Which comes first—urbanization or economic growth? Evidence from heterogeneous panel causality tests

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ABSTRACT

Heterogeneous panel causality tests are employed to consider the relationship between urbanization change and economic growth (i.e., differenced logged GDP per capita). Income- and geography-based panels demonstrated substantial variation in that relationship. Urbanization caused economic growth in high income countries, but non-causality could not be rejected for both middle-income and Latin American countries. A bi-directional, equilibrium relationship was uncovered for low-income, predominately African countries where economic growth had a positive, causal effect on urbanization, but where urbanization, in turn, had a negative, causal effect on economic growth. Hence, urbanization and economic growth either co-evolve, as they do for low income/African countries and (likely) for high income countries, or else the two processes are somewhat decoupled, as they are for middle income and Latin American countries, despite their high degree of correlation.

Keywords: Heterogeneous panel causality; Economic growth; Urbanization

JEL: C23; O18; O54; O55

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1. Introduction and background

The level of world urbanization crossed the 50% mark in 2009; the United Nations expects that over the next 40 years urban areas will absorb virtually all of the projected 2.3 billion global population growth. The highly intertwined relationship between economic growth/development and urbanization is well recognized (Henderson 2010)みspecifically, both economic development and urbanization are associated with the shift of labor from agriculture to industry and services. Indeed, for modernization theorists, urbanization is both a by-product of economic development/growth and a proxy for modernization (e.g., Gibbs 2000). This paper adds to the urbanization-economic growth/development literature by testing for Granger-causality between urbanization and the natural log of real GDP per capita using the most current heterogeneous panel methods and a large panel of developed and developing countries.

A key reason urbanization tends to accompany economic development is the industrialization process through which the typically rural agricultural labor force migrates to the typically urban manufacturing plants. Beyond employment prospects, development can encourage urbanization (through rural to urban migration) for other opportunities like access to culture, education, and health care. But urbanization or large cities have been thought to drive economic growth, too, via advantages in economies of scale in infrastructure (transport and telecommunications), capital, labor, and managerial resources (e.g., Wheaton and Shishido 1981). More advanced economies can benefit from concentration through knowledge spillovers. Similarly, the mutually reinforcing phenomena of people with high human capital being attracted to areas of high quality of life, and aspects of quality of life (education, health care, arts) being driven by people with high human capital, helps to create centers of excellence and innovation in multiple but not necessarily related fields, as is the case in Silicon Valley, CA or Bangalore, India. Lastly, it is well noted that urban economies are more productive than rural ones, i.e., cities produce a disproportional amount of national GDP (Beall and Fox 2009; Liddle 2013a).

On the other hand, urbanization may not so much be a catalyst for economic growth, as be evidence of economic progress. Indeed, Henderson (2010) argued that the relationship between urbanization and development “is an equilibrium not causal relationship” (p. 518). Furthermore, urbanization is a transitory process in which, at some level of population living in urban areas, nearly all countries will cease to urbanize any more—i.e, they become “fully urbanized” (Henderson 2003). At the same time, the structure of the economy and GDP per capita may, and usually will, continue to change/rise. Furthermore, taking OECD countries as an example, the level of urbanization for fully urbanized countries varies considerably. For example, the level of urbanization has changed very little since 1950 for both Austria and Belgium (having increased by only 6% since then or 0.1% per year); yet, their current urbanization levels are substantially different, 68% and 97%, respectively. Another way to appreciate the different paths urbanization and economic development have taken in different countries is to consider Figure 1, which shows the GDP per capita (in log form)-urbanization paths for Africa, Asia, Latin America and Caribbean (LAC), and Western Europe as a whole, over the long-term (from the 19th century to present). Figure 1 indicates that there were rather extended periods for Africa and Latin America where urbanization was experienced but was unaccompanied by economic growth. By contrast, periods of sustained economic growth appear always to be accompanied by urbanization. Also, Asia and Africa currently are at similar levels of urbanization, but Asia has a substantially higher GDP per capita; whereas, LAC has only a slightly higher GDP per capita than Asia, but LAC is considerably more urbanized. These phenomena have led some to question whether Africa and LAC are over-urbanized (e.g., Todaro 1995; Fay and Opal 2000).

