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**Working Paper**

## The urbanization, development, environment, and inequality nexus: Stylized facts and empirical relationships

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## **ADB Working Paper Series**

### **THE URBANIZATION, DEVELOPMENT, ENVIRONMENT, AND INEQUALITY NEXUS: STYLIZED FACTS AND EMPIRICAL RELATIONSHIPS**

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Brantley Liddle

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**Abstract**

This paper summarizes and expands the state-of-the-art understanding of the urbanization, development, environment, and inequality nexus. Economic growth/development, urbanization, and energy/electricity consumption are all highly correlated. While urbanization may be more evidence of economic progress than a catalyst for economic growth, there is some evidence that poor countries are overurbanized. Also, electricity consumption is at least a proxy for, if not a cause of, both nonagricultural employment and improved quality-of-life opportunities that help to encourage/cause rural-urban migration; in other words, electricity/energy consumption may cause urbanization and not the other way around. Urban density is associated with energy efficiency/savings in buildings and transport, but is probably not related to energy/emissions from industry; and, national urbanization levels are not indicative of the density of the cities within. Lastly, cities are disproportionately wealthy, but are associated with poverty, too. Increases in gross domestic product per capita unambiguously lower poverty and narrow rural-urban gaps. By contrast, levels of urbanization were either unrelated to such measures, or had a nonlinear effect, where initially increases in urbanization likewise led to improvements, but at higher levels of urbanization, increases in urbanization exacerbated poverty and rural-urban gaps.

**Keywords:** energy/emissions and urban density, urbanization and energy/carbon emissions, economic growth and urbanization, panel causality/regressions, urbanization and inequality/poverty

**JEL Classification:** O18, Q43, R11, R12

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# 1. OVERVIEW AND STYLIZED FACTS

The world's urbanization exceeded the 50% mark for the first time in 2009. According to the United Nations, urban areas will absorb all of the projected 2.5 billion global population growth and continue to draw in some of the rural population over the next 40 years (UN 2014). Also, less developed regions will account for most of the population growth expected in urban areas. This project analyzes the determinants and impacts of urbanization on growth/development, the environment, and inequality—with a particular emphasis on Asia. The following subsections cover several stylized facts about the urbanization process and the growing importance of cities. The next three sections discuss, in turn, (i) urbanization and economic growth; (ii) urbanization/urban density and the environment/energy consumption; and (iii) urbanization and poverty/inequality. The paper concludes with a summary of the main findings, their implications for policy, and future directions for related research.

## 1.1 Stylized Facts: Urbanization Trends and “Full Urbanization”

By urbanization we refer to a process in which the proportion of the population residing in urban areas changes over time (urbanization time series are available for most countries from the World Bank). Urbanization, a stock-based indicator, rarely, if ever, declines (Sri Lanka is an outlier since its urbanization levels declined throughout the study period). Because population agglomerations can be and are recharacterized (by national government statistical agencies), many/most urbanization series contain breaks.

Indeed, a break analysis of the urbanization series for 105 countries over the period 1971–2009 determined that almost all countries (93%) experienced at least one break, most countries (78%) experienced two breaks, and many countries (52%) experienced three breaks (Liddle and Lung 2014). Yet, most of the breaks occurred at five-year intervals (e.g., 1980, 1985, 1990, 1995, 2000); thus, some of the breaks likely represent reassessments of urban areas (as discussed above), and those reassessments are apparently happening less frequently over time.

If the change in urbanization since the last break in a country's urbanization series to 2009 is considered that country's current urbanization path, then the break analysis suggests a slowing of urbanization (as a process) worldwide, despite the trend toward higher urbanization levels (Liddle and Lung 2014). The post-break median annual rate of change in urbanization is less than one half of 1%. In addition, for nearly 75% of countries the post-break annual rate of change is less than the annual rate of change for the entire period; that change/shift indicates that the break in the series marks a slowing of urbanization. Moreover, the post-break annual rate of change for only seven countries is substantially greater than the annual rate of change for the entire period.

Many developed countries are fully urbanized (Henderson 2003). Yet, several developed countries have stopped urbanizing at widely varying levels. For example, while both Austria's and Belgium's urbanization levels have changed very little since 1950, their current urbanization levels are substantially different, at 68% and 97%, respectively. If we ranked countries by their post-break annual urbanization change rate, and if countries in the lowest quartile (i.e., those with the slowest current rates of change) were considered fully urbanized, then the ultimate, fully urbanized share of people living in urban areas would have a mean of 76% and standard deviation of 20 (Liddle and Lung 2014). So, even full urbanization is highly heterogeneous.

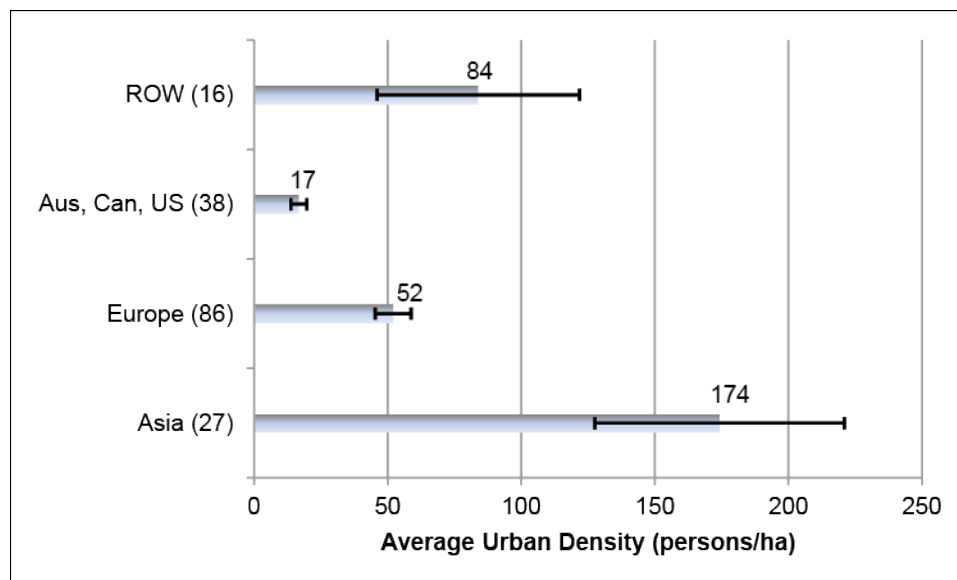
## 1.2 Stylized Facts: Megacities and Urban Density

