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How Much Does Technology Affect the Management of Cities in Latin American and the Caribbean?[1]

Morgane de Halleux,[2] Antonio Estache,[3] and Tomas Serebrisky[4]

Abstract

The paper reports a new performance ranking of 27 cities in Latin American and the Caribbean based on a composite indicator of six broad policy dimensions typically used to assess the quality of city management. All cities show management gaps on at least some dimensions. Porto Alegre, Brazil is the top performer overall. A correlation of the results with the information and communications technology (ICT) characterization of each city suggests that ICT interacts with only a few dimensions. The result may mean that ICT is not efficient enough to affect the quality of city management or that city management is not ready to make the most of the possibilities offered by ICT.

[1] This document is a product of the research program developed for the preparation of the Inter-American Development Bank 2020 flagship report: *Infrastructure Services in Latin America*. To know all the documents from the research program, see: www.iadb.org/infrastructureservices

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1. Introduction

The population of Latin America and the Caribbean (LAC) is 81 percent urban, and the rate of urbanization is projected to reach 90 percent by 2050 (UN DESA), increasing the growing economic, environmental, financial, social, and political urban challenges. These challenges increase the importance of monitoring the effectiveness with which cities manage the urban growth process.

The literature on city rankings has grown in recent years. Most of them cover Europe; only a few even partially cover Latin America. IESE's City in Motion incudes 79 indicators across 10 dimensions of urban life: the economy, technology, human capital, social cohesion, international outreach, the environment, mobility and transportation, urban planning, public administration and governance. It covers only 14 Latin American cities, however.

Some of the more commercially oriented rankings produced by consulting firms cover some Latin American cities. Most focus on subjective measures, although they cover many of the dimensions covered by academic papers. They are usually less policy oriented and have somewhat narrower focuses. For instance, Mercer assesses the quality of life in in 231 cities (including 26 in LAC) for firms with internationally mobile staff.[5] AT Kearney—which focuses on the scope for cities to foster growth, create jobs, and provide a good quality of life—covers 15 Latin American cities.[6] *The Economist* ranks 140 cities based on 30 quantitative and qualitative factors (many subjective qualitative assessments), including stability, infrastructure, education, health, and the environment.[7] It covers a range of Latin American cities but does not make the details publicly available for free.

One of the recurring themes across these rankings is the effort to account for the role of information and communications technology (ICT) as a driver of city management performance. Most assessments highlight the potential impact based on anecdotal evidence rather than by linking performance to progress in terms of ICT achievements. This focus largely reflects the desire to emphasize technology as a way of making city management smarter. It ignores the fact that many dimensions of city management are unlikely to be influenced by technology for a while given the current state of technology.

The main purpose of this paper is to add to the literature on this issue on LAC. The paper makes two main contributions. First, it produces a performance ranking of 27 large cities in the region, anchored in detailed data on multiple dimensions characterizing city management. Second, it assesses the extent to which their ICT characterization affects the ranking, allowing an unbundling of the management dimensions that are likely to be influenced by ICT from the others.

The paper examines six dimensions of city life: economic strength, environmental quality, governance, human capital, infrastructure, and living standards. The idea is to identify the scope for improvement globally but also in specific policies. The dimensions

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[5] Mercer. 2018. *Quality of Living Ranking*. https://mobilityexchange.mercer.com/Insights/quality-of-living-rankings.

[6] AT Kearney. 2017. *Global Cities 2017: Leaders in a World of Disruptive Innovation*. https://www.atkearney.com/documents/10192/12610750/Global+Cities+2017+-+Leaders+in+a+World+of+Disruptive+Innovation.pdf/c00b71dd-18ab-4d6b-8ae6-526e380d6cc4.

[7] Economist Intelligence Unit. 2017. *The Global Liveability Report 2017*. http://pages.eiu.com/rs/753-RIQ-438/images/Liveability_Free_Summary_2017.pdf.

identified are the most common ones examined in the recent literature on "city smartness." Once each city has been characterized in terms of these dimensions, the paper uses Pearson and Spearman correlations to assess the strength of the linear association between a specific management performance dimension and an aggregated ICT performance measure.

For the cities covered, the analysis provides many new details while producing a big picture consistent with earlier, less encompassing diagnostics. The main global dimension and country-specific issue diagnostics can be used to identify and rank a wide range of requirements for policy interventions.

The fact that Porto Alegre, Brazil; San Jose, Costa Rica; and Montevideo, Uruguay are the top three cities in the ranking is not surprising. Nor is the fact that Port-au-Prince, Haiti; Guatemala City, Guatemala; and Santo Domingo, Dominican Republican have the largest margins for improvement. It is not surprising that Buenos Aires is the top-ranked city in terms of human capital and living standards achievements or that Monterrey, Mexico has the best economic performance; Montevideo the best governance performance; or Quito, Peru the best environmental performance.

As for the role of ICT, the analysis shows the need to avoid being cornered into the smartness of management based on the extent to which technology is making a difference. Correlations are high but could be improved, notably for the management of the economy, education, and human capital. Making cities smarter is clearly important, but some dimensions require better management independently of how smart the technology adopted is.

The paper suffers from a few limitations, most of them driven by data gaps, as global monitoring agencies still largely ignore detailed city-based data, despite the growing relevance of cities in the economic, social, political, and environmental performance of many countries. To minimize data gaps, we sometimes had to rely on country rather than city indicators on some dimensions (see appendix A). That option seemed better than simply ignoring some characteristics because of lack of city-specific data.

The paper is organized as follows. The next section summarizes the literature, in order to identify the main dimensions that need to be quantified, based on a review of recent work on the assessment of city performance. The third section describes the methodology used to quantify performance on each of the six dimensions covered and to produce a single composite indicator that aggregates all of the information. The fourth section describes the data (appendix A provides more details). The fifth section discusses the results. The last section summarizes the paper's main conclusions.

2. Insights from the Academic Literature

The literature on comparative assessments of the quality of city management has largely converged toward a recognition that any policy-relevant ranking has to be multidimensional. There also seems to be some convergence on the key dimensions likely to define the efficient city of the future. Caragliu, del Bo, and Nijkamp (2011) identify six dimensions that characterize the smartness and effectiveness of a city: management of the economic prospects of the city, environmental quality, governance quality, living standards, mobility of people and goods, and people skills.

To turn this synthesis into a policy tool, it is necessary is to come up with specific quantifiable indicators for each of them. Building on this suggestion and refining it to better account from some of the recurring insights from the more recent literature, we

stick to six dimensions but broaden the scope of some of them. We argue that the performance of a city can be assessed based on the effectiveness with which it handles its economy, environment, governance, human capital, infrastructure, and living standards. We broaden mobility to include the management of other infrastructure dimensions and focus on human capital.

The literature identifies specific indicators for each dimension. Economic performance is usually characterized by a city's degree of competitiveness (which is related to its industrial structure, productivity, or geography); its capacity to innovate; or the importance of its informal economy. The environmental dimension tends to focus on pollution, congestion, water, and waste management. Governance is usually measured in terms of corruption and, when possible, political (in)stability and citizen participation. Infrastructure can be approximated by access rates, affordability measures, mobility speed, and ICT coverage and quality. The degree of smartness of a city's human capital is linked to the education levels and standards of its population; the degree of digitalization of education; and the accessibility of education, illustrated by, for instance, the share of the poor with access to higher education. The most common indicators of living standards are a city's attractiveness in terms of quality, safety, housing, health standards, job opportunities, poverty management, and cultural or tourist attractions. These indicators can be measured by very concrete dimensions, such as the share of the population living in slums, the share of the population that is poor, unemployment rates, and crime rates to get an idea of the social exclusion challenge, as well as in terms of numbers of foreign visitors, international events, or museums.

The main drawback of the multiplicity of indicators available is that it ends up leaving too much discretion to the analysts to decide which ones to include and exclude, making comparisons across approaches challenging. Changes in indicators may lead to changes in performance perceptions and hence rankings. (These risks are examined in the discussion of the methodology used to come up with a ranking of cities in terms of their smartness and of its limitations.)

With respect to the role of ICT in the management of cities, the literature has evolved. Initially, the focus was on the concept of the "digital city" (Anthopoulos and Tsoukalas 2006; Albino et al. 2015; Alawadhi et al. 2012; Graham 2002; Graham and Marvin 2001; Komninos 2002). Most practitioners and academics have now moved well beyond this purely technological focus (Attour and Rallet 2014). The latest perspectives emphasize that cities need to adopt and commit to a continuous processes to make the most of the opportunities to rely on ICT to achieve efficiency gains, attractiveness, social inclusion, and environmental goals (Pfaeffli et al. 2016).

The payoffs to ICT flow from its ability to deliver an information and knowledge network that can be used to improve the management of cities and the accountability of managers to the large number of stakeholders they are supposed to cater to. ICT is expected not only to make urban service delivery more cost-efficient and better targeted but also to help improve urban environmental sustainability and social inclusiveness. The ex ante expectation of the correlation analysis conducted in this paper is thus that ICT should be correlated with each of the indicators used to quantify management performance.

3. Methodology

The paper follows the lead of Giffinger et al. (2007) and Giffinger, Haindlmaier, and Kramar (2010), who consider cities' "smartness" in terms of the six characteristics and

the methodological improvements suggested by Lazaroiu and Roscia (2012). Both normalize data on basic indicators reflecting the insights from theory by converting these indicators into standardized values with an average of 0 and a standard deviation of 1. The main difference between the approaches of Giffinger et al. (2007) and Lazaroiu and Roscia (2012) is with respect to the decision to assign a weight to the various indicators. Giffinger et al. aggregate all indicators into a single score by giving equal weighting to the indicators; Lazaroiu and Roscia compute a weighting factor for each indicator based on experts' opinion, which introduces its own biases.