Figure 1

1.1 Previous urbanization-GDP causality, cointegration analyses

Although there is a substantial literature focusing on the urbanization process and its relationship with economic growth, there have been very few studies that directly investigate the direction (or existence) of causality between urbanization and GDP per capita/development. The most comprehensive, in terms of countries analyzed (163), was Bloom et al. (2008), who found that urbanization did not Granger-cause GDP per capita. However, their analysis involved just 4-5 time observations per country (10-year rates of change), and thus, did not consider unit roots or time-series-based modeling. The only urbanization-GDP Granger-causality studies employing time-series methods considered either a single country or relatively small panels. Halicioglu (2007) focused on Turkey; Mishra et al. (2009) focused on nine Pacific Island countries, and Michieka and Fletcher (2012) focused on China; all three studies failed to determine causality between urbanization and GDP. By contrast, Hossain (2011), who focused on nine newly industrialized countries, determined one-way causality from urbanization to GDP; whereas, Shahbaz and Lean (2012), who focused on Tunisia, found bi-directional causality.

Though not a causality analysis per se, McCoskey and Kao (1999) added urbanization as a shift factor to a production-function model, where GDP per capita was a function of physical capital per capita, and estimated elasticities with heterogeneous, non-stationary panel methods and data from 52 OECD and non-OECD countries. While they found the three variables (GDP per capita, physical capital per capita, and urbanization) to be panel cointegrated, urbanization's panel elasticity was insignificant. However, their individual cross-sectional (country) estimations indicated wide variation across countries: i.e., statistically insignificant elasticities, statistically significant negative elasticities, and statistically significant positive elasticities.

Liddle (2013b) expanded on the McCoskey and Kao analysis by adding energy/electricity consumption per capita to the production function, by addressing cross-sectional dependence in the estimations, and by considering income-based panels, which were comprised from 79 countries. Liddle estimated panel elasticities for urbanization that were positive for high and upper middle income countries, but near zero to negative for lower middle and low income countries—suggesting, as others have argued, that less developed countries are over-urbanized. Thus, Liddle (2013b) argued urbanization has a “ladder” effect on economic growth: it has a strong negative impact for the poorest countries, a less negative to neutral impact for countries with moderate incomes, and a growth promoting/reinforcing relationship for the wealthier middle income countries and wealthiest countries. Furthermore, that “urbanization ladder” effect was confirmed by the individual country estimations. When the individual country urbanization elasticity estimates were plotted against the corresponding country sample period average GDP per capita, the urbanization elasticity displayed an increasing relationship with average income.

2. Data, pre-testing methods and results

Real GDP per capita comes from the Penn World Tables (the constant chain series from Heston et al. 2012), and urbanization, or the share of people living in urban areas, comes from the World Bank (World Development Indicators). We form a balanced panel of 100 countries with data spanning from 1960-2009. In addition, since the analysis of Liddle (2013b) found that the sign of urbanization’s effect on GDP per capita varied according to income, we form three income-based panels (of high, middle, and low income countries), which roughly conform to the income definitions used in World Bank data. The make-up of those three income-based panels is displayed in Appendix Table A-1. Lastly, because both previous work and Figure 1 suggested there may be geographic differences in urbanization-GDP causality, we use two geography-based panels formed from the non-high income countries: Africa and Latin America and Caribbean (which contain 36 and 38 countries, respectively).[1]

A recent advance in panel econometrics is the relaxation of the assumption that variables are cross-sectionally independent. Indeed, for variables like urbanization and GDP per capita, cross-sectional dependence is likely because of, for example, regional and macroeconomic linkages. The Pesaran (2004) test for cross-sectional dependence indicates that cross-sectional independence can be rejected for both GDP per capita and urbanization in levels, and the resulting absolute value mean correlation coefficients are high (results shown in Table 1).[2] Yet, when first differences are taken, for GDP per capita cross-sectional dependence is mitigated (highly so for the middle- and low-income panels since their absolute value mean correlation coefficients are now quite small); for urbanization cross-sectional independence cannot be rejected for the middle- and low-income panels, and cross-sectional dependence is mitigated for the high-income panel. The reasons cross-sectional dependence is more prevalent in the high-income panel after differencing may be (i) that the high-income countries (by definition) have experienced more consistent, persistent economic growth (the first difference of GDP per capita) than other countries, and (ii) that those high-income countries tend to be fully urbanized, and thus, have experienced similar low rates of urbanization change.