Not only is the number (or share) of the world's people living in cities important, but so too is the population size of cities. Two distinct patterns of urban development are emerging: (i) most people are urban dwellers, who live in various-size cities (small-to-medium and large); and (ii) most urban dwellers live in huge megacities, i.e., metropolitan areas with total populations in excess of 10 million. The world currently has 36 such megacities, of which only 10 are in Organisation for Economic Co-operation and Development (OECD) countries and 22 are in Asia. Moreover, of the 21 cities with populations in excess of 18 million, 15 are located in Asia.<sup>1</sup>

Also important are the physical (or geographic) size of cities and resulting population density. Urban density is important because both energy consumption in transport and local pollution from transport are negatively associated with urban density (Newman and Kenworthy 1989; Kenworthy and Laube 1999; Liddle 2013a, 2015); however, the number of people exposed to such local pollutants increases with density (Liddle 2015). Not only does Asia contain the most populated cities, but it also has the densest ones.

Figure 1 considers city-based data from three data sets (Kenworthy et al. 1999; Kenworthy and Laube 2001; UITP 2005)—a total of 167 cities are included—and displays the average urban density for each of four geographic/cultural groups: Asia; Europe; Australia, Canada, and the US; and a rest of the world group. Figure 1 also shows the 99% confidence bounds for those averages (the vertical lines).

**Figure 1: The Average Urban Density by Geographic/Cultural Group for 167 Cities**



ha = hectare, ROW = rest of world.

Notes: In addition to the average density, the figure displays each group's 99% confidence bounds (the error bars). Thus, the difference between any two groups' average is statistically significant (at the 0.01 level) if one group's upper error bound is outside another group's lower error bound. The ROW group contains cities from Africa (6), the Middle East (4), and South America (6).

Sources: Kenworthy et al. (1999), Kenworthy and Laube (2001), UITP (2005).

Reproduced from Liddle (2013a).

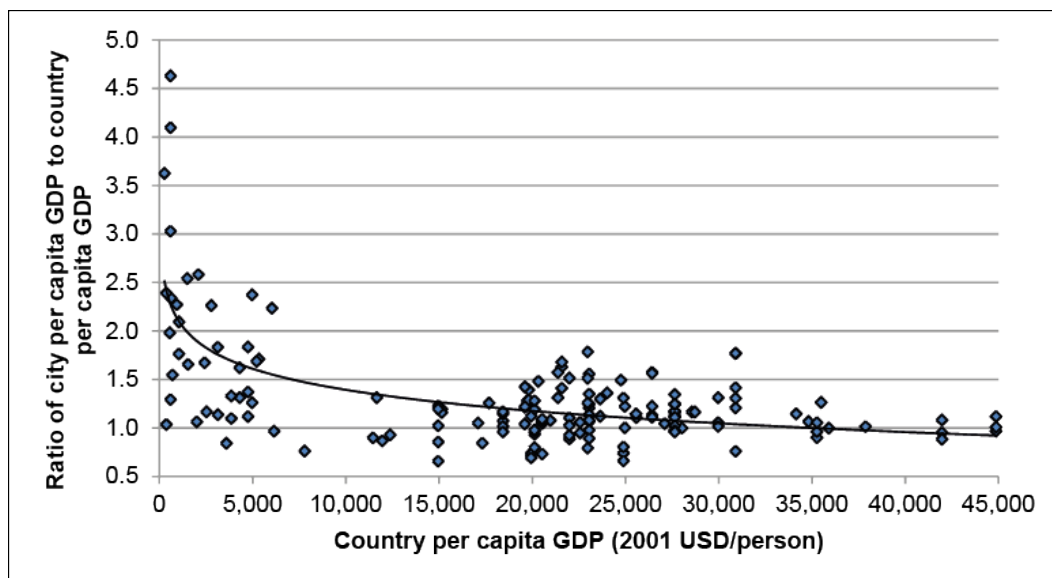
<sup>1</sup> <https://en.wikipedia.org/wiki/Megacity>; viewed 3 January 2017.

The cities with the lowest average urban density are in Australia, Canada, and the US—cities Newman and Kenworthy (1989) described as “auto-dependent.” The average urban densities of European cities are considerably higher than those of auto-dependent cities, and the average urban densities of Asian cities are considerably higher than those of European cities. In addition, the average urban densities for those three groups are all statistically significantly different from one another. Lastly, for the data set mentioned above, the correlation ( $\rho$ ) between urban density and the corresponding national population density is only 0.35, and urban density is actually negatively correlated ( $\rho = -0.59$ ) with national urbanization levels (Liddle 2013a).

