclusion in the analysis is arbitrary. I drop the five metros that had fewer than 10,000 multifamily units in 2010, reflecting that multifamily permitting rates in these metros are especially sensitive to idiosyncratic factors. I also drop 14 metros where college and graduate student enrollment in 2000 exceeded 10 percent of total metro population. Especially high multifamily permitting rates in some of these metros was likely driven by students. The 14 metros are Ann Arbor, MI; Durham, NC; Fort Collins, CO; Gainesville, FL; Kalamazoo, MI; Lansing, MI; Lincoln, NE; Lubbock, TX; Madison, WI; Provo, UT; San Luis Obispo, CA; Santa Barbara, CA; Santa Cruz, CA; and Tallahassee, FL.

[3]The mean and standard deviation of the multifamily permitting rate across the 161 metros is 1.6 percent and 1.3 percent, respectively. Summary statistics for all variables are reported in Table A-1. Only one metro, Rockford, IL, had zero permitting.

[4]I construct the single-family permitting rate analogously to the multifamily permitting rate—that is, I divide average annual single-family permits during 2013–15 by the number of single-family units in 2010.

[5]The correlation between multifamily and single-family permitting is considerably tighter across large metropolitan areas, specifically those with a population of at least 500,000. For these metros, regressing multifamily permitting on single-family permitting gives a slope of 1.42 with standard error 0.15 and an R-squared value of 0.47. Performing the same exercise for metros with populations from 250,000 to 500,000 gives a slope of 0.29 with standard error 0.13 and an R-squared value of 0.08.

[6]Regressing the multifamily permitting rates of the 161 metros on their population growth rate (and a constant) gives a coefficient of 0.85 with standard error 0.09 and R-squared value 0.38. The correlation between multifamily permitting and population growth is tighter in metros with a population of at least 500,000. For these metros, regressing multifamily permitting on population growth gives a coefficient of 1.12 with standard error 0.11 and an R-squared value of 0.51. For smaller metros—those with populations from 250,000 to 500,000—the analogous regression gives a coefficient of 0.36 with standard error 0.12 and R-squared value of 0.13.

[7]Census tracts are relatively small areas delineated by the Census Bureau that typically encompass from 1,000 to 8,000 residents. I construct the ratio of most-dense to least-dense census tract using 500 persons per square mile (0.78 persons per acre) as the minimum for all metros, a lower threshold that the Census Bureau uses to classify a census tract as part of an "urbanized area." Actual minimum tract density in metros is considerably lower, reflecting that the OMB delineates CBSAs as combinations of whole counties, thereby including considerable agricultural and unsettled land. The vast majority of land in most CBSAs has a population density below 500 persons per square mile (Rappaport 2014).

[8]A metro's average population density can also be measured by the population-weighted mean of the densities of all its census tracts. Doing so is equivalent to thinking of a metro's residents as each experiencing the density of the tract in which they live and then calculating the simple mean of experienced density across all residents. "Raw" population density—total population divided by total land—is average population density as experienced by parcels of land tracts (Glaeser and Kahn; Rappaport 2008a).

[9]Regressions on metro population and median density with no other measures of population density falsely suggest that multifamily permitting is unrelated to median density.

[10]I use the 99th percentile rather than maximum density as the top bound, as there is considerable idiosyncratic variation in the increase in density between the two. Multifamily permitting's partial correlations with the increase in density from the 95th percentile to maximum density have the same sign as its correlations with the increase from 95th to 99th percentile density. But coefficient estimates are typically less precise using maximum density, and for some sets of observations and additional controls, the magnitude of the estimated coefficient is considerably smaller.

[11]Simple regressions of multifamily permitting on only log population for the three groups of metros give coefficients with similar magnitude and statistical significance to those reported in Table 2.

[12]There is no consensus definition for metros' CBD. For this analysis, I define the CBD as the combination of all census tracts with an employment density of at least 8,000 workers per square mile in 2000 that are within five miles of the centroid of a metro's largest primary city as returned by Google Earth (Holian and Kahn; Rappaport 2014). Data to calculate employment density is from the Census Transportation Planning Product (CTTP) 2000, which re-tabulates the 2000 decennial census by place of work. I use the 2000 CTTP rather than the most recent one, based on data from the combined 2006–10 American Community Surveys, because its sample size is considerably larger.

[13]Multifamily construction's lack of correlation with centralized employment for the smaller metros may reflect mismeasurement. Specifically, the algorithm I use to identify CBD tracts may poorly delineate CBDs in smaller metros because its threshold employment density of 8,000 workers per square mile is inappropriately high.

[14]The R-squared statistic rises from 0.27 under the baseline specification reported in column 1 of Table 3 to 0.33 when including fixed effects for the four census regions and to 0.37 when including fixed effects for the nine census divisions. In both cases, estimated coefficients remain very close to those in the baseline specification.