Table 1

Several panel studies have determined that GDP per capita is *I*(1) (e.g., Liddle 2013b; McCoskey and Kao 1999). Although urbanization is clearly stock-based and rarely, if ever, declines, determining urbanization's order of integration can be challenging (see the discussions in Liddle 2013b and Liddle and Lung 2014). Yet, several panel studies have found the natural logarithm of urbanization (McCoskey and Kao 1999; Liddle and Lung

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[1] A panel made-up of non-high income Asian countries would contain only 10 countries—which we judged too small to be worthwhile/insightful.

[2] This test is implemented via the STATA command xtcd, which was developed by Markus Eberhardt.

2014) or the logistic transformation of urbanization (Liddle 2013b) to be I(1). Those two most recent studies addressed cross-sectional dependence and allowed for endogenous breaks in their panel unit root tests. Furthermore, Apergis and Tang (2013), performed individual (time series) unit root tests on a sample of 85 (developed and developing) countries (with data spanning 1975-2007), and determined that urbanization was I(1) for over 70% of those countries when the test (Zivot-Andrews) allowed for endogenous breaks.

The Bai and Carrion-i-Silvestre (2009) panel unit root test accounts for cross-sectional dependence (via multiple common factors) and allows for multiple endogenous breaks (in either the trend or level). The test is flexible enough to allow countries to have breaks at different times and with different magnitudes. The Bai and Carrion-i-Silvestre test produces two sets of three statistics; Bai and Carrion-i-Silvestre (2009) claim that the simplified set are most appropriate for the level and trend break model, and suggest that the Z and P statistics have the best small sample properties; hence, we focus on those two (simplified) statistics in Table 2.[3] Those results do not provide evidence to question our a priori belief (which is motivated by previous research discussed above) that urbanization and GDP per capita are I(1) or difference stationary variables.

Table 2

If two variables are integrated order one, a next step is to test for cointegration, i.e., whether there is a long-run relationship between them. Banerjee and Carrion-i-Silvestre (2006) acknowledge that cointegration tests tend to be biased when either structural change or cross-sectional dependence are present. The former tends to bias the tests toward accepting the null hypothesis of no cointegration while the latter tends to bias the results toward rejecting that null. Banerjee and Carrion-i-Silvestre propose a residual-based test that allows for heterogeneity, multiple unknown breaks, and cross-sectional correlation.[4] However,

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[3] Gauss code for the Bai and Carrion-i-Silvestre (2009) test was provided by J. Carrion-i-Silvestre.

[4] Gauss code for the Banerjee and Carrion-i-Silvestre (2006) test was provided by Tuomas Malinen.

Banerjee and Carrion-i-Silvestre allow for common factors only in the cointegrating vectors but not in the individual variables. Di Iorio & Fachin (2012) take issue with that assumption, and thus, develop a residual-based bootstrap test for panel cointegration that is robust to short-run and long-run cross-sectional dependence.[5] Table 3 reports the results of the both of those cointegration tests. For the Banerjee and Carrion-i-Silvestre test, the normalised Z_ρ test statistic with level and cointegrating vector shift is reported; and for the Di Iorio and Fachin test, the mean ADF statistic with a time trend is reported. Urbanization is the dependent variable in the first (of two) columns in each test while GDP is the dependent variable in the second column (in each test). Pervasively, the test results indicate that the null hypothesis of no cointegration cannot be rejectedみperhaps, not surprising for a bi-variate model.

Table 3

Our finding of no cointegration is different from the cointegration determination of both McCoskey and Kao (1999) and Liddle (2013b);[6] however, both of those studies investigated multivariate (production function) models. But we are interested in investigating causality specifically between urbanization and GDP per capita (as opposed to causality/exogeneity among several variables); and thus, we employ a bi-variate model and bi-variate causality methods (similar to Bloom et al. 2008). And, since we have determined the two variables are I(1) but not cointegrated, we consider the first difference of urbanization and GDP per capita and employ the heterogeneous panel causality test of Dumitrescu and Hurlin (2012),[7] which is designed for bi-variate models of stationary, non-cointegrated variables.