### 1.3 Stylized Facts: Cities and Wealth and Poverty

In Figure 2, the ratio of city gross domestic product (GDP) per capita to the associated country GDP per capita is plotted against that country GDP per capita for 160 of those cities from Figure 1.<sup>2</sup> The GDP per capita is higher for most cities than for their respective countries as a whole—the ratio of city-to-country GDPs is less than one for only 35 cities, and less than 0.85 for only 14. Also, the relative economic importance of cities is stronger in countries with lower GDP per capita. That second point (i) illustrates that cities in developing countries exercise an important migratory pull, and (ii) helps explain why over three quarters of megacities are located in less developed countries (29 out of 37 if we count Mexico and Turkey as developing), and why urban areas will be the locus of all UN-projected future population growth (over the next 40 years).

**Figure 2: The Economic Importance of Cities**



GDP = gross domestic product, USD = US dollars.

Notes: The ratio of city per capita GDP to the corresponding country per capita GDP is plotted against that corresponding country per capita GDP for 160 world cities. Logarithmic trend line also shown.

Sources: Kenworthy et al. (1999), Kenworthy and Laube (2001), UITP (2005).

Reproduced from Liddle (2013a).

<sup>2</sup> The city-states Hong Kong, China; Singapore; and Taipei, China have been excluded from this figure, and from all other city-to-nation comparisons.



While people in cities tend to have more opportunities and income than people in rural areas, there is poverty in urban areas too, of course. Table 1 displays data from the World Bank's World Development Indicators database on various measures of urban poverty and rural-urban differences. Data were collected for all countries not classified as high-income countries by the World Bank (this meant a maximum of 135 countries, but not all of these have data for each variable). For data that is collected annually, the most recent year was used (typically either 2014 or 2012); for data that is less frequently collected, the average over the period 2010–2014 was used.

**Table 1: Descriptive Statistics for Urban Poverty Indicators and Rural-urban Poverty Comparisons. Two Samples: All Non-high-income Countries and Asian Countries.**

Indicator	Mean	Median	Maximum	Minimum	Std. Dev.	x-sects.
<b>Non-high-income countries</b>						
Urban electricity access	84.1	98.1	100	12.3	22.1	137
Rural-urban electricity ratio	0.62	0.71	1.00	0.02	0.35	137
Urban water access	93.4	96.7	100	58.4	8.3	131
Rural-urban water ratio	0.83	0.89	1.04	0.37	0.17	128
Rural-urban poverty gap ratio	2.83	2.01	12.72	0.79	2.34	48
Urban poverty share	23.0	20.3	61.6	0.65	14.5	68
Rural-urban poverty share ratio	2.34	1.95	9.28	0.99	1.51	67
Urban slum share	46.1	46.2	95.6	5.5	23.7	82
<b>Asian non-high-income countries</b>						
Urban electricity access	93.6	98.4	100	40.6	14.0	18
Rural-urban electricity ratio	0.70	0.72	1.00	0.21	0.27	18
Urban water access	92.9	95.6	100	66.4	8.9	18
Rural-urban water ratio	0.91	0.96	1.01	0.60	0.12	18
Rural-urban poverty gap ratio	3.44	1.88	12.00	1.48	3.16	11
Urban poverty share	12.0	10.0	27.6	0.6	8.5	15
Rural-urban poverty share ratio	2.92	1.98	9.28	1.39	2.07	14
Urban slum share	39.2	39.6	62.7	21.8	13.8	14

Std. Dev. = Standard Deviation, x-sects. = cross sections.

Note: Observations taken from 2010–2014, depending on availability.

Source: World Bank. World Development Indicators. <http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators>

Nearly all urban dwellers have access to electricity and good-quality water (the median share with access is 98% and 97%, respectively). The ratio of the population share for rural to urban demonstrates that urban dwellers are more likely to have such access than their rural counterparts. The median ratio is 0.71 and 0.89 for electricity and water, respectively, suggesting the urban population is about 30%–10% more likely to have access.

There is widespread poverty in urban areas, however, as nearly half of urban populations live in settlements defined as slums (the World Bank defines a slum as a house that lacks one or more of the following conditions: access to improved water, access to improved sanitation, sufficient living area, and durability of housing). Moreover, over a fifth of the urban population lives below their national poverty lines. Yet, the share of people living below the poverty line is double in rural areas since the median ratio of rural-to-urban poverty share is 2. Also, the urban poor tend to be less poor than their rural counterparts. The poverty gap is a population's mean shortfall

(i.e., % below poverty lines), and the mean and median for the rural-to-urban poverty gap ratio is 2.8 and 2.0, respectively, so the rural poor are about two to three times as poor as the urban poor (relative to a country's nonpoor population).

Table 1 also separates the Asian countries. For the most part, the numbers are quite similar to the larger panel. The main difference is that the share of urban people living below the poverty line is about half as large for Asian countries.

## 2. URBANIZATION AND ECONOMIC GROWTH/DEVELOPMENT

Urbanization and economic development tend to accompany one another, in part because the industrialization process involves the agricultural labor force migrating from the rural farms to the urban manufacturing plants. Development can encourage urbanization (through rural-to-urban migration) for other opportunities besides employment prospects, such as access to culture, education, and health care. Likewise urbanization or large cities can drive economic growth too, via advantages in economies of scale in infrastructure, capital, labor, and managerial resources (e.g., Wheaton and Shishido 1981). Concentration through knowledge spillovers can benefit more advanced economies. Lastly, cities produce a disproportional amount of national GDP (Beall and Fox 2009; Liddle 2013a).

On the other hand, urbanization may be more evidence of economic progress than a catalyst for economic growth. Indeed, Henderson (2010, 518) argued that any urbanization and development relationship "... is an equilibrium not a [sic] causal relationship." Moreover, because urbanization is a transitory process, nearly all countries will eventually cease to urbanize further and instead will become "fully urbanized" (Henderson 2003).