In this paper, we follow the broad approach adopted by these two papers, but we update the dimensions to account for the latest insights in policy and academic discussions of what drives "smartness." We also follow weight the indicators, as ignoring the relevance of weights boils down to ignoring the relevance of a possible correlation across indicators. Our approach to identify weights is somewhat different from the approach adopted by Lazaroiu and Roscia (2012), however.

The analysis was conducted in six steps:

1. We identified specific indicators to measure the six smartness dimensions and the various factors within each dimension, following Giffinger el al. (2007). The selection was based partly on the availability of comparable data.
2. We selected cities based largely on data availability for each indicator of interest and on regional representativeness. All indicators used to jointly describe the factors of a smart city are available through open access on the Internet. We selected 27 indicators, including 13 at the local level and 12 at the national level; 2 are national urban averages. The inclusion of national and urban average data was necessary to broaden the database and to address data quality concerns (more reliable data are available at that level). The most recent data available were used, but sometimes, the dataset was completed with older inputs. The dataset consists of data from 1995 to 2018. Appendix A reports the specific indicators for each factor for each dimension.
3. We normalized the data using the max-min method, in order to eliminate the bias of scale and to report all data in the same direction.
4. We computed the weighting factors for each indicator.
5. We summed the weighted indicators in order to obtain a single score for each dimension.
6. We developed a composite indicator measuring a city's smartness by aggregating the six single scores based on the same method (normalizing, computing weighting factors, and summing). The composite indicator allows us to benchmark the smartness of each city compared with the other cities in this study.

The final score is the aggregation of the partial scores achieved on each dimension. Each individual dimension may actually be the aggregation of various subdimensions. For instance, how smart the city economy is depends how smart it is in terms of innovation and productivity. Each dimension or subdimension is itself a composite indicator obtained from the aggregation of the individual indicators available to characterize the various components. For instance, mobility smartness is approximated by both the road traffic death rate per 100,000 inhabitants and the stock of cars and motorcycles per person. Formally, the composite indicator is expressed as

$$I = \sum_{i=1}^{n} w_i x_i, \qquad (1)$$

where I is the composite indicator, x_i is the normalized variable; w_i is the weight of the x_i; $\sum_{i=1}^{n} w_i = 1$; $0 \leq w_i \leq 1$; and $i = 1, \ldots, n$.

The most challenging part is to come up with the partial composite indicator at a given dimension or subdimension level. It requires the following:

- multivariate analysis to check correlations between indicators (and thus redundancy)
- normalization of the indicators to provide comparable data
- principal component analysis followed by factor analysis to compute the weighting factor for each indicator, in order to take into account its redundancy (for details, see Freudenberg 2003).

Once normalized and weighted, the indicators can be aggregated. The final single score for city smartness replicates the approach from the partial composite indicators computed for each dimension. The composite indicators for each dimension are weighted (multivariate analysis followed by principal component analysis/factor analysis) and summed to develop the final single score.

Table 1 displays the data on individual basic indicators for living smartness of 27 cities. It reports seven basic indicators, one on cultural smartness, two on health smartness, one on safety smartness, two on equality smartness, and one on domestic purchasing power. The data reported are raw; the variables have different measurement units and therefore cannot be aggregated. They need to be standardized to eliminate the bias of scale in the calculation of the composite indicator.

Table 1. Raw values of Smart Living indicators in 27 cities in Latin America and the Caribbean

		Smart Culture	*Smart Health*		*Smart Safety*	*Smart Equality*		*Smart Domestic Purchasing Power*
Country	*City*	*Number of museums*	*Infant mortality (deaths of children under 1 or 5 year of age per 1,000 live births)* [a]	*Government expenditures on health (percent of GDP)*	*Crime index* [b]	*Poverty ratio (percent)* [c]	*Gini coefficient*	*Monthly rent for apartment in city center (U.S. dollars)*
Argentina	Buenos Aires	162	10.5	8.1	62.4	18.9	0.5	402.3
Bolivia	La Paz	28	38.1	5.2	54.1	46.3	0.6	342.0
Brazil	Brasilia	60	11.4	8.9	64.4	37.7	0.7	378.1
	Rio de Janeiro	124	11.3	8.9	77.0	23.9	0.6	483.8
	São Paulo	132	11.1	8.9	72.4	28.1	0.6	527.9
	Porto Alegre	63	9.8	8.9	77.3	23.7	0.5	287.5
Chile	Santiago	53	6.7	7.5	49.7	20.1	0.6	486.5
Colombia	Bogota	52	14.3	6.1	61.6	11.6	0.5	386.3
	Medellin	18	9.5	6.1	46.4	14.1	0.5	323.0
Costa Rica	San Jose	16	4.2	10.9	53.1	4.3	0.5	531.2
Dominican Republic	Santo Domingo	8	39.0	5.4	67.2	26.7	0.6	315.3
Ecuador	Quito	23	13.3	7.3	53.5	7.3	0.5	456.3
El Salvador	San Salvador	7	8.0	6.8	73.5	21.9	0.4	422.1
Guatemala	Guatemala City	29	25.4	6.7	59.9	18.6	0.5	456.6
Guyana	Georgetown	8	18.0	5.9	69.5	26.0	0.4	187.9
Haiti	Port au Prince	2	30.0	7.9	72.3	33.8	0.5	1250.0
Honduras	Tegucigalpa	10	23.0	8.6	72.6	47.7	0.5	292.4

Jamaica	Kingston	8	23.8	4.9	70.3	14.4	0.4	468.6
Mexico	Guadalajara	18	7.0	6.2	55.1	22.5	0.4	264.2
	Mexico City	152	10.5	6.2	66.6	27.6	0.5	770.0
	Monterrey	20	12.8	6.2	50.6	16.7	0.4	285.6
Nicaragua	Managua	14	18.5	10.1	41.3	19.5	0.5	302.4
Panama	Panama City	7	11.6	8.2	48.4	13.0	0.5	950.0
Paraguay	Asuncion	17	16.0	9.7	46.7	13.4	0.5	262.2
Peru	Lima	70	12.0	4.8	68.4	11.0	0.4	497.3
Uruguay	Montevideo	73	7.3	8.0	55.9	26.5	0.4	539.4
Venezuela	Caracas	23	9.2	5.2	82.6	10.1	0.4	251.9

Note:

a. Depending on city data availability.
b. Overall level of crime (the higher the index, the higher the level of crime).
c. Percentage of population whose income falls below the poverty line.

We normalize the data using the min-max method, transforming each indicator q for a city c as follows:

$$I_{qc} = \frac{x_{qc} - \min(x_q)}{\max(x_q) - \min(x_q)}, \quad (2)$$

where $\min(x_q)$ and $\max(x_q)$ are the minimum and maximum values, respectively, of x_q across all cities. The normalized indicator I_{qc} has values between 0 and 1.

For indicators that are inversely proportional to city smartness, we adapt the min-max procedure in order to link positively the indicator value with city smartness (an increase in the value will increase smart city character). For instance, in the Smart Economy dimension, a high score on patent applications will increase the "smartness score," whereas the unemployment rate reduces it. Indicators inversely proportional to city smartness are adapted with the following equation:

$$I'_{qc} = 100\ percent - \frac{x_{qc} - \min(x_q)}{\max(x_q) - \min(x_q)}, \quad (3)$$

where I'_{qc} is the normalized indicator q of type "less is better." Table 3 reports the results of the normalization process.

This approach is simple, but it has limitations. For instance, the range is sensitive to the choice of cities. If any of the cities is performing poorly on an indicator and/or another city performs very well, the values produced by the approach will be affected.

Table 2. Normalized values of Smart Living indicators in 27 cities in Latin America and the Caribbean (percent)								
		Smart Culture	*Smart Health*		*Smart Safety*	*Smart Equality*		*Smart Domestic Purchasing Power*
Country	*City*	*Number of museums*	*Infant mortality*	*Government expenditures on health*	*Crime index*	*Poverty ratio*	*Gini*	*Rent per month for Apartment in City Centre*
Argentina	Buenos Aires	100.0	81.8	54.1	48.8	66.4	54.2	79.8
Bolivia	La Paz	16.3	2.6	6.6	68.9	3.2	33.9	85.5
Brazil	Brasilia	36.3	79.1	67.2	43.9	23.0	0.0	82.1
	Rio de Janeiro	76.3	79.4	67.2	13.5	55.0	30.5	72.1
	São Paulo	81.3	80.0	67.2	24.6	45.2	40.7	68.0
	Porto Alegre	38.1	83.9	67.2	12.8	55.3	74.6	90.6
Chile	Santiago	31.9	92.7	44.3	79.8	63.7	37.3	71.9
Colombia	Bogota	31.3	70.9	21.3	50.8	83.3	44.1	81.3
	Medellin	10.0	84.6	21.3	87.7	77.5	69.8	87.3
Costa Rica	San Jose	8.8	100.0	100.0	71.3	100.0	67.8	67.7
Dominican Republic	Santo Domingo	3.8	0.0	9.8	37.3	48.5	30.5	88.0
Ecuador	Quito	13.1	73.9	41.0	70.3	93.2	54.2	74.7
El Salvador	San Salvador	3.1	89.0	32.8	21.9	59.4	88.1	78.0
Guatemala	Guatemala City	16.9	39.0	31.148	55.0	67.1	54.2	74.7
Guyana	Georgetown	3.8	60.3	18.0	31.6	50.0	77.6	100.0
Haiti	Port au Prince	0.0	25.8	50.8	25.0	32.1	50.8	0.0
Honduras	Tegucigalpa	5.0	45.9	62.3	24.1	0.0	54.2	90.2
Jamaica	Kingston	3.8	43.6	1.6	29.7	76.8	100.0	73.6
Mexico	Guadalajara	10.0	91.9	23.0	66.5	58.1	80.3	92.8
	Mexico City	93.8	81.8	23.0	38.7	46.4	61.0	45.2
	Monterrey	11.3	75.2	23.0	77.6	71.5	78.0	90.8
Nicaragua	Managua	7.5	58.8	86.9	100.0	65.0	54.2	89.2
Panama	Panama City	3.1	78.6	55.7	82.9	80.0	67.8	28.2
Paraguay	Asuncion	9.4	66.0	80.3	87.0	79.2	57.6	93.0
Peru	Lima	42.5	77.5	0.0	34.2	84.6	91.5	70.9
Uruguay	Montevideo	44.4	91.0	52.5	64.6	48.9	81.4	66.9
Venezuela	Caracas	13.1	85.6	6.6	0.0	86.7	98.3	94.0

Note: A score of 100 percent indicates that a city is the best performer.