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[5] Gauss code for the Di Iorio and Fachin (2012) test was provided by Stefano Fachin.

[6] That finding is different as well from the several previously mentioned single-country and small-sample studies.

[7] Matlab code for the Dumitrescu and Hurlin (2012) test was retrieved from: www.runmycode.org/CompanionSite/site.do?siteId=51

3. Causality testing methods, results, and discussion

The Dumitrescu and Hurlin (2012) test of Granger non-causality for heterogeneous panels is based on the stationary fixed-effects panel model:

$$\Delta U_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^k \Delta U_{i,t-k} + \sum_{k=1}^{K} \beta_i^k \Delta I_{i,t-k} + \varepsilon_{i,t} \qquad (1)$$

where Δ is the difference operator, U is urbanization, I is the log of income for country i (i=1,2,∧N) in period t, γ and β are parameters that vary across countries, and ε are residuals that are independently and normally distributed, are independently distributed across countries, and have heterogeneous variances. The authors derive a Wald statistic that tests the null of H_0: $\beta_i = 0$ (I = 1,∧N) for all lagged autoregressive parameters. They show that the statistic has very good properties in finite-samples and use bootstrap to obtain critical values.

The heterogeneous panel approach is based on the cross sectional average of the individual Wald statistics, and thus, does not require panel estimations; that approach is particularly appropriate since, as Figure 1 suggests, the urbanization-economic growth relationship is unlikely to be the same for all countries. Furthermore, if one mistakenly assumes that the dynamics at the country level are homogeneous, when the true coefficients of a dynamic panel indeed are heterogeneous, then all of the panel parameter estimates will be inconsistent (Pesaran and Smith 1995). Lastly, while the approach of Dumitrescu and Hurlin as currently formulated does not explicitly address cross-sectional dependence, it is important to note that, after first differencing our two variables, either cross-sectional independence cannot be rejected or any remaining cross-sectional correlation has been highly mitigated (see Table 1 and accompanying discussion).

Using up to three autoregressive lags, bivariate regressions were employed to assess optimal lag length for each individual country. When urbanization was the dependent variable, Bayesian Information Criteria (BIC) showed that for 98 out of 100 countries one lag was the optimum (two lags and three lags were optimum for one country each). When GDP per capita was the dependent variable, the BIC suggested one lag was optimal for 95 countries, two lags was optimal for four countries, and three lags was optimal for one country. Hence, for robustness we report the causality results for both one and two lags in Table 4.[8]

Table 4

The top panel of Table 4 displays the panel p-values for the non-causality test. While non-causality is rejected in both directions for an all countries panel, income-based disaggregation indicates that causality is heterogeneous and based on development level. For high income countries, causality runs from urbanization to economic growth; whereas for middle income countries, non-causality cannot be rejected in either direction; different still, for low income countries, non-causality is rejected in both directions.

Also, when geography is considered, it becomes clear that the causality in the low income panel reflects a predominately African phenomenon—Haiti, India, and Nepal were the only non-African, low income countries for which non-causality was not rejected. Indeed, bi-directional causality is found for the African panel too. Although the over-urbanized idea has been applied to Latin America as well as Africa, non-causality cannot be rejected in either direction for the Latin American panel.

The bottom panel of Table 4 indicates the number of countries in each panel for which the non-causality hypothesis could be rejected at the 10 percent level. There is evidence of heterogeneity within the various panels since, even for panels in which non-causality is rejected at a very high significance level, the individual countries for which non-causality is rejected form a minority of that panel. Yet, if there were really no causality, then we would expect to reject the hypothesis, and would accept causality in 10 percent of the

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[8] Dumitrescu and Hurlin's present code does not allow for the lag structure to vary by cross-section.

countries if we use the 10 percent significance level for our test. Thus, rejections of no causality in substantially more than 10 percent of countries can be taken as evidence against the hypothesis that there is no causality in any country (an asterisk indicates panels for which a statistically significant number of countries, at the 1 percent level, reject non-causality).[9]

The tests displayed in Table 4 indicate the *direction* of the causal relationship (i.e., which variable むcausesめwhich variable); but those causality tests do not determine the *sign* of that relationship (i.e., whether the variables move togetherみa positive relationshipみor counter to one anotherみa negative relationship). Based on the results of Liddle (2013b), we assume that the sign of the causal relationship from urbanization to GDP per capita is dependent on development level, so that it is negative for low income/African countries but positive for high income countries. While we expect the sign of the causal relationship from GDP per capita to urbanization to be positive for all development and urbanization levels, we are not aware whether such an empirical determination has been made. Hence, for the low income and Africa panels we employ a system-GMM regression[10] to confirm such a positive relationship.