Africa and Latin America, according to historical data, experienced rather extended periods of urbanization that was unaccompanied by economic growth (Liddle 2013b). Indeed, Asia and Africa are currently at similar levels of urbanization, but Asia has a substantially higher GDP per capita, whereas Latin America has only a slightly higher GDP per capita than Asia, but Latin America is considerably more urbanized. These relationships have led some to question whether Africa and Latin America are overurbanized (e.g., Todaro 1995). By contrast, periods of sustained economic growth always appear to be accompanied by urbanization (Fay and Opal 2000).

While there is a substantial literature focusing on the urbanization process and its relationship with economic growth (e.g., Wheaton and Shishido 1981; Henderson 2003), very few studies directly consider the direction (or existence) of causality between urbanization and GDP per capita. The earliest such study, Bloom, Canning, and Fink (2008), found that urbanization did not Granger-cause GDP per capita. However, their analysis did not consider time-series-based modeling or heterogeneity.

Liddle and Messinis (2015) employed time-series data and heterogeneous panel methods that addressed stationarity on both income- and geography-based panels. While that paper could not reject noncausality for either middle-income or Latin American countries, it determined that urbanization Granger-caused economic growth in high-income countries. The authors also found that, for low-income, predominately African countries, economic growth had a positive causal effect on urbanization, but urbanization had a negative causal effect on economic growth. Such a bidirectional relationship, or balancing feedback loop, suggests an equilibrium relationship—a finding in concert with Henderson (2010).

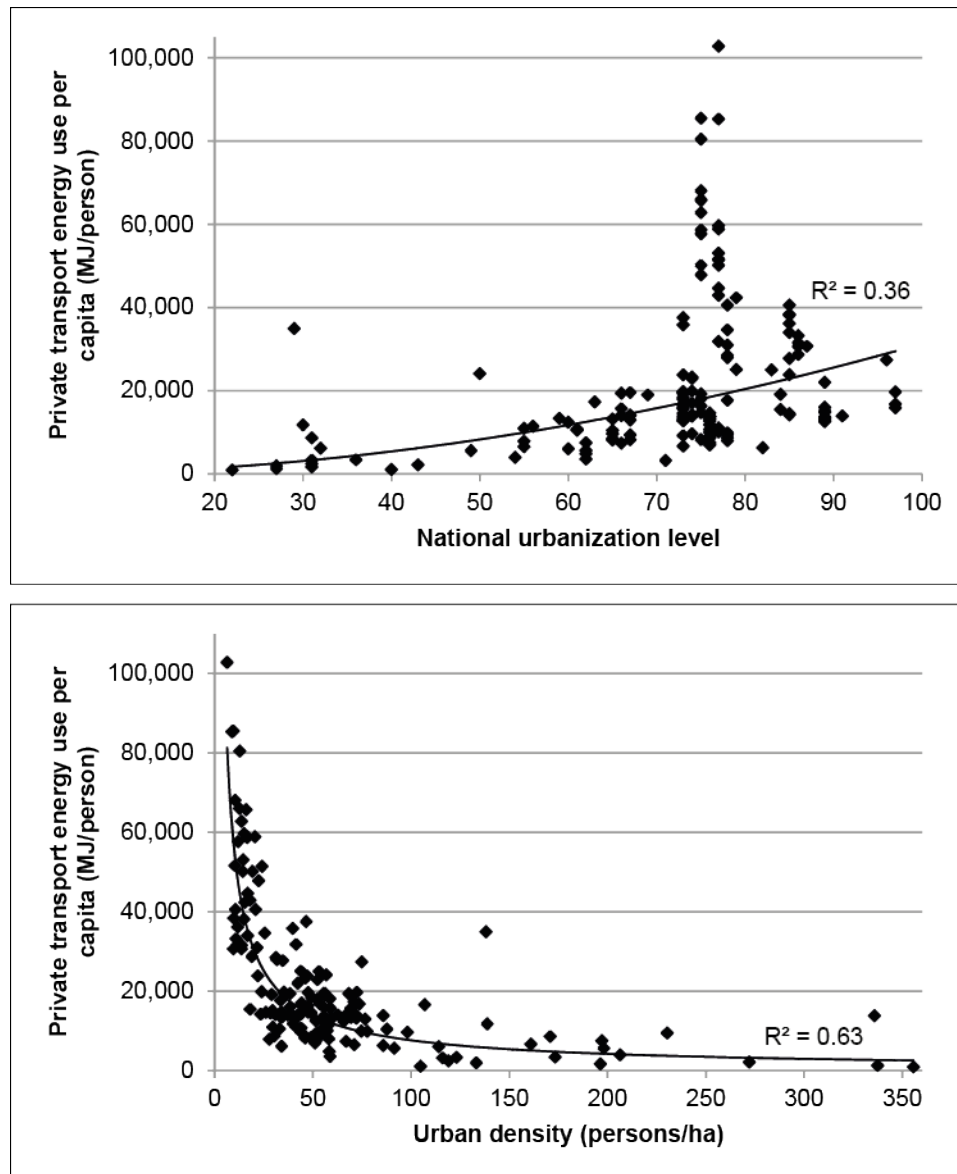
McCoskey and Kao (1999) added urbanization as a shift factor to a production-function model, in which GDP per capita was a function of physical capital per capita. Liddle (2013b) advanced McCoskey and Kao (1999) by (i) adding energy/electricity consumption per capita to the production function, (ii) addressing cross-sectional dependence in the estimations, and (iii) considering income-based panels. The panel urbanization elasticities estimated by Liddle (2013b) were positive for high-income and upper-middle-income countries, but near zero to negative for lower-middle-income and low-income countries—results that suggest, as others have argued, that less developed countries are overurbanized. Liddle (2013b) described the impact of urbanization on economic growth as a “ladder” effect: i.e., it has a strong negative impact for the poorest countries, a less negative to neutral impact for moderate-income countries, and a growth-promoting/reinforcing relationship for the wealthier middle-income and wealthiest countries.