The next step is to compute the correlations between the basic indicators. Table 3 does so for each dimension computed in the first step. If the correlation is low, it is unlikely that the indicators share common determining factors. Values marked with * are significant at the 5 percent level; values marked with ** are significant at the 2 percent level (Pearson correlation test). These levels of significance indicate that a large number of common parameters influence their values.

Principal component analysis/factor analysis helps reduce redundancy. For instance, the Gini coefficient and the poverty ratio are significantly correlated, which means that a city with a high level of income inequality will generally have a higher poverty ratio. Several economic studies highlight the relationship between economic inequality and poverty (Karagiannaki et al. 2017; Lynch, Baker, and Cantillon 2000).

Table 3. Correlation matrix of Smart Living indicators							
	Indicator						
Indicator	*Number of museums*	*Infant mortality*	*Government expenditures on health*	*Crime index*	*Poverty ratio*	*Gini coefficient*	*Rent per month*
Number of museums	1.0						
Infant mortality	0.3*	1.0					
Government expenditures on health	0.1	0.3	1.0				
Crime index	−0.3	0.1	0.2	1.0			
Poverty ratio	−0.1	0.5**	0	0.3	1.0		
Gini	−0.3	0.3	−0.4*	−0.1	0.5**	1.0	
Rent per month	−0.1	0.1	−0.1	0.1	0	0.1	1.0

Note: Pearson correlation matrix. Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent.

The weights significantly affect the composite indicator value and hence the city rankings. The easiest option is equal weighting method (computing the mean of all indicators). However, giving all indicators equal weighting implies that there is no redundancy. It may be that certain performance features will be overestimated while gathering variables with a high degree of correlation. To tackle this issue, we tested indicators for statistical correlations and balanced their weights based on those correlations. We computed the weighs using principal component analysis in order to reduce redundancy in the calculation of the composite indicator in each dimension.

Principal component analysis transforms correlated indicators into a set of independent factors (principal components) while preserving the maximum proportion of the total variation in the dataset (Nardo et al. 2005). It reduces the overlapping information between two or more variables. Formally, the analysis takes Q variables $x_1, x_2, \dots x_q$ and finds linear combination of them to produce components $Z_1, Z_2, \dots Z_Q$ that are uncorrelated:

$$
\begin{aligned}
Z_1 &= a_{11}x_1 + a_{12}x_2 + \dots + a_{1Q}x_Q \\
Z_2 &= a_{21}x_1 + a_{22}x_2 + \dots + a_{2Q}x_Q \\
&\dots \\
Z_Q &= a_{Q1}x_1 + a_{Q2}x_2 + \dots + a_{QQ}x_Q \qquad (4)
\end{aligned}
$$

At this point, there are still Q principal components (that is, as many components as there are variables). The weights a_{ij} (also called *factor loadings*) of the principal components applied to the variables x_j are chosen so that the principal components Z_i satisfy three conditions:

1. They are uncorrelated/orthogonal.
2. The first principal component supports the maximum proportion of the variance, the second supports the maximum of the remaining variance, and so on, until the last principal component absorbs all the remaining variance not accounted for by the preceding components,

3. $a_{i1}^2 + a_{i2}^2 + \cdots + a_{iQ}^2 = 1, i = 1,2, \ldots Q$ (Nardo et al. 2005). The eigenvalues of the indicators' correlation matrix are the variances of the principal component and provide information on the variability in the data.

The decision on how many principal components should be retained without losing too much information depends on the criteria (stopping rules) selected. A criteria usually used to select and determine the number of components consists of (a) having associated eigenvalues larger than 1, (b) individually contributing more than 10 percent to the explanation of overall variance, and (c) cumulatively contributing more than 80 percent to the explanation of the overall variance (Nardo et al. 2005).

A principal component analysis of Smart Living (conducted with the software package FactoMineR) illustrates this process (table 4). It retains the four first factors.

Table 4. Principal component analysis of Smart Living dimension

	Principal component						
Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Variance	1.9	1.6	1.3	1.0	0.6	0.4	0.2
Percent of variance explained	27.0	23.3	18.8	13.9	8.8	5.2	3.1
Cumulative percent of variance explained	27.0	50.2	69.1	83.0	91.7	96.9	100.0

After the extraction of the four first principal components representing the data, we consider them as factors for the factor analysis. The next step consists of rotating the factor loadings, in order to minimize the number of individual indicators that have a high loading on the same factor (Nardo et al. 2005). It simplifies the structure of the factors and enhances the interpretability of the factors.

Different rotational methods have been proposed. Each implies different meanings of the principal components. The most commonly used is the Varimax rotation, which is used here (table 5). The Varimax method is an orthogonal rotation minimizing the number of variables with high loadings on each factor.

Table 5. Factor loadings of Smart Living indicators

	Factor			
Indicator	*1*	*2*	*3*	*4*
Number of museums	0	0.1	0.9	0
Infant mortality	0.7	0.3	0.4	0.1
General government expenditures on health	0	0.8	0.2	–0.1
Crime index	0.2	0.6	–0.6	0.1
Poverty ratio	0.9	0.1	–0.2	0
Gini coefficient	0.7	–0.5	–0.2	0
Rent per month	0	–0.1	0	1.0

Note: Extraction method: principal components, Varimax rotation.

The last step involves setting the weighting coefficients for the factor loadings matrix after Varimax rotation, given that the square of the factors depicts the proportion of the

total unit variance of the indicator that is explained by the factor (Nardo et al. (2005). We use the method proposed by Nicoletti, Scarpetta, and Boyland (2000), in which each factor loading is first squared, the factors with the highest value are then selected, and the values are divided by the sum of the largest factor loadings. The weighting coefficients for each indicator reported in table 6 are the outcome of this procedure.

Table 6. Weights of Smart Living indicators	
Indicator	*Weight*
Number of museums (NM)	0.2
Infant mortality (IM)	0.1
General government expenditures on health (GGEH)	0.1
Crime index (CI)	0.1
Poverty ratio (PR)	0.2
Gini coefficient (GC)	0.1
Rent per month (RPM)	0.2

Note: Extraction method: principal components, Varimax rotation.

Based on the results reported in table 6, the composite indicator of Smart Living can be reduced as follows:

$$Smart\ Living\ index = 0.2\ NM + 0.1\ IM + 0.1\ GGEH + 0.1\ CI + 0.2\ PR + 0.1\ GC + 0.2\ RPM \quad (5)$$

Based on the value observed for each indicator for each city, we can compute the degree of Smart Living for each city. The same procedure needs to be repeated for each of the other five smartness dimensions (Smart Governance, Smart Economy, Smart Education, Smart Environment, and Smart Infrastructure). The appendixes present the detailed partial results for each dimension.

In the last step, we use the same methodology to produce a single indicator for each city from these six indicators. We use that indicator to rank cities on their overall commitment to smartness.

4. Description of the Data

We used two criteria to select the cities. First, we selected capitals of all countries in LAC (we excluded the capitals of Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Saint Kitts, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago because of lack of information). Second, we selected cities in which smart initiatives are in effect. Examples include the following:

- Buenos Aires is supporting environmental sustainability by considering energy efficiency. It created the lighting management system CityTouch[8] and the data platform SAP HANA.[9]

[8] CityTouch is a management system that allows operators to monitor and manage public outdoor lighting infrastructure and store, visualize, and analyze historical information about performance. (See "Buenos

- Mexico City installed surveillance cameras and created an open data portal that provides more than 1,000 datasets. It engages citizens in the development of the knowledge society and the management of public affairs. It uses technology innovation to improve traffic flow and reduce pollution.
- Rio de Janeiro received the national title of smartest and most connected city of Brazil (Schreiner 2016). It is trying to reinvent itself by exploiting new technologies for urban planning and bringing the government closer to citizens (Schreiner 2016). The city launched the Rio Operations Centre, to anticipate climatic events and reduce the burdens they impose by alerting citizens. It seeks to preserve its environment, mostly by initiatives in transportation and the management of public spaces.
- Santiago, Chile created SmartCity Santiago, a high-tech integrated smart city pilot project designed to increase life quality by coordinating technologies in an integrated, functional, and safe way.

The choice of indicators was based on two criteria. The first was to try to rely as much as possible on the indicators used in previous studies. We added various indicators when proxy choices were incomplete.

The second criterion was the availability of data. The choice of indicators was determined by the number of cities covered. In some cases, we were forced to adjust the choice of specific indicators. It was not always possible to include the same indicators used in studies of Europe, because less information is available for developing and emerging economies on key indicators.

For some indicators, data were not available for all cities the same year. The year of the data on the poverty ratio, for instance, ranges from 2006 (for Montevideo) to 2018 (for Guadalajara).

Many indicators are available only at the country level or for all urban populations. For example, no information on the percentage of the population owning a mobile phone in Caracas was available. We therefore had to use national data.

Data gaps are significant in LAC. A considerable amount of available information on some cities was lost because of the removal of indicators with missing values on other cities. Some dimensions are much better documented than others. For instance, data on only two indicators were collected to measure Smart Governance; the indicator is therefore not reliable.

These limitations imply that the ranking produced should be viewed only as a first-order approximation, which will have to be improved upon once better data become available.

The rest of this section describes the indicators to measure each dimension. Appendix A describes the dimensions, subdimensions, and indicators used and the level of data collected. Appendix B provides the values for each indicator.