We use system-GMM since bi-directional causality was determined for those panels, and this method can address endogeneity via lagged instruments. System-GMM results are robust estimates with the finite-sample correction of Windmeijer (2005) and a constraint on instruments set by principal component analysis. As Table 5 indicates, the results demonstrate that the causal relationship from GDP per capita to urbanization indeed is positive for both the low income and Africa panels (following the previously discussed BIC results the optimum lag length is one). The Arellano-Bond serial correlation, AR(2), test statistic confirms that the bivariate model with one lag is correctly specified. Although the

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[9] Under the null of no causality, the *percentage* of countries rejecting that null hypothesis at the 10 percent significance level has an expected value of 10 and a standard deviation of $30N^{-1/2}$ (for N large).

[10] This regression is implemented via the STATA command xtabond2, which was developed by David Roodman.

Sargan test statistic is significant, Hansen test statistic that is robust to heterogeneity suggests the instruments are appropriate.

Table 5

Hence, for low income/African countries the mutual causality between economic growth and urbanization forms a balancing feedback loop (i.e., one negative and one positive relationship). In other words, economic growth leads to greater urbanization, which in turn, retards further economic growth. A balancing feedback loop suggests an equilibrium relationship—a finding in concert with a conclusion of Henderson (2010).

4. Conclusions

We performed heterogeneous panel causality tests on urbanization change and economic growth (i.e., differenced logged GDP per capita). While an all countries panel suggested bi-directional causality, income- and geography-based panels demonstrated substantial variation in the relationship. Urbanization caused economic growth in high income countries, but non-causality could not be rejected for both middle-income and Latin American countries. A bi-directional, balancing feedback (i.e., equilibrium) relationship was uncovered for low-income, predominately African countries where economic growth had a positive, causal effect on urbanization, but urbanization, in turn, had a negative, causal effect on economic growth.

Despite that today’s developing countries have policies explicitly attempting to control urbanization (Henderson 2010), it is not clear how our results might inform policy. That urbanization causes economic growth in high income countries would seem to have minimal relevance for today’s developing countries since nearly all of those high income countries were already rich and fully urbanized at the onset of our study coverage; furthermore, urbanization occurred at a slow pace that played out over 100-150 years (Henderson 2010). Also, non-causality in either direction could not be rejected for middle income or Latin American countries, and the bi-directional relationship for low-income, African countries was determined to be of equilibrium character. Hence, perhaps the policy message could be summarized as: urbanization policies should be motivated by factors other than achieving/encouraging economic growth (i.e., such policies should be concerned with issues like equality and improved health and educational access), and policies to facilitate economic growth should not focus on urbanization.

The paperやtitle asks a question: which comes firstみurbanization or economic growth? As for answering that question, it would appear that urbanization and economic growth either co-evolve, as they do for low income/African countries and perhaps/probably for high income countries (since those countries were already high income and either highly or fully urbanized when our data began), or else the two processes are somewhat decoupled, as they are for middle income and Latin American countries, despite their high degree of correlation.

References

Apergis, N. and Tang, C. 2013. Is the energy-led growth hypothesis valid? New evidence from a sample of 85 countries. Energy Economcis 38, 24-31.

Bai, J. and Carrion-i-Silvestre, J. (2009) Structural changes, common stochastic trends, and unit roots in panel data. Review of Economic Studies, 76, pp. 471-501.

Banerjee, A. and Carrion-i-Silvestre, J. 2006. Cointegration in Panel Data with Breaks and Cross-Section Dependence. European Central Bank, working paper 591, Frankfurt am Main, Germany.