### **3. URBANIZATION AND URBAN DENSITY AND ENVIRONMENT**

Urbanization’s several “associations” may lead to greater emissions/energy consumption. First, urbanization is associated with industrialization—i.e., the shift from agriculture to industry and services. People migrating over time both from rural to urban areas and from agricultural to industrial employment leads to increased energy consumption in three ways: (1) as agricultural operations become less labor-intensive because of rural-to-urban migration, such operations must mechanize; (2) urbanization spatially separates food consumers from food producers, thereby creating a transport need that did not exist under traditional agriculture and settlement patterns (Jones 1989); and (3) modern industry/manufacturing uses more energy per unit of output and per worker than traditional agricultural and manufacturing (Jones 1991). Second, urbanization is associated with economic growth, and so, since energy consumption is a normal good associated itself with economic growth, urbanization may lead to greater energy consumption. Finally, urbanization is considered a proxy for the number of people having access to a country’s energy/electricity grid, and so, urbanization would be associated with greater energy/electricity consumption. Indeed, most studies that have examined the impact of urbanization on energy consumption/emissions have found a positive, significant one (Liddle 2014).

That energy/electricity consumption could “cause” urbanization, too, seems plausible. For example, rural-to-urban migration to fill manufacturing jobs would be associated with higher energy consumption (since manufacturing would likely consume more energy than traditional agriculture). Likewise, migration motivated by the improved quality of life that energy/electricity may bring means that energy causes urbanization. Indeed, Liddle and Lung (2014) uncovered a long-term, causal relationship from several aggregations of electricity consumption (i.e., total electricity consumption, industry electricity consumption, and residential electricity consumption) to urbanization for panels of (i) high-, middle-, and low-income countries, and (ii) non-OECD countries pooled geographically (i.e., Africa, Asia, and Latin America). Specifically, the total electricity consumption per capita Granger-caused urbanization in high-income, low-income, African, and Asian countries; the industry electricity consumption per capita Granger-caused urbanization in high-income, middle-income, African, and Asian countries; and the residential electricity consumption per capita Granger-caused urbanization in high-income countries.

**Figures 3 a and b: The Relationships between Urban Private Transport Energy Use per Capita for 160 World Cities and Both the Corresponding National Urbanization Level (i.e., Figure 3a, the Upper Graph) and Urban Density (i.e., Figure 3b, the Lower Graph).**



ha = hectares, MJ = megajoules.

Note: Power-based trend lines and corresponding R-squared values shown.

Sources: Kenworthy et al. (1999), Kenworthy and Laube (2001), UITP (2005).

Reproduced from Liddle (2013a).

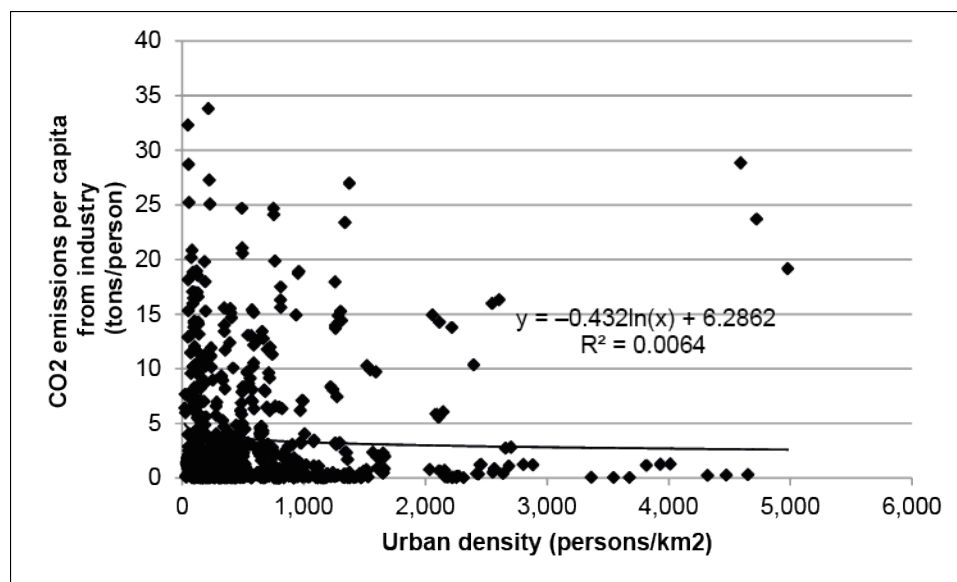
Alternatively, urbanization could lead to lower energy consumption since cities benefit from energy efficiencies by (i) allowing people to live in high-rise buildings, (ii) providing public transit networks, and (iii) encouraging energy-free transport modes (e.g., walking and cycling). Yet, as mentioned above, national levels of urbanization do not really measure/correlate with urban density, and thus those energy-efficient activities that could lead to less energy consumption or emissions. Indeed, plotting the relationship between urban private transport energy use per capita (from the city data set in Liddle 2013a) and the corresponding national urbanization level for each city

revealed a *positive* (but somewhat weak) relationship between urban private transport and urbanization—see Figure 3a below. That higher national urbanization levels are correlated with higher urban private transport energy use reflects the positive correlation between urbanization and income ( $\rho = 0.61$  for the countries represented in the Liddle 2013a data set).