Aires: Pioneering Future-Proof Connected Lighting," http://www.lighting.philips.com/main/cases/cases/road-and-street/citytouch-buenos-aires.)

[9] SAP HANA is a platform that collects data from various city departments, such as street lighting, waste management, and traffic lights, and shares it through a single city dashboard. It provides a city with real-time insight into power outages, broken lights, and vandalism. (See "Pioneering Scalable Connected Lighting," http://images.philips.com/is/content/PhilipsConsumer/PDFDownloads/Global/smart-cities/SmartCityInitiatives_Buenos_Aires_leaflet.pdf.)

4.1 Smart Governance

Smart Governance is approximated by two indicators, the corruption perception index and election turnout (parliamentary), which is measured only at the national level. These indicators provide only a weak approximation of governance. They were used because no city-specific measure allows comparable comparisons across cities in the region.

This measure does not pick up the complexity of the interactions between cities and states/provinces and national authorities in a region in which many mandates are shared by various levels of government. There is evidence, for instance, that the lack of political alignment across government levels on shared mandates can drive local ineffectiveness (Estache, Garsous, and da Motta 2016).

4.2 Smart Economy

Smart Economy includes three subdimensions:

- innovation, approximated by the number of patent applications per million inhabitants
- general economy, approximated by the ease of doing business and the volume of foreign direct investment in the country
- labor market performance, approximated by the unemployment rate.

The first two subdimensions are measured at the national level. The last subdimension is available at the city level.

4.3 Smart Education

Smart Education includes three subdimensions:

- educational institutions, approximated by the number of universities in the top 50 in LAC
- human capital, approximated by the adult illiteracy rate
- public expenditure, approximated by total public expenditure on education as a percentage of GDP.

The first two subdimensions are measured at the city level. The last subdimension is measured at the national level.

4.4 Smart Environment

The environmental performance measure includes three subdimensions:

- environmental quality, approximated by the fine particulate matter (PM2.5) concentration
- waste management effectiveness, approximated by a combination of the share of waste collected and adequately disposed and the waste generated per inhabitant
- energy management, approximated by energy consumption per capita.

The first measure is an urban average for the country. The second is measured at the city level. The third is measured at the national level.

4.5 Smart Infrastructure

Infrastructure includes mobility, utilities, and ICT:

- Mobility is measured by road traffic death rate per 100,000 inhabitants and the stock of cars and motorcycles.

- Utilities reflects the share of households without sanitation, the share of households without drinking water, and the share of households without electricity supply service
- ICT is approximated by the number of mobile subscriptions per 100 inhabitants and the share of population owning a mobile phone.

These measures are available only at the national level.

5. Discussion of Results

Table 7 reports the correlation between the various dimensions. Many dimensions (other than Smart Environment) appear to be correlated. Smart Living is significantly correlated with all dimensions except Smart Environment, suggesting that a relatively large number of common parameters influences both values.

Table 7. Correlation matrix of "smartness" dimensions

	Dimension					
Dimension	*Smart Governance*	*Smart Economy*	*Smart Education*	*Smart Living*	*Smart Environment*	*Smart Infrastructure*
Smart Governance	1.0					
Smart Economy	0.2	1.0				
Smart Education	0.4*	0.6***	1.0			
Smart Living	0.4**	0.5***	0.5**	1.0		
Smart Environment	0.3*	0.1	–0.1	0.2	1.0	
Smart Infrastructure	0.5**	0.3	0.2	0.7***	0.3	1.0

Note: Pearson correlation matrix. Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent.

Principal component analysis and factor analysis are used to reduce the risks of redundancies. The principal component analysis identifies six factors for the single score. Only the first three seem to matter, as they jointly explain 80 percent of the cumulative variance (the rule of thumb cut-off). The others are hence ignored in the following steps. Once the factor loadings for each dimension are measured, the weights can be computed. They are reported in table 8, along with the results of the full ranking diagnostic. To make the table easier to read, for each dimension, the best and worst performances are highlighted in dark and light grey, respectively.

To get a full sense of the policy relevance of the results and the usefulness of the approach, the table needs to be read in four ways:

- Focus on the last column, which reports the ranking of cities based on the synthetic composite indicator, accounting for all weighted dimensions jointly.
- Look at the rankings in terms of each dimensions of smartness individually. This approach shows that no city is a top performer on every dimension.
- Look at the relative performance of each dimension.
- Read the table horizontally, in order to identify weak spots. Some cities are best performers on some dimensions and poor performers on others.

Table 8. "Smartness" scores of 27 cities in Latin America and the Caribbean (percent except for ranking)

Country	*City*	*Smart Government (0.116)*	*Smart Economy (0.145)*	*Smart Education (0.201)*	*Smart Living (0.156)*	*Smart Environment (0.180)*	*Smart Infrastructure (0.201)*	*Composite score*	*Ranking*
Argentina	Buenos Aires	61.2	49.3	83.6	72.1	65.6	81.0	82.3	7
Bolivia	La Paz	62.9	33.2	67.1	32.3	71.8	50.9	66.8	20
Brazil	Brasilia	62.0	79.8	65.2	50.2	82.6	65.3	82.6	5
	Rio de Janeiro	62.0	81.3	75.4	60.6	78.9	64.0	84.9	4
	São Paulo	62.0	75.0	80.7	61.1	70.4	66.1	82.5	6
	Porto Alegre	62.0	83.7	71.1	63.4	83.1	66.4	86.8	1
Chile	Santiago	67.1	76.4	81.2	59.4	50.8	82.2	79.3	10
Colombia	Bogota	36.2	52.5	71.2	56.6	87.0	77.4	81.9	8
	Medellin	36.2	51.6	52.9	61.1	86.1	76.8	78.3	11
Costa Rica	San Jose	72.7	61.3	74.3	71.9	76.9	76.2	86.6	3
D. Republic	Santo Domingo	45.4	42.5	23.9	35.0	77.1	56.8	60.9	25
Ecuador	Quito	58.0	43.0	51.4	59.8	90.3	72.1	79.7	9
El Salvador	San Salvador	35.4	44.8	37.7	53.5	64.5	79.5	65.8	21
Guatemala	Guatemala City	46.7	40.7	30.9	49.3	58.9	65.0	59.5	26
Guyana	Georgetown	57.1	35.8	33.1	50.8	79.5	62.9	67.7	19
Haiti	Port au Prince	3.8	4.0	11.6	23.3	56.8	37.0	34.9	27
Honduras	Tegucigalpa	39.6	37.1	55.9	42.5	57.2	64.0	61.4	24
Jamaica	Kingston	45.8	40.4	46.9	47.4	59.1	74.4	64.3	22
Mexico	Guadalajara	31.4	95.6	54.9	59.6	60.9	66.4	73.1	15
	Mexico City	31.4	94.2	77.8	55.8	62.5	66.2	77.5	12
	Monterrey	31.4	95.9	59.0	60.2	64.7	66.0	75.4	14
Nicaragua	Managua	39.5	37.2	40.2	64.9	73.7	69.5	68.7	18
Panama	Panama City	58.2	53.9	39.0	51.5	78.4	85.6	76.0	13
Paraguay	Asuncion	45.7	44.9	22.9	67.4	80.0	79.1	71.7	16
Peru	Lima	62.9	51.3	48.8	57.9	63.4	68.8	70.3	17
Uruguay	Montevideo	100.0	64.2	54.3	62.5	79.8	81.4	86.8	2
Venezuela	Caracas	39.0	36.6	78.1	57.8	47.2	55.4	62.7	23
	Average	50.2	55.8	55.2	55.1	70.6	68.8	72.9	

Note: Figures in parentheses are weights. Best and worst performances are highlighted in dark and light grey, respectively.

The first reading of the table, focusing on the final score, shows that Porto Alegre (Brazil), with an overall score of 86.8, is the leading city in the sample in terms of smartness overall, even though it does not have the highest score in any dimension. It is followed closely by Montevideo, Uruguay (86.8 percent) and San Jose, Costa Rico (86.6 percent). Port-au-Prince, Haiti is the worst performer, at 34.9 percent.

The differences in margins for improvements are large. Port-au-Prince, Santo Domingo, Guatemala City, Tegucigalpa, and Caracas are much farther from the top performer than is Montevideo, for instance. It is also striking to see how much Port-au-Prince is penalized by its poor governance and economy score compared to the average.

The second reading of the table, focusing on performance on individual dimensions, shows that, Buenos Aires performs best on Smart Education and Smart Living. These results are influenced mainly by the adult illiteracy rate and the number of museums, respectively. Montevideo leads on Smarter Governance. Monterrey, Mexico performs best on Smart Economy, leading on three out of the four indicators (ease of doing business, foreign direct investment, and unemployment rate). Quito, Ecuador performs best on Smart Environment. Port-au-Prince has the lowest score on every dimension except Smart Environment, on which it ranks second to last.

The third reading suggests that the main hurdle for the region remains primarily in Smart Governance (except for Montevideo). The average score of 50.2 percent is much lower than the average for Smart Environment (70.6 percent) or Smart Infrastructure (69.0 percent). However, the Smart Governance indicator includes only two indicators, both at the national level. Most countries in LAC are still young democracies facing politically complex contexts. Decentralization has been imperfect, with blurred mandates assigned to cities in most of the dimensions of smartness.

Table 8 allows a rough diagnostic to be made of the main challenges each city faces. Although the results are influenced by the indicators chosen and better data might lead to different conclusions, it allows city managers to see how external observers perceive their performance in terms of smart management.

6. How Technologically Smart Are All Dimensions?

Many observers emphasize the role of ICT in defining overall management quality of cities. It therefore seems useful to try to get a rough sense of the interaction between the technological characterization of cities and the other dimensions used to measure their overall smartness. We did so by computing the correlation between Smart ICT and the other main dimensions. In addition, we unbundled the infrastructure dimension and report the correlation between Smart Infrastructure and ICT and the correlation between Smart Infrastructure without ICT (a composite indicator made up only of mobility and utility). Table 9 reports the results.