Bairoch, P. (1988). *Cities and Economic Development: From the Dawn of History to the Present.* Chicago: University of Chicago Press.

Beall, J. and Fox, S. 2009. Cities and Development. Routledge, Hoboken.

Bloom, D., Canning, D., and Fink, G. 2008. Urbanization and the wealth of nations. Science, 319, 772-775.

Di Iorio, F. and Fachin, S. (2012) Savings and Investments in the OECD - A panel cointegration study with a new bootstrap test. DSS Empirical Economics and Econometrics, Sapienza Universita di Roma, working paper 2012/2.

Dumitrescu, E. and Hurlin, C. (2012) Testing for Granger non-causality in heterogeneous panels. Economic Modelling, 29, 1450-1460.

Fay, M. and Opal, C. 2000. Urbanization without growth. A not-so-uncommon phenomenon. World Bank Policy Research Working Paper, WPS 2412.

Gibbs, D. 2000. Ecological modernization, regional economic development and regional development agencies. Geoforum, 31, 9-19.

Halicioglu, F. 2007. Residential electricity demand dynamics in Turkey. Energy Economics 29, 199-210.

Henderson, V. 2010. Cities and development. Journal of Regional Science, 50(1), 515-540.

Henderson, V. (2003). The urbanization process and economic growth: The so-what question. Journal of Economic Growth 8: 47-71.

Heston, A., Summers, R., and Bettina A. (2012) Penn World Table Version 7.1, Center for International Comparisons of Production, Income, and Prices, University of Pennsylvania.

Hossain, S. 2011. Panel estimation for CO_2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. Energy Policy 39, 6991-6999.

Liddle, B. 2013a. Urban density and climate change: A STIRPAT analysis using city-level data. Journal of Transport Geography 28, 22-29.

Liddle, B. 2013b. The energy, economic growth, urbanization nexus across development: Evidence from heterogeneous panel estimates robust to cross-sectional dependence. The Energy Journal 34, 223-224.

Liddle, B. and Lung, S. 2014. Might electricity consumption cause urbanization instead? Evidence from heterogeneous panel long-run causality tests. Global Environmental Change 24, 42-51.

McCoskey S. and Kao, C. (1999). Testing the stability of a production function with urbanization as a shift factor. Oxford Bulletin of Economics and Statistics, 671-690.

Michieka, N. And Fletcher, J. 2012. An investigation of the role of Chinaやs urban population on coal consumption. Energy Policy 48, 668-376.

Mishra, V., Smyth, R., and Sharma, S. (2009). The energy-GDP nexus: Evidence from a panel of Pacific Island countries. Resource and Energy Economics.

Pesaran, M. and Smith, R. 1995. Estimating long-run relationships from dynamic heterogeneous panel. Journal of Econometrics, 68, 79-113.

Pesaran, M. (2004). General Diagnostic Tests for Cross Section Dependence in Panels. IZA Discussion Papers 1240, Institute for the Study of Labor (IZA).

Shahbaz, M. and Lean, H.H. 2012. Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia. Energy Policy 40, 473-479.

Todaro, M. 1995. むA model of rural-urban migration,めin Meir, G. (ed.) Leading Issues in Economic Development, Oxford University Press, Oxford, 140-145.

Wheaton, W. and Shishido, H. 1981. Urban concentration, agglomeration economies and the level of economic development. Economic Development and Cultural Change, 30, 17-30.

Windmeijer, F., 2005. A finite sample correction for the variance of linear efficient two-step GMM estimators. Journal of Econometrics 126 (1), 25ま51.

Table 1. Cross-sectional dependence: Absolute value mean correlation coefficients and Pesaran (2004) CD test.

Panels	**GDP**	**Δ GDP**	**Urban**	**Δ Urban**
High-income (25 countries)	0.96	0.37	0.91	0.54
	(0.00)	(0.00)	(0.00)	(0.00)
Middle-income (37)	0.70	0.16	0.88	0.45
	(0.00)	(0.00)	(0.00)	(0.62)
Low-income (38)	0.45	0.12	0.88	0.44
	(0.00)	(0.00)	(0.00)	(0.44)

Notes: Absolute value mean correlation coefficient shown. P-value for the CD-test statistic is in parentheses. Null hypothesis is cross-sectional independence. ふ=first difference.