By contrast, plotting urban private transport energy use per capita (the dependent variable) and urban density—Figure 3b—displays the now well-known negative, nonlinear relationship between urban private transport and urban density. Indeed, studies that employ city-based data do find that urban density is associated with (i) lower levels of transport energy consumption (e.g., Newman and Kenworthy 1989; Kenworthy and Laube 1999; Liddle 2013a), (ii) lower levels of transport-based pollutants, such as CO and NO<sub>x</sub> (Liddle 2015), (iii) lower levels of electricity consumption in buildings (e.g., Lariviere and Lafrance 1999), and (iv) lower levels of greenhouse gas emissions (e.g., Marcotullio et al. 2012).

Yet, it is important to emphasize that the types of energy consumption/emissions that should have a negative relationship with urban density are those caused by human activity that is itself influenced by economies of scale that exist in dense environments—e.g., energy-free transport modes, public transport, and smaller living spaces. In other words, there may be little reason to expect industrial energy consumption to be lowered by urban density. Indeed, Figure 4 plots industrial carbon emissions in OECD cities by the urban density of those cities, and indicates no relationship between the two.

**Figure 4: The Relationship between Industrial CO<sub>2</sub> Emissions per Capita and Urban Density for 250 OECD Cities**



CO<sub>2</sub> = carbon dioxide, km = kilometer, OECD = Organisation for Economic Co-operation and Development.

Notes: Observations from 2000, 2005, and 2008. Trend line and corresponding R-squared shown.

Source: <https://data.oecd.org/searchresults/?r=+f/type/datasets>

## 4. URBANIZATION AND INEQUALITY/POVERTY

In Kuznets' (1955) well-known paper he demonstrated that there is an inverted-U-shaped relationship between income inequality and economic growth, i.e., as countries initially get wealthier, inequality increases, but at some sufficiently high level of wealth/development, further increases in wealth correspond with lower levels of inequality. We revisit that analysis by also considering urbanization levels via cross-sectional regressions. We use the Gini index<sup>3</sup> as the measure of inequality and estimate it as a nonlinear function of GDP per capita (in constant 2011 international dollars that are adjusted for purchasing power parity) and as a nonlinear function of urbanization. The data are from the World Bank's World Development Indicators, and the observations are from 2013 for GDP per capita and urbanization and from the average over 2007–2013 for the Gini index (which is stable over time and for many countries is observed/recorded only occasionally). All variables have been converted to natural logs so that their estimated coefficients can be interpreted as elasticities. The cross section contains 133 countries (which include high-income countries), and the regression results are displayed in Table 2.

**Table 2: Kuznets-style Cross-sectional Regressions.  
GINI Index is Dependent Variable.**

Regression	All Countries	Asian Countries	
	I	II	III
GDP per capita	0.60*** (0.20)	2.01* (1.04)	1.53*** (0.49)
GDP per capita squared	−0.04*** (0.01)	−0.11* (0.06)	−0.08*** (0.03)
Urbanization	−0.81* (0.45)	−0.95 (1.32)	
Urbanization squared	0.13** (0.06)	0.13 (0.20)	
Adjusted R <sup>2</sup>	0.20	0.10	0.17
Observations	133	20	20
Turning point			
GDP per capita	\$1,711	\$8,273	\$9,377
Urbanization	23%		

GDP = gross domestic product.

Notes: All variables in natural logs. White-heteroskedasticity-consistent standard errors in parentheses. Statistical significance is indicated by: \*\*\* p < 0.01, \*\* p < 0.05, and \* p < 0.1.

Data from World Bank. World Development Indicators. <http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators>

For the polynomial model considered here, an inverted-U relationship between the dependent and independent variables is said to exist if the coefficient for the linear term,  $\beta_1$ , is statistically significant and positive, while the coefficient for the squared term,  $\beta_2$ , is statistically significant and negative. Furthermore, when the estimations

<sup>3</sup> The Gini index is based on the Lorenz curve, which plots the proportion of the total income of a population that is cumulatively earned by the bottom x% of the population. The 45-degree line represents perfect equality of incomes, and the Gini index is the ratio of the area that lies between the 45-degree line and the Lorenz curve. Hence, a Gini index of 0 represents perfect equality.

suggest a parabolic relationship (i.e., one coefficient is positive and the other negative), the implied turning point,  $\tau$ —or the level of the independent variable at which the sign of the relationship between dependent and independent variable changes—can be calculated by:

$$\tau = \exp(-\beta_1/(2\beta_2)) \quad (1)$$

The all-country sample result (Regression I) confirms an inverted-U relationship between income inequality and income. The turning point of under \$2,000 per capita is well within the sample range—indeed, the mean income is over \$14,500, and the median is over \$9,300. Interestingly, urbanization has a U-shaped relationship with inequality, i.e., initially, increases in urbanization are associated with lower levels of inequality, but ultimately, increases in urbanization are associated with higher levels of inequality. Again, the estimated turning point of 23% urbanization is well within the sample range; both the mean and median levels of urbanization are around 55%. For the 20-country Asian sample (Regression II), both urbanization coefficients are highly insignificant (and the GDP per capita coefficients are only marginally so); so the regression was run with only the GDP per capita terms. This result, shown in Regression III, suggests an income turning point of just over \$9,000 per capita—around the middle of the range (the mean and median were approximately \$8,800 and \$6,000, respectively).