Table 9. Correlation between ICT and other dimensions of "smartness"

Dimension	*Pearson correlation*	*Spearman correlation*
Smart Governance	0.5***	0.5**
Smart Economy	0.1	0.2
Smart Education	0.3	0.2
Smart Living	0.5**	0.4*
Smart Environment	0.3	0.3
Smart Infrastructure without ICT (with mobility and utility only)	0.4*	0.3

Note: Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent.

A weak Pearson correlation coefficient does not mean that there is no relationship between dimensions; they can have a nonlinear relation. To test for this possibility, we also report the Spearman correlation coefficient. Jointly, the two tests provide insights other than the main one: that the proxies used to measure each of the policy dimensions of interest are weakly correlated with ICT in these cities. The lack of correlation may mean that, on average, ICT is not yet developed enough to make a difference in many of the key dimensions of city management. Alternatively, it can mean that the key dimensions of city management are not yet anchored well enough in the margin for improvement allowed by more effective use of ICT.

Several other messages emerge from the table. First, it reveals a positive and statistically significant correlation between Smart ICT and Smart Governance (both Pearson and Spearman coefficients). This finding is not surprising, as technological diffusion and digital transformation generate more digitalization of government processes, increase public awareness and information levels, and as a result increase detection risks and the

chance of getting caught in the act of engaging in corrupt practices (Haafst 2017a, 2017b).

Second, the correlation between Smart ICT and Smart Living from the Pearson correlation coefficient perspective is significant. Digital technology can enable real-time information on public life in cities, which can increase safety, security, and healthcare services (Deloitte 2018). The result is not confirmed by the Spearman correlation coefficient, implying that the relationship is strongly linear.

Third, Smart ICT is not correlated, even at the 5 percent level, with other infrastructure dimensions of city management. In countries in the Organisation for Economic Co-operation and Development (OECD), it is common to argue that the future of utilities and mobility are connected to the increased use of ICT in the monitoring of both supply and demand, which is apparently not yet happening in LAC.

This simple correlation analysis highlights the importance of the concept of smartness in the assessment of overall city management. ICT offers useful opportunities to become smarter in some dimensions. But there are also some dimensions on which the correlation is unlikely to be high, because there is much more to sound city management than simply betting on ICT to solve all problems.

Table 10 displays the overall smartness scores without taking into account the subdimension "Smart ICT." Principal component analysis and factor analysis identified six factors for the composite index. Only the first three are taken because they explain more than 80 percent of the cumulative variance (see appendix B). The weights of each dimension were recalculated to create a new single score without the subdimension ICT. In this ranking, Porto Alegre drops from first place to third, and San Jose rises to first place. Asuncion moves to first place in Smart Infrastructure; Port-au-Prince remains in last place.

Table 10. "Smartness" scores of 27 cities in Latin America and the Caribbean without ICT subdimension (percent except for ranking)

Country	*City*	*Smart Government (0.134)*	*Smart Economy (0.127)*	*Smart Education (0.212)*	*Smart Living (0.134)*	*Smart Environment (0.177)*	*Smart Infrastructure without ICT (0.216)*	*Composite score*	*Ranking*
Argentina	Buenos Aires	61.2	49.3	83.6	72.0	65.6	80.4	70.8	6
Bolivia	La Paz	62.9	33.2	67.1	32.3	71.8	58.6	56.6	20
Brazil	Brasilia	62.0	79.8	65.2	50.2	82.6	69.0	68.5	9
	Rio de Janeiro	62.0	81.3	75.4	60.6	78.9	67.3	71.2	5
	São Paulo	62.0	74.9	80.7	61.1	70.4	70.0	70.7	7
	Porto Alegre	62.0	83.7	71.1	63.4	83.1	70.4	72.4	3
Chile	Santiago	67.1	76.4	81.2	59.4	50.8	86.8	71.6	4
Colombia	Bogota	36.2	52.5	71.2	56.6	87.0	86.0	68.2	10
	Medellin	36.2	51.6	52.9	61.1	86.1	85.2	64.5	14
Costa Rica	San Jose	72.7	61.3	74.3	71.9	76.9	81.4	74.1	1
Dominican Republic	Santo Domingo	45.4	42.5	23.9	35.0	77.1	71.4	50.3	26
Ecuador	Quito	58.0	43.0	51.3	59.8	90.3	85.81	66.7	11
El Salvador	San Salvador	35.4	44.8	37.7	53.5	64.5	84.1	55.2	23
Guatemala	Guatemala City	46.7	40.7	30.8	49.3	58.9	74.9	51.2	25
Guyana	Georgetown	57.1	35.8	33.1	50.8	79.5	73.5	56.0	21
Haiti	Port au Prince	3.8	4.0	11.6	23.3	56.8	44.0	26.2	27
Honduras	Tegucigalpa	39.6	37.1	55.9	42.5	57.2	75.6	54.0	24
Jamaica	Kingston	45.8	40.4	46.9	47.4	59.1	81.2	55.6	22
Mexico	Guadalajara	31.4	95.6	54.9	59.6	60.9	82.2	64.5	13
	Mexico City	31.4	94.2	77.8	55.8	62.5	82.1	69.0	8
	Monterrey	31.4	95.9	59.0	60.2	64.7	81.8	66.1	12

Nicaragua	Managua	39.5	37.2	40.2	64.9	73.7	78.7	57.3	18
Panama	Panama City	58.2	53.9	39.0	51.5	78.4	87.2	62.6	15
Paraguay	Asuncion	45.7	44.9	22.9	67.4	80.0	88.6	59.0	17
Peru	Lima	62.9	51.3	48.8	57.9	63.4	84.2	62.5	16
Uruguay	Montevideo	100.0	64.2	54.3	62.5	79.8	83.1	73.5	2
Venezuela	Caracas	39.0	36.6	78.1	57.8	47.2	66.3	56.9	19

Note: Figures in parentheses are weights. Best and worst performances are highlighted in dark and light grey, respectively.

7. Conclusions

Many LAC cities are having a hard time taking on the challenges of urbanization. Even in the cities that are best able to access financial and human capital, managers are not addressing some of the core policy dimensions they are expected to tackle. On most dimensions, ICT is not yet having an impact.

The analysis identifies some dimensions on which each city needs to focus to be able to make the most of the resources each enjoys and achieve what international best practice define as smart city management. On some dimensions, all LAC cities need improvement. The region is particularly weak in meeting the multiple requirements of Smart Living and Smart Governance. In contrast, most, although not all, cities perform well on other dimensions, notably the indicators defining Smart Environment and Smart Infrastructure, where digitalization has been paying off. This emphasis has not affected most other dimensions of smartness.

Two insights for policy emerge from the analysis. First, the scarce data availability at the city level is symptomatic of the lack of commitment to transparency and accountability. The 2017 Odebrecht corruption scandal affected many national politicians and had a direct impact on many of the largest cities of the region, including cities covered by the sample analyzed in this paper.

Second, many of the areas in which cities seem to be weak are not under the direct control of city managers. For many of the decisions that would strengthen these dimensions, local authorities need to work with national or provincial/state authorities, as shared mandates are common in LAC.

Consulting firms have applied the approach adopted in this paper to more general diagnostics of LAC. Their findings needs to be made more transparent and less subjective, in order to stimulate accountability and allow all stakeholders to come up with ideas for closing gaps. A much more realistic assessment would also be of the scope and limits of ICT as a driver of city smartness, considering the multiplicity of concerns city managers need to account for.

As international databases are likely to be constraining in the short run, an alternative would be to create national benchmarks, to make the most of each country's ability to mobilize local information, even if it does not fully match some international standards. National city benchmarking exercises can be just as useful as international ones if they can be used to identify gaps and put in place monitoring systems that help improve performance.

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Appendix A. Description of "Smartness" Indicators

Table A.1 Dimensions, subdimensions, and indicators of "smartness"		
Dimension/Subdimension	*Indicator*	*Level of data*
Smart Governance		
Governance	Corruption Perception Index score (global average score out of 176 countries = 43)	National
Political engagement	Election turnout (Parliamentary) (percent)	National
Smart Economy		
Innovation	Number of patent applications (direct and Patent Cooperation Treaty[a] national phase entries) (total count by filing office) per million inhabitants	National
General economy	Ease of doing business score composite indicator (out of 190 countries)[b]	National
	Foreign direct investment[c]	National
Labor market	Unemployment rate (people 15 years and older) (percent)	City
Smart Education		
Educational institutions	Number of universities in top 50 in Latin America and the Caribbean	City
Human capital	Quality of education: adult illiteracy rate (percent population 15 years or more illiterate)	City
Public education expenditures	Total public expenditure on education as a percent of GDP	National
Smart Living		
Culture	Number of museums	City
Health	Infant mortality (deaths of children under age 1or 5 per 1,000 live births)	City
	General government expenditures on health (percent of GDP)	National
Safety	Crime Index	City
Equality	Poverty ratio (percent)	City
	Gini coefficient (with 0 representing perfect equality and 1 representing perfect inequality)	City
Domestic purchasing power	Rent per month for one-bedroom apartment in city center (U.S. dollars)	City
Smart Environment		
Environmental quality	Fine particulate matter (PM2.5) concentration (μg/cubic meter)	National urban average
Waste	Percent of waste collected and adequately disposed (percent)	City
	Waste generated per person per year (Kg/person/year)	City
Energy	Energy consumption per capita (kW/capita)	National
Smart Infrastructure		
Mobility	Road traffic death rate (per 100,000 population)	National
	Stock of cars and motorcycles (vehicles/person)	National
Utilities	Percent of population without sanitation (population-weighted average of estimates for urban populations) (= open defecation + unimproved sanitation)	National urban average
	Percent of population with drinking water	City
	Percent of households without electricity supply service	City
ICT	Mobile subscription per 100 inhabitants	National
	Percent of households with access to mobile phone	National

Note:

a. The Patent Cooperation Treaty (PCT) is an international patent system that helps applicants seeking international patent protection for their inventions (WIPO Statistics).

b. The index was created by the World Bank Group. Higher rankings (a low numerical value) indicate better, usually simpler, regulations for businesses and stronger protections of property rights

c. Figure captures net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital, as shown in the balance of payments (UN Habitat 2005).