Table 2. Bai and Carrion-i-Silvestre (2009) panel unit root test with endogenous, heterogeneous breaks (in level and trend) and cross-sectional dependence.

	Variables in levels			**Variables in first differences**		
Test	High Income	Middle Income	Low Income	High Income	Middle Income	Low Income
			Urbanization			
Z*	49.8	37.7	52.1	-3.4**	-2.0*	-1.0
P*	4.2	12.6	5.6	96.3**	79.3	110.1**
			GDP per capita			
Z*	1.8	20.7	0.4	-3.6**	-4.8**	-5.0**
P*	32.4	33.6	74.0	245.6**	518.6**	581.1**

Notes: The z statistic follows the standard normal distribution; whereas, the P statistic follows the Chi-square distribution. The null hypothesis of a unit root is rejected at 5% and 1% significance level, denoted by * and **, respectively.

Table 3. Panel cointegration tests robust to structural breaks and cross-sectional dependence.

	Banerjee and Carrion-i-Silvestre (2006)		**Di Iorio & Fachin (2012)**	
	Dependent variable			
Panels	Urbanization	GDP	Urbanization	GDP
High-income	1.51	3.18	-2.22	-2.41
Middle-income	2.90	2.31	-2.35	-2.08
Low-income	3.46	1.18	-2.20	-2.33

Notes: The Banerjee and Carrion-i-Silvestre test is the normalized, Z_p, test statistic with level and cointegrating vector shift, and the Di Iorio and Fachin test is the mean ADF with a time trend. Statistical significance for the Di Iorio and Fachin test is determined by bootstrapping. None of the test statistics are statistically significant at even the 10% level. (Indeed, the highest/most significant p-value was 0.16.)

Table 4. Dumitrescu and Hurlin (2012) heterogeneous panel Granger-causality test results.

	GDP ⇒ Urban		**Urban ⇒ GDP**	
Panels	**Panel P-values**			
	Lags: 1	Lags: 2	Lags: 1	Lags: 2
All countries (100)	0.000	0.000	0.000	0.000
High-income (25)	0.179	0.310	0.001	0.004
Middle-income (37)	0.822	0.660	0.980	0.841
Low-income (38)	0.000	0.000	0.029	0.004
Africa (36)	0.000	0.000	0.012	0.020
Latin America (38)	0.415	0.254	0.998	0.633
	Number of countries with p-value < 0.10			
	Lags: 1	Lags: 2	Lags: 1	Lags: 2
All countries (100)	18*	19*	26*	18*
High-income (25)	6	4	9*	7*
Middle-income (37)	4	6	7	2
Low-income (38)	8	9*	10*	9*
Africa (36)	9*	9*	10*	7
Latin America (38)	1	2	5	2

Notes: Both variables in first differences. ⇒=does cause. Top panel: P-values associated with the [illegible] statistic shown. Null hypothesis is no causality. Bottom panel: The *share* of countries rejecting the null hypothesis at the 10% significance level has expected value of 10 and a normal standard error of 30[illegible]/[illegible]. Statistical significance indicated by * < 0.01.

Table 5. System GMM regressions to determine the sign of GDP to Urbanization causality. Urbanization is the dependent variable.

Panel	**Low-income**	**Africa**
Constant	0.01	0.01
Δ Urban (-1)	0.94**	0.95**
Δ GDP (-1)	0.51**	0.46*
AR(2)	0.87	0.83
Sargan test	233.5*	322.6*
Hansen test	0.00	0.00
Instruments	128	128
Time effects	Yes	Yes
Observations	1,824	1,728

Notes: Using four maximum lags in bivariate time-series regressions by individual countries, both BIC and AIC information criteria indicate that the optimal lag length was 1. The 5% and 1% significance levels are denoted by * and **, respectively.