[15]The population growth regression estimates the coefficient on log population to be 0.16 with a standard error of 0.11, which is statistically significant only at the 13 percent level (Table 3, column 3). Running the same regression for the full sample of 161 metros yields a coefficient on log population of 0.17 with a standard error of 0.08, which is statistically significant at the 5 percent level. The increase in statistical confidence captures that average population growth in the larger metros significantly exceeds average population growth in the smaller metros. An analogous regression establishes that population growth is uncorrelated with log population among the smaller metros.

[16]A different possibility is that an unrelated characteristic may have affected population growth for many years prior to 2010, causing some metros to become larger than others. If this same characteristic continued to affect population growth from 2010 to 2015, population growth could be positively correlated with population without there necessarily being a causal relationship between the two. While I cannot rule out this different possibility, regressions analogous to those reported in Tables 2 and 3 that include population and population density measured in 2000 give similar estimates to the regressions using population and population density measured in 2010. Separately, net inflows of population should eventually stop once they sufficiently increase housing costs and commuting congestion to offset higher wages and amenities. Once this occurs, population growth would be uncorrelated with initial population (Rappaport 2016; Desmet and Rappaport). The recent positive correlation of population growth with population suggests that the productivity and amenity benefits of size may have increased over the last few decades.

[17]Couture and Handbury argue that the increase in young professionals living near CBDs during the 2000s was driven more by demand for proximity to urban amenities than by demand to cut commute times. Specifically, they find that the increase in young professionals living near CBDs during the 2000s was positively correlated with the number of bars and restaurants near CBDs and that many of the young professionals living near CBDs "reverse" commuted to less central work locations. My interpretation regarding the desire to cut commute times reflects that my regressions control for the increase in population density from the 95th to the 99th percentile, which is likely to capture a significant portion of the urban amenities (specifically, bars and restaurants near CBDs) that Couture and Handbury measure. In particular, CBDs with nearby spikes in population density seem likely to have more nearby bars and restaurants.

[18]Regressing single-family permitting on the baseline characteristics and population growth yields a coefficient on median density of 0.35 with standard error of 0.06, which is statistically significant at the 1 percent level. The same regression

estimates a coefficient on 95th/50th percentile density of –0.19 with standard error 0.07, which is statistically significant at the 1 percent level. The estimated coefficients on the remaining three baseline characteristics are relatively small and do not statistically differ from zero.

[19]More precisely, the final cost of developing new multifamily units in such pockets—including land acquisition, demolition, and construction—is likely to be lower than the cost of developing multifamily units in tracts with uniformly high population density.

[20]Based on subjective criteria, I combine pairs of municipalities as the city portion of nine metro areas: Dallas-Fort Worth, Miami-Fort Lauderdale, Boston-Cambridge, San Francisco-Oakland, Riverside-San Bernardino, Minneapolis-St. Paul, Denver-Boulder, Tampa-St. Petersburg, and Portland-Vancouver. I combine three municipalities each as the city portion of Seattle-Tacoma-Bellevue and Virginia Beach-Norfolk-Newport News. I exclude the New York City metro from the analysis because of the especially large number of municipalities that arguably should be included in its city portion.

[21]The suburban multifamily permitting rate in Boise (not shown) exceeded the city multifamily permitting rate by more than 6 percentage points (8.7 percent versus 2.5 percent). The best-fit linear relationship of the suburban multifamily permitting rate against the city multifamily permitting rate has an intercept of 0.67 with a standard error of 0.28, a slope of 0.53 with a standard error of 0.12, and an R-squared of 0.22. Aggregate multifamily permits for the 67 metro areas were split approximately evenly between the city and the suburban portions.

[22]Values of these characteristics describe the entire metropolitan area rather than just the city or suburban portion. Hence, they are identical to each other in the two regressions as well as to the values used in the metropolitan regression reported in Section II.

[23]A robust regression, as implemented with Stata's "rreg" command and default settings, uses an iterative algorithm to downweight observations that disproportionately affect estimated coefficients. A robust regression of suburban multifamily permitting on the specification in Table 4 yields a coefficient on log population of 0.39 with an associated standard error of 0.17, which statistically differs from zero at the 5 percent level. The robust suburban regression also estimates a considerably smaller coefficient on the CBD employment share than the value reported in column 2 of Table 4, but the coefficient is nevertheless large and statistically significant. All other coefficients reported in Table 4 are qualitatively similar using robust regressions.

[24]Regressing suburban population growth on the explanatory variables reported in Table 4 yields a coefficient on the CBD employment share of 3.19 with a standard error of 1.19, which is statistically significant at the 1 percent level.

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