Appendix B Creation of the Composite Index

Table B.1. Raw and normalized values of Smart Governance indicators and their raw and normalized values in 27 cities in Latin America and the Caribbean

		Governance		*Political engagement*	
		Corruption perception index		*Election turnout*	
Country	*City*	Raw (global score)	*Normalized (percent)*	Raw (percent)	Normalized (percent)
Argentina	Buenos Aires	39	40.4	76.7	82.1
Bolivia	La Paz	33	28.8	87.5	97.0
Brazil	Brasilia	37	36.5	80.6	87.4
	Rio de Janeiro	37	36.5	80.6	87.4
	São Paulo	37	36.5	80.6	87.4
	Porto Alegre	37	36.5	80.6	87.4
Chile	Santiago	67	94.2	46.5	40.0
Colombia	Bogota	37	36.5	43.6	35.9
	Medellin	37	36.5	43.6	35.9
Costa Rica	San Jose	59	78.8	65.6	66.5
Dominican Republic	Santo Domingo	29	21.2	67.8	69.6
Ecuador	Quito	32	26.9	81.7	89.0
El Salvador	San Salvador	33	28.8	48.0	42.0
Guatemala	Guatemala City	28	19.2	71.1	74.2
Guyana	Georgetown	38	38.5	72.2	75.7
Haiti	Port au Prince	22	7.7	17.8	0.0
Honduras	Tegucigalpa	29	21.2	59.5	58.0
Jamaica	Kingston	44	50.0	47.7	41.6
Mexico	Guadalajara	29	21.2	47.7	41.6
	Mexico City	29	21.2	47.7	41.6
	Monterrey	29	21.2	47.7	41.6
Nicaragua	Managua	26	15.4	63.5	63.7
Panama	Panama City	37	36.5	75.2	79.9
Paraguay	Asuncion	29	21.2	68.2	70.2
Peru	Lima	37	36.5	81.9	89.2
Uruguay	Montevideo	70	100.0	89.6	100.0
Venezuela	Caracas	18	0.0	73.8	77.9

Table B.2. Correlation matrix of Smart Governance indicators

	Indicator	
Indicator	*Corruption perception index*	*Election turnout*
Corruption perception index	1.0	
Election turnout	0.2	1.00

Note: Pearson correlation matrix. Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent.

Table B.3. Principal component analysis of Smart Governance indicators

	Principal component	
Variable	*1*	*2*
Variance	1.2	0.8
Percent of variance explained	58.9	41.1
Cumulative percent of variance explained	58.9	100.0

Table B.4. Factor loadings of indicators of Smart Governance		
	Factor	
Indicator	*1*	*2*
Corruption perception index	0.8	−0.6
Election turnout	0.78	0.6

Note: Extraction method: principal components, Varimax rotation.

Table B.5. Weights of Smart Living indicators	
Indicator	*Weight*
Corruption perception index	0.5
Election turnout	0.5

Table B.6. Raw and normalized values of Smart Economy indicators in 27 cities in Latin America and the Caribbean (percent except where otherwise indicated)

		Innovation		*General economy*				*Labor market*	
		Number of patent applications		*Ease of Doing Business*		*Foreign direct investment*		*Unemployment rate*	
Country	*City*	*Raw score (number per million habitant)*	*Normalized score*	*Raw score (score)*	*Normalize d score*	*Raw score (net inflows)*	*Normalized score*	*Raw score*	*Normalized score*
Argentina	Buenos Aires	86.9	52.9	58.1	65.8	478	4.4	9.4	84.4
Bolivia	La Paz	23.2	13.2	50.2	46.6	160	1.4	11.0	81.0
Brazil	Brasilia	134.9	82.7	56.5	61.8	10144	94.1	13.1	76.5
	Rio de Janeiro	134.9	82.7	56.5	61.8	10144	94.1	10.0	83.2
	São Paulo	134.9	82.7	56.5	61.8	10144	94.1	22.8	55.9
	Porto Alegre	134.9	82.7	56.5	61.8	10144	94.1	5.1	93.6
Chile	Santiago	162.3	99.8	71.2	97.5	2982	27.6	6.9	89.8
Colombia	Bogota	45.3	27.0	69.4	93.1	1762	16.3	9.0	85.3
	Medellin	45.3	27.0	69.4	93.1	1762	16.3	10.8	81.4
Costa Rica	San Jose	104.0	63.5	69.1	92.4	587	5.4	3.5	97.0
Dominican Republic	Santo Domingo	25.6	14.7	60.9	72.6	310	2.8	5.8	92.1
Ecuador	Quito	22.8	13.0	57.8	65.1	1555	14.4	7.1	89.3
El Salvador	San Salvador	27.6	15.9	66.4	85.9	157	1.4	7.1	89.3
Guatemala	Guatemala City	16.2	8.9	61.2	73.2	104	0.9	5.6	92.5
Guyana	Georgetown	23.3	13.3	56.3	61.4	26	0.2	11.8	79.3
Haiti	Port au Prince	2.0	0.0	38.2	17.8	8	0.0	49.0	0.0
Honduras	Tegucigalpa	21.4	12.1	58.5	66.6	198	1.8	12.0	78.9
Jamaica	Kingston	27.1	15.6	67.3	87.9	520	4.8	18.6	64.8
Mexico	Guadalajara	136.6	83.8	72.3	100.0	10783	100.0	2.6	98.8
	Mexico City	136.6	83.8	72.3	100.0	10783	100.0	5.5	92.7
	Monterrey	136.6	83.8	72.3	100.0	10783	100.0	2.1	100.0
Nicaragua	Managua	24.3	13.9	55.4	59.2	201	1.8	9.3	84.6
Panama	Panama City	103.4	63.1	65.3	83.1	792	7.3	15.0	72.5
Paraguay	Asuncion	58.8	35.4	59.2	68.4	82	0.7	8.4	86.6
Peru	Lima	36.6	21.6	69.5	93.2	1377	12.7	6.6	90.4
Uruguay	Montevideo	162.6	100.0	62.0	75.2	263	2.4	6.8	90.0
Venezuela	Caracas	54.2	32.5	30.9	65.8	2531	23.4	5.4	93.0

Table B.7. Correlation matrix of Smart Economy indicators				
Indicator	*Total patent applications*	*Ease of doing business*	*Foreign direct investment IN*	*Unemployment rate*
Total patent applications	1.0			
Ease of doing business	0.3	1.0		
Foreign direct investment	0.7***	0.2	1.0	
Unemployment rate	0.2	0.5**	0.2	1.0

Note: Pearson correlation matrix. Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent.

Table B.8. Principal component analysis of Smart Economy indicators				
	Principal component			
Variable	*1*	***2***	***3***	***4***
Variance	2.1	1.1	0.5	0.3
Percent of variance explained	52.2	27.7	13.3	6.7
Cumulative percent of variance explained	52.2	80.0	93.3	100.0

Table B.9. Factor loadings of indicators of Smart Economy		
	Factor	
Indicator	*1*	*2*
Total number of patents application	0.9	0.3
Ease of doing business	0.1	0.8
Foreign direct investment	0.9	0
Unemployment rate	0.1	0.8

Note: Extraction method: principal components, Varimax rotation.

Table B.10. Weights for the Smart Economy's indicators	
Indicator	*Weight*
Total patent applications	0.3
Ease of doing business	0.2
Foreign direct investment (IN)	0.3
Unemployment rate	0.2

Table B.11. Raw and normalized values of Smart Education indicators in 27 cities in Latin America and the Caribbean (percent except where otherwise indicated)

		Educational institutions		*Human capital*		*Public education expenditures*	
		Universities in top 50 in Latin America and the Caribbean		*Adult illiteracy rate*		*Total public expenditure on education as a percent of GDP*	
Country	*City*	*Raw score (number)*	*Normalized score*	*Raw score*	*Normalized score*	*Raw score*	*Normalized score*
Argentina	Buenos Aires	4	80	0	100.0	5.9	73.5
Bolivia	La Paz	0	0	4.6	84.0	7.3	100.0
Brazil	Brasilia	1	20	2.1	92.9	6.0	74.8
	Rio de Janeiro	3	60	2.9	90.0	6.0	74.8
	São Paulo	4	80	3.2	88.9	6.0	74.8
	Porto Alegre	2	40	1.8	93.9	6.0	74.8
Chile	Santiago	5	100	0.5	98.4	4.9	55.1
Colombia	Bogota	4	80	1.6	94.6	4.5	47.2
	Medellin	1	20	3.0	89.6	4.5	47.2
Costa Rica	San Jose	1	20	1.5	94.9	7.1	95.7
Dominican Republic	Santo Domingo	0	0	7.4	74.2	2.1	1.5
Ecuador	Quito	0	0	3.0	89.6	5.0	57.0
El Salvador	San Salvador	0	0	4.6	84.0	3.5	27.8
Guatemala	Guatemala City	0	0	6.5	77.3	2.8	16.2
Guyana	Georgetown	0	0	6.9	75.9	3.2	22.7
Haiti	Port au Prince	0	0	18.0	36.9	2.0	0
Honduras	Tegucigalpa	0	0	4.9	83.0	5.9	73.3
Jamaica	Kingston	0	0	9.5	66.8	5.4	63.7
Mexico	Guadalajara	0	0	2.1	92.8	5.3	63.2
	Mexico City	4	80	1.5	95.0	5.3	63.2
	Monterrey	1	20	3.4	88.2	5.3	63.2
Nicaragua	Managua	0	0	9.5	66.8	4.5	47.2
Panama	Panama City	0	0	1.6	94.6	3.2	22.9
Paraguay	Asuncion	0	0	28.5	0	5.0	56.2
Peru	Lima	1	20	2.1	92.8	3.8	34.6
Uruguay	Montevideo	1	20	0.9	97.0	4.4	44.9
Venezuela	Caracas	2	40	1.8	93.8	6.9	92.1

Table B.12. Correlation matrix of Smart Education indicators

	Indicator		
Indicator	*Number of universities in top 50 in Latin America and the Caribbean*	*Adult illiteracy rate*	*Total public expenditure on education as a percent of GDP*
Number of universities in top 50 in Latin America *and the Caribbean*	1.0		
Adult illiteracy rate	0.4**	1.0	
Total public expenditure on education as a percent of GDP	0.3*	0.3	1.0

Note: Pearson correlation matrix. Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent.