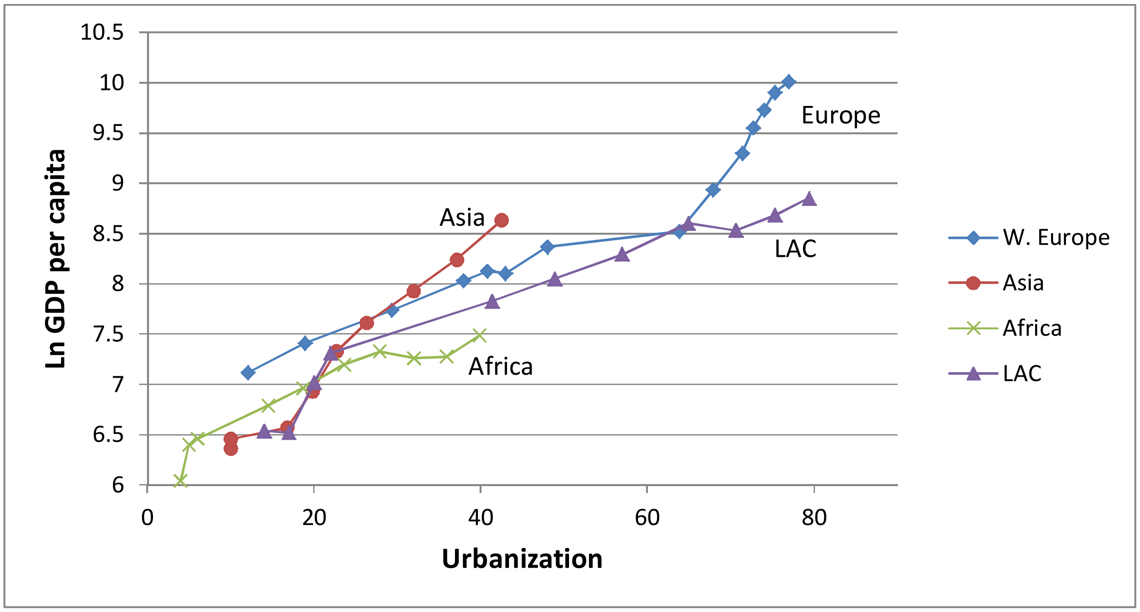

Figure 1. Urbanization-development paths. The level of urbanization is plotted against natural log of GDP per capita for four regions. The paths begin in 1800/1820 (urbanization/GDP per capita data) and continue to present (2008/2010, GDP per capita/urbanization data). Because of data availability, there is some variation in the timing of the intermittent points; however, each region has regular decade-wise observations from 1950 onward. The GDP per capita data is from Angus Maddison (http://www.ggdc.net/) and is in 1990 international Geary-Khamis dollars. Urbanization data beginning in 1950 is from the UN World Urbanization Prospects (http://esa.un.org/unup/); whereas, the earlier urbanization data is from Bairoch (1988).

Appendix

Table A-1. Countries included in the high-income, middle-income, and low-income panels.

High Income	Middle Income	Low Income
Australia	Algeria	Bangladesh
Austria	Argentina	Benin
Belgium	Barbados	Burkina Faso
Canada	Bolivia	Burundi
Cyprus	Botswana	Cameroon
Denmark	Brazil	Central African Republic
Finland	Chile	Congo, Dem. Rep.
France	China	Congo, Rep.
Greece	Colombia	Cote d'Ivoire
Iceland	Costa Rica	Egypt, Arab Rep.
Ireland	Dominican Republic	Ethiopia
Israel	Ecuador	Gambia, The
Italy	El Salvador	Ghana
Japan	Fiji	Guinea
Korea, Rep.	Gabon	Haiti
Luxembourg	Guatemala	India
Netherlands	Honduras	Kenya
New Zealand	Indonesia	Lesotho
Norway	Iran, Islamic Rep.	Madagascar
Portugal	Jamaica	Malawi
Spain	Jordan	Mali
Sweden	Malaysia	Mauritania
Switzerland	Mauritius	Mozambique
United Kingdom	Mexico	Nepal
United States	Morocco	Nicaragua
	Namibia	Niger
	Panama	Nigeria
	Paraguay	Pakistan
	Peru	Papua New Guinea
	Romania	Philippines
	South Africa	Rwanda
	Syrian Arab Republic	Senegal
	Thailand	Sri Lanka
	Trinidad and Tobago	Tanzania
	Turkey	Togo
	Uruguay	Uganda
	Venezuela, RB	Zambia
		Zimbabwe