Next, we revisit the variables on urban poverty and rural-urban differences introduced in Table 1 to determine whether/how the level of income or urbanization is associated with those indicators via cross-sectional regressions (income and urbanization data are the same as described above). As before, the variables have been converted to natural logs so that their estimated coefficients can be interpreted as elasticities. We believe that income should improve these measures monotonically, so we do not consider a polynomial of GDP per capita. However, we do allow for a possible nonlinear relationship with urbanization level (urbanization squared was usually insignificant, and only significant results for this transformation are shown in the table). The regression results are displayed in Table 3.

**Table 3: Cross-sectional Regressions of the Effects of GDP per Capita and Urbanization on Urban Poverty Indicators and Rural-urban Poverty Comparisons**

Regression	IV	V	VI	VII	VIII	IX
Dependent Variable	Urban Electricity Access	Rural-urban Electricity Ratio	Urban Poverty Gap	Urban Poverty Share	Rural-urban Poverty Share Ratio	Urban Slum Share
GDP per capita	0.28*** (0.05)	0.67*** (0.10)	-1.19*** (0.17)	-0.90*** (0.13)	0.19** (0.07)	-0.42*** (0.09)
Urbanization	-0.08 (0.09)	3.29* (1.83)	-5.87** (2.34)	1.17*** (0.18)	-0.39*** (0.13)	-0.19 (0.15)
Urbanization squared		-0.42* (0.25)	1.08*** (0.36)			
Adjusted R <sup>2</sup>	0.39	0.52	0.43	0.41	0.07	0.47
Observations	128	128	47	67	66	78
Turning point		49%	15%			

GDP = gross domestic product.

Notes: All variables in natural logs. Sample excludes all countries World Bank-designated as high-income. White-heteroskedasticity-consistent standard errors in parentheses. Statistical significance is indicated by: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , and \*  $p < 0.1$ .

Data from World Bank. World Development Indicators. <http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators>

For the share of urban population with electricity access and the share of urban population living in slums (i.e., Regressions IV and IX), GDP per capita had the expected statistically significant impact. For urban electricity access, a 1% increase in GDP per capita leads to a 0.3% *increase* in access, whereas for urban slum share, a 1% increase in GDP per capita leads to a 0.4% *fall* in the share of people living in slums. For both of those regressions the level of urbanization was insignificant. For the rural-to-urban share of people living in poverty (i.e., Regression VIII), both income and urbanization were statistically significant, but the associated R-squared for the regression was very low, i.e., the model had a poor fit.

Urbanization had a more interesting relationship for the other dependent variables. For example, for the rural-to-urban electricity access ratio (i.e., Regression V), urbanization had an inverted-U relationship. A 1% increase in GDP per capita raised the ratio by two thirds of a %—i.e., the rural-urban electricity access gap narrows at higher income. Initially, higher urbanization levels are associated with a higher access ratio/narrower gap as well, but at urbanization of 49%—approximately the mean and median for the 128-country sample—higher levels of urbanization are associated with a lower access ratio/larger rural-urban gap (i.e., disproportionately less electricity access for rural populations). In other words, at higher levels of urbanization, rural populations are more likely to be “left behind.”

The urban poverty gap regression (Regression VI) reveals a similar nonlinear relationship with respect to urbanization. The urban poverty gap is the urban population's mean shortfall from the poverty lines (counting the nonpoor as having zero shortfall) as a percentage of the poverty lines—so the measure reflects the depth of poverty and its incidence. Again, not surprisingly, GDP per capita has a strong, negative relationship—indeed, increases in GDP per capita reduce this gap more than proportionally. Urbanization now has a U-shaped relationship with the urban poverty gap; however, because of the definition of the dependent variable, the basic relationship is the same as with the rural-to-urban electricity access ratio, i.e., initially, increases in urbanization are associated with an improvement, but ultimately, urbanization is correlated with a worsening of rural-urban differences/poverty.

What is particularly surprising about Regression VI is the relatively low turning point for urbanization—indeed, the turning point is only 15%, whereas the mean/median is approximately 40%. It is possible that when urbanization increases because of rural-to-urban migration, those rural migrants settle in marginal urban areas, so that urban poverty increases. However, one should be mindful of the relatively small sample size of Regression VI (only 47 out of 128 countries had the urban poverty gap data). Moreover, those included countries in Regression VI were disproportionately poorer than the “full sample” (of Regressions IV and V). For example, the mean and median GDP per capita for Regression VI were only \$5,200 and \$3,600, respectively, compared to \$8,000 and \$6,500, respectively, for the 128-country sample (Regressions IV and V). Furthermore, the maximum GDP per capita for Regression VI was approximately \$14,500, which means the 21 richest countries in the 128-country sample were not included. By contrast, the range of urbanization levels is similar for the smaller sample (Regression VI) and the larger ones (e.g., Regression IV): 12%–78% compared to 12%–89%, respectively.

Finally, the urban poverty share regression (Regression VII) is similar to Regression VI in two ways: (i) the smaller sample of countries (67) are poorer than the larger sample—mean and median GDP per capita are \$6,600 and \$4,700, respectively; and (ii) increases in urbanization seem to offset improvements from increases in GDP per capita. Indeed, increases in GDP per capita lower the share of urban population living in poverty by nearly one-to-one; however, increases in urbanization appear to more



than offset that improvement in poverty reduction (urbanization's elasticity is 1.2). Again, the results could be interpreted as suggesting that when urbanization increases because of rural-to-urban migration, poverty among the (newly designated) urban population will increase as well.