Table B.13. Principal component analysis of Smart Education indicators			
	Principal component		
Variable	*1*	*2*	*3*
Variance	1.7	0.7	0.6
Percent of variance explained	57.5	23.7	18.8
Cumulative percent of variance explained	57.5	81.2	100.0

Table B.14. Factor loadings of indicators of Smart Education		
	Factor	
Indicator	*1*	*2*
Number of universities in top 50 in Latin America and the Caribbean	0.8	0.2
Adult illiteracy rate	0.9	0.1
Total public expenditure on education as a percent of GDP	0.2	1.0

Note: Extraction method: principal components, Varimax rotation.

Table B.15. Weights of Smart Education indicators	
Indicator	*Weight*
Number of universities in top 50 in Latin America and the Caribbean	0.3
Adult illiteracy rate	0.3
Total public expenditure on education as a percent of GDP	0.4

Table B.16. Raw and normalized values of Smart Environment indicators in 27 cities in Latin America and the Caribbean (percent except where otherwise indicated)

		Environmental quality		*Waste*				*Energy*	
		Fine particulate matter (PM2.5) concentration		*Percent of waste collected and adequately disposed*		*Waste generated per person per year*		*Energy consumption per capita*	
Country	*City*	*Raw score (µm)*	*Normalized score*	*Raw score*	*Normalized score*	*Raw score (kilograms per person per year)*	*Normalized score*	*Raw score (kilowatt)*	*Normalized score*
Argentina	Buenos Aires	16	82.8	100.0	100.0	1.2	57.1	1,845.1	14.6
Bolivia	La Paz	32	27.6	87.0	83.3	0.5	100.0	561.0	89.7
Brazil	Brasilia	11	100.0	95.1	93.7	0.8	84.4	1,232.6	50.4
	Rio de Janeiro	11	100.0	98.6	98.2	1.2	54.4	1,232.6	50.4
	São Paulo	11	100.0	100.0	100.0	2.0	0	1,232.6	50.4
	Porto Alegre	11	100.0	99.0	98.7	0.8	78.9	1,232.6	50.4
Chile	Santiago	25	51.7	98.9	98.6	1.6	25.2	1,856.8	13.9
Colombia	Bogota	18	75.9	99.7	99.6	0.7	87.1	637.5	85.2
	Medellin	18	75.9	100.0	100.0	0.8	81.0	637.5	85.2
Costa Rica	San Jose	19	72.4	100.0	100.0	1.0	68.0	1,031.8	62.2
Dominican Republic	Santo Domingo	17	79.3	92.1	89.9	1.3	50.3	766.1	77.7
Ecuador	Quito	13	93.1	100.0	100.0	0.7	87.1	747.0	78.8
El Salvador	San Salvador	37	10.3	96.4	95.4	0.8	81.0	736.2	79.4
Guatemala	Guatemala City	33	24.1	70.0	61.5	1.0	71.4	621.3	86.2
Guyana	Georgetown	16	82.8	100.0	100.0	1.5	32.0	668.6	83.4
Haiti	Port au Prince	25	51.7	22.0	0	0.6	95.2	384.5	100.0
Honduras	Tegucigalpa	40	0	75.0	67.9	0.7	90.5	608.4	86.9
Jamaica	Kingston	17	79.3	66.0	56.4	1.0	68.0	1,507.6	34.3
Mexico	Guadalajara	20	69.0	90.0	87.2	1.2	54.4	1,623.0	27.6
	Mexico City	20	69.0	100.0	100.0	1.4	42.2	1,623.0	27.6
	Monterrey	20	69.0	100.0	100.0	1.2	55.1	1,623.0	27.6
Nicaragua	Managua	26	48.3	80.0	74.4	0.7	87.8	521.9	92.0
Panama	Panama City	13	93.1	80.0	74.4	0.9	72.1	882.5	70.9
Paraguay	Asuncion	17	79.3	99.0	98.7	1.3	46.9	708.8	81.0
Peru	Lima	36	13.8	78.1	71.9	0.7	87.8	506.7	92.9
Uruguay	Montevideo	11	100.0	90.0	87.2	1.2	52.4	947.8	67.1
Venezuela	Caracas	24	55.2	80.0	74.4	1.1	61.2	2,095.1	0

Table B.17. Correlation matrix of Smart Environment indicators

Indicator	*Fine particulate matter (PM2.5) concentration*	*Percent of waste collected and adequately disposed*	*Waste generated per person per year*	*Energy consumption per capita*
Fine particulate matter (PM2.5) concentration	1.0			
Percent of waste collected and adequately disposed	0.4*	1.0		
Waste generated per person per year	−0.4**	−0.4**	1.0	
Energy consumption per capita	−0.3	−0.3	0.5***	1.0

Note: Pearson correlation matrix. Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent.

Table B.18. Principal component analysis of Smart Environment indicators				
	Principal component			
Variable	*1*	*2*	*3*	*4*
Variance	2.2	0.7	0.6	0.5
Percent of variance explained	54.3	18.6	15.5	11.6
Cumulative percent of variance explained	54.3	72.9	88.4	100.0

Table B.19. Factor loadings of indicators of Smart Environment			
	Factor		
Indicator	*1*	*2*	*3*
Fine particulate matter (PM2.5) concentration	−0.2	0.2	1.0
Percent of waste collected and adequately disposed	−0.2	1.0	0.2
Waste generated per person per year	0.7	−0.3	−0.3
Energy consumption per capita	0.9	−0.1	−0.1

Note: Extraction method: principal components, Varimax rotation.

Table B.20. Weights of Smart Environment indicators	
Indicator	*Weight*
Fine particulate matter (PM2.5) concentration	0.3
Percent of waste collected and adequately disposed	0.2
Waste generated per person per year	0.2
Energy consumption per capita	0.3

Table B.21. Raw values of Smart Infrastructure indicators in 27 cities in Latin America and the Caribbean

		Mobility		*Utilities*			*ICT*	
Country	*City*	*Number of road traffic deaths per 100,000 people*	*Stock of cars and motorcycles (number of vehicles)*	*Percent of population without sanitation*	*Percent of households with drinking water*	*Percent of households without electricity supply*	*Mobile subscriptions per 100 inhabitants*	*Percent of households with access to mobile phone*
Argentina	Buenos Aires	13.6	314.0	1	99.6	0.2	146.7	89.6
Bolivia	La Paz	23.2	70.0	9	97.5	18.1	92.2	57.0
Brazil	Brasilia	23.4	249.0	8	95.1	0.1	126.6	67.5
	Rio de Janeiro	23.4	249.0	8	89.4	0.0	126.6	67.5
	São Paulo	23.4	249.0	8	98.2	0.1	126.6	67.5
	Porto Alegre	23.4	249.0	8	99.5	0.1	126.6	67.5
Chile	Santiago	12.4	230.0	0	99.9	0.1	129.5	83.8
Colombia	Bogota	16.8	148.0	2	99.9	0.1	115.7	71.5
	Medellin	16.8	148.0	2	97.0	0.0	115.7	71.5
Costa Rica	San Jose	13.9	287.0	1	99.0	0.2	150.7	59.6
Dominican Republic	Santo Domingo	29.3	128.0	4	86.4	0.3	82.6	44.2
Ecuador	Quito	20.1	109.0	0	97.9	0.9	79.8	69.9
El Salvador	San Salvador	21.1	94.0	0	96.2	2.0	145.3	65.0
Guatemala	Guatemala City	19.0	69.0	9	93.7	5.0	111.5	54.8
Guyana	Georgetown	17.3	95.0	2	96.5	12.7	67.2	79.7
Haiti	Port au Prince	19.2	12.0	22	33.4	7.8	68.8	67.0
Honduras	Tegucigalpa	17.4	95.0	5	89.4	6.2	95.5	58.4
Jamaica	Kingston	11.5	179.0	2	96.9	5.7	111.5	79.2
Mexico	Guadalajara	12.3	275.0	2	99.5	0.5	86.0	55.2
	Mexico City	12.3	275.0	2	97.7	0.1	86.0	55.2
	Monterrey	12.3	275.0	2	96.7	0.1	86.0	55.2
Nicaragua	Managua	15.3	54.0	11	99.8	5.0	116.1	61.7
Panama	Panama City	10.0	132.0	6	98.6	0.8	174.2	69.0
Paraguay	Asuncion	20.7	57.0	1	99.5	0.1	105.4	75.0
Peru	Lima	13.9	73.0	8	94.0	0.7	109.9	42.4
Uruguay	Montevideo	16.6	200.0	2	99.0	0.2	160.2	70.8
Venezuela	Caracas	42.2	147.0	2	97.4	0.1	93.0	43.4