Lastly, we consider another method for analyzing potential nonlinearities, i.e., quantile regression (initially proposed by Koenker and Bassett 1978). A quantile regression estimates the linear relationship between regressors and a specified quantile of the dependent variable. Among the questions quantile regressions can address are: (i) whether the coefficient estimates vary across different quantiles of the dependent variable; and (ii) whether the coefficients for the median are statistically different from those estimated at the upper and lower quartile.

The quantile regressions typically suggest a uniform impact of urbanization. The main exception to that result is for the Gini index, for which urbanization is significant only at the higher quantiles of the index, i.e., urbanization matters in societies that are the most unequal. There was more evidence of differences across quantiles for income—this was the case for nearly half of the dependent variables as displayed in Table 4 (results for the other quantile regressions are not shown, but are available upon request).

**Table 4: Cross-sectional Quantile Regressions of the Effects of GDP per Capita and Urbanization on Select Urban Poverty Indicators and Rural-urban Poverty Comparisons**

	Dependent Variable	Gini Index	Urban Electricity Access	Rural-urban Electricity Ratio	Urban Poverty Share
	Quantile/s				
GDP per capita	0.25	−0.09** (0.04)	0.33*** (0.05)	0.73*** (0.11)	−0.92*** (0.13)
	0.50	−0.10*** (0.03)	0.19*** (0.04)	0.70*** (0.09)	−0.73*** (0.15)
	0.75	−0.14*** (0.04)	0.10*** (0.04)	0.29** (0.12)	−0.46*** (0.17)
Slope equality test	0.25, 0.50	0.69	0.00	0.75	0.15
	0.50, 0.75	0.18	0.01	0.00	0.07
Urbanization	0.25	0.09 (0.11)	−0.11* (0.07)	0.33 (0.22)	1.09*** (0.23)
	0.50	0.08 (0.08)	−0.05 (0.05)	0.11 (0.21)	1.10*** (0.27)
	0.75	0.19*** (0.06)	−0.06 (0.05)	0.02 (0.19)	0.78** (0.30)
Slope equality test	0.25, 0.50	0.91	0.24	0.27	0.95
	0.50, 0.75	0.098	0.78	0.60	0.23
Observations		133	128	128	67

GDP = gross domestic product.

Notes: All variables in natural logs. Sample excludes all countries World Bank-designated as high-income. White-heteroskedasticity-consistent standard errors in parentheses. Statistical significance is indicated by: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , and \*  $p < 0.1$ . For slope equality test, p-value is shown.

Data from World Bank. World Development Indicators. <http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators>

The impact of GDP per capita declines significantly when the share of urban population with electricity access is sorted by quartiles (consider the reported p-value of the slope equality test between the lower and median quartile and between the upper and median quartile)—a not surprising saturation effect. A similar pattern is observed for both the rural-to-urban electricity access ratio and the urban poverty share; however, the difference between estimations is only statistically significant when comparing the median quartile with the top quartile. For the rural-to-urban electricity access ratio, that relationship is in concert with the same finding for urban electricity access, as would be expected. Whereas, for the urban poverty share, the quantile regression suggests (surprisingly) that the income effect on lowering urban poverty is significantly smaller in societies with the highest share of urban people living in poverty.

## 5. SUMMARY, POLICY IMPLICATIONS, AND AVENUES FOR FUTURE WORK

This work has summarized and expanded the state-of-the-art understanding of the urbanization, development, environment, and inequality nexus. Economic growth/wealth, urbanization, and energy/electricity consumption are all highly correlated; however, those relationships may not be fully causal. While urbanization may be more evidence of economic progress than a catalyst for economic growth, there is some evidence that poor countries are overurbanized. Also, modern (i.e., nonagricultural) employment and improved quality-of-life opportunities (e.g., lighting, space conditioning, communication technologies) help to encourage/cause rural-to-urban migration, and urban-based access to electricity is considered at least a proxy for, if not a cause of, such employment and opportunities. Thus, electricity/energy consumption may cause urbanization and not the other way around. Yet, urbanization is a transitory process, and countries become “fully urbanized” at substantially different urbanization levels.

Urban density is associated with energy efficiency/savings in buildings and transport, but is probably not related to energy/emissions from industry. National urbanization levels are not indicative of the density of the cities within. Asian cities (including those in the Republic of Korea and Japan) are substantially more dense than OECD cities. Also, Asian cities are the world’s largest (the vast majority of megacities are located in Asia).

Lastly, cities are disproportionately wealthy—likely a key reason why the world is becoming more urban. Yet, cities are associated with poverty, too. Increases in GDP per capita unambiguously lower poverty and narrow rural-urban gaps. By contrast, levels of urbanization were either unrelated to such measures, or had a nonlinear effect, where initially increases in urbanization likewise led to improvements, but at higher levels of urbanization, increases in urbanization exacerbated poverty and rural-urban gaps.

Given the tenuous causal relationship outlined here between urbanization and economic growth/development: (i) urbanization policies should be motivated by factors such as equality in health and educational access, not by encouraging economic growth; and (ii) urbanization should not be the focus of economic growth facilitation. However, how cities are formed is important. For example, denser cities lead to energy efficiency that can reduce energy use (in buildings and transport) and the resulting pollution. On the other hand, denser cities mean more people are exposed to those pollutants. Also, how cities are formed likely has an impact on urban poverty and whether rural-urban gaps are reduced or exacerbated.

Hence, one area for future work is to employ data at a high level of spatial disaggregation (e.g., regional or city-level) and focus on the processes that lead to more or less dense cities. The inequality dimension is the least explored in the urbanization, development, environment, and inequality nexus, so clearly there is room for further work here. For example, future work could seek to improve the understanding regarding the potential nonlinear relationships among urbanization and some urban poverty measures and rural-urban differences.

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