Table B.22. Normalized values of Smart Infrastructure indicators in 27 cities in Latin America and the Caribbean								
		Mobility		*Utilities*			*ICT*	
Country	*City*	*Number of road traffic deaths per 100,000 people*	*Stock of cars and motorcycles (number)*	*Percent of population without sanitation*	*Percent of households with drinking water*	*Percent of households without electricity supply*	*Mobile subscriptions per 100 inhabitants*	*Percent of households with access to mobile phone*
Argentina	Buenos Aires	88.8	0	95.5	99.5	98.8	74.3	100.0
Bolivia	La Paz	59.0	80.8	59.1	96.4	0	23.4	30.9
Brazil	Brasilia	58.4	21.5	63.6	92.8	99.4	55.5	53.2
	Rio de Janeiro	58.4	21.5	63.6	84.2	99.9	55.5	53.2
	São Paulo	58.4	21.5	63.6	97.4	99.4	55.5	53.2
	Porto Alegre	58.4	21.5	63.6	99.4	99.5	55.5	53.2
Chile	Santiago	92.5	27.8	100.0	100.0	99.4	58.2	87.7
Colombia	Bogota	78.9	55.0	90.9	100.0	99.4	45.4	61.7
	Medellin	78.9	55.0	90.9	95.6	100.0	45.4	61.7
Costa Rica	San Jose	87.9	8.9	95.45	98.6	98.7	78.0	36.4
Dominican Republic	Santo Domingo	40.0	61.6	81.82	79.7	98.3	14.4	3.8
Ecuador	Quito	68.6	67.9	100.00	97.0	95.0	11.8	58.3
El Salvador	San Salvador	65.5	72.8	100.00	94.4	89.0	73.0	47.9
Guatemala	Guatemala City	72.0	81.1	59.09	90.7	72.3	41.4	26.3
Guyana	Georgetown	77.3	72.5	90.91	94.9	29.7	0	79.0
Haiti	Port au Prince	71.4	100.0	0.00	0	56.8	1.5	52.1
Honduras	Tegucigalpa	77.0	72.5	77.27	84.2	65.8	26.5	33.9
Jamaica	Kingston	95.3	44.7	90.91	95.5	68.4	41.4	78.0
Mexico	Guadalajara	92.9	12.9	90.91	99.4	97.4	17.6	27.1
	Mexico City	92.9	12.9	90.91	96.6	99.7	17.6	27.1
	Monterrey	92.9	12.9	90.91	95.2	99.4	17.6	27.1
Nicaragua	Managua	83.5	86.1	50.00	99.8	72.3	45.7	40.9
Panama	Panama City	100.0	60.3	72.73	98.0	95.6	100.0	56.4
Paraguay	Asuncion	66.7	85.1	95.45	99.3	99.6	35.7	69.1
Peru	Lima	87.9	79.8	63.64	91.1	96.1	39.9	0
Uruguay	Montevideo	79.5	37.7	90.91	98.6	98.9	86.9	60.2
Venezuela	Caracas	0	55.3	90.91	96.2	99.4	24.1	2.1

Table B.23 Correlation matrix of Smart Infrastructure indicators							
Indicator	*Road traffic death rate*	*Stock of cars and motorcycles*	*Percent of population without sanitation*	*Percent of population with drinking water*	*Percent of households without electricity supply*	*Mobile subscription per 100 inhabitants*	*Percent of households with access to mobile phone*
Road traffic death rate	1.0						
Stock of cars and motorcycles	−0.2	1.0					
Percent of population without sanitation	0.1	−0.4**	1.0				
Percent of population with drinking water	0.1	−0.4**	0.7***	1.0			
Percent of households without electricity supply	0	−0.5***	0.4*	0.2	1.0		
Mobile subscription per 100 inhabitants	0.2	−0.3*	0.2	0.4*	0.4**	1.0	
Percent of households with access to mobile phone	0.4**	−0.2	0.2	0.1	0	0.3*	1.0

Note: Pearson correlation matrix. Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent.

Table B.24 Principal component analysis of Smart Infrastructure indicators							
	Principal component						
Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Variance	2.7	1.4	1.0	0.7	0.6	0.4	0.1
Percent of variance explained	39.2	19.4	14.2	10.1	8.6	6.3	2.1
Cumulative percent of variance explained	39.2	58.6	72.9	83.0	91.6	97.9	100.0

Table B.25. Factor loadings of indicators of Smart Infrastructure				
	Factor			
Indicator	*1*	*2*	*3*	*4*
Road traffic death rate	0	0.1	0.9	0
Stock of cars and motorcycles	−0.3	−0.8	−0.2	0
Percent of population without sanitation	0.9	0.2	0.1	0
Percent of population with drinking water	0.9	0.1	0	0.2
Percent of households without electricity supply	0.1	0.9	−0.1	0.2
Mobile subscription per 100 inhabitants	0.1	0.3	0.1	0.9
Percent of households with access to mobile phone	0.1	−0.1	0.7	0.4

Note: Extraction method: principal components, Varimax rotation.

Table B.26. Weights of Smart Infrastructure indicators	
Indicator	*Weight*
Road traffic death rate	0.2
Stock of cars and motorcycles	0.1
Percent of population without sanitation	0.2
Percent of population with drinking water	0.2
Percent of households without electricity supply	0.1
Mobile subscription per 100 inhabitants	0.2
Percent of households with access to mobile phone	0.1

Table B.27 Principal component analysis of Smart Infrastructure without ICT indicators					
	Principal component				
Variable	*1*	*2*	*3*	*4*	*5*
Variance	2.4	1.0	0.9	0.5	0.2
Percent of variance explained	47.6	19.9	18.6	9.0	4.9
Cumulative percent of variance explained	47.6	67.5	86.1	95.1	100.0

Table B.28. Factor loadings of Smart Infrastructure without ICT indicators			
	Factor		
Indicator	*1*	*2*	*3*
Road traffic death rate	0.1	1	0
Stock of cars and motorcycles	−0.3	−0.2	−0.8
Percent of population without sanitation	0.9	0	0.2
Percent of population with drinking water	0.9	0	0.1
Percent of households without electricity supply	0.1	−0.1	0.9

Note: Extraction method: principal components, Varimax rotation.

Table B.29. Weights of Smart Infrastructure without ICT indicators	
Indicator	*Weight*
Road traffic death rate	0.2
Stock of cars and motorcycles	0.2
Percent of population without sanitation	0.2
Percent of population with drinking water	0.2
Percent of households without electricity supply	0.2

Table B.30. Smartness dimensions in 27 cities in Latin America and the Caribbean (percent)							
Country	*City*	*Smart Governance*	*Smart Economy*	*Smart Education*	*Smart Living*	*Smart Environment*	*Smart Infrastructure*
Argentina	Buenos Aires	61.2	49.3	83.6	72.1	65.6	81.0
Bolivia	La Paz	62.9	33.2	67.1	32.3	71.8	50.9
Brazil	Brasilia	62.0	79.8	65.2	50.2	82.6	65.3
	Rio de Janeiro	62.0	81.3	75.4	60.6	78.9	64.0
	São Paulo	62.0	75.0	80.7	61.1	70.4	66.1
	Porto Alegre	62.0	83.7	71.1	63.4	83.1	66.4
Chile	Santiago	67.1	76.4	81.2	59.4	50.8	82.2
Colombia	Bogota	36.2	52.5	71.2	56.6	87.0	77.4
	Medellin	36.2	51.6	52.9	61.1	86.1	76.8
Costa Rica	San Jose	72.7	61.3	74.3	71.9	76.9	76.2
Dominican Republic	Santo Domingo	45.4	42.5	23.9	35.0	77.1	56.8
Ecuador	Quito	58.0	43.0	51.4	59.8	90.3	72.1
El Salvador	San Salvador	35.4	44.8	37.7	53.5	64.5	79.5
Guatemala	Guatemala City	46.7	40.7	30.9	49.3	58.9	65.0
Guyana	Georgetown	57.1	35.8	33.1	50.8	79.5	62.9
Haiti	Port au Prince	3.8	4.0	11.6	23.3	56.8	37.0
Honduras	Tegucigalpa	39.6	37.1	55.9	42.5	57.2	64.0
Jamaica	Kingston	45.8	40.4	46.9	47.4	59.1	74.4
Mexico	Guadalajara	31.4	95.6	54.9	59.6	60.9	66.4
	Mexico City	31.4	94.2	77.8	55.8	62.5	66.2
	Monterrey	31.4	95.9	59.0	60.2	64.7	66.0
Nicaragua	Managua	39.5	37.2	40.2	64.9	73.7	69.5
Panama	Panama City	58.2	53.9	39.0	51.5	78.4	85.6
Paraguay	Asuncion	45.7	44.9	22.9	67.4	80.0	79.1
Peru	Lima	62.88	51.3	48.8	57.9	63.4	68.8
Uruguay	Montevideo	100.00	64.2	54.3	62.5	79.8	81.4
Venezuela	Caracas	38.96	36.6	78.1	57.8	47.2	55.4

Note: A score of 100 percent indicates that a city is the best performer.

Table B.31. Principal component analysis of composite index						
	Principal component					
Variable	1	*2*	*3*	*4*	*5*	*D 6*
Variance	2.8	1.3	0.7	0.6	0.4	0.2
Percent of variance explained	47.1	20.5	12.1	10.8	5.8	3.7
Cumulative percent of variance explained	47.1	67.6	79.7	90.5	96.3	100.0

Table B.32. Factor loadings of dimensions of composite index			
	Factor		
Dimension	*1*	*2*	*3*
Smart Governance	0.2	0.7	0.4
Smart Economy	0.3	0	0.8
Smart Education	0.1	0	0.9
Smart Living	0.8	0.1	0.4
Smart Environment	0.1	0.9	-0.1
Smart Infrastructure	0.9	0.2	0.1

Note: Extraction method: principal components, Varimax rotation.

Table B.33. Weights of dimensions of composite index	
Dimension	*Weight*
Smart Governance	0.1
Smart Economy	0.1
Smart Education	0.2
Smart Living	0.2
Smart Environment	0.2
Smart Infrastructure	0.2

Table B.34. Smartness dimensions without ICT indicators in 27 cities in Latin America and the Caribbean (percent)

Country	*City*	*Smart Governance*	*Smart Economy*	*Smart Education*	*Smart Living*	*Smart Environment*	*Smart Infrastructure without ICT*
Argentina	Buenos Aires	61.2	49.3	83.6	72.1	65.6	80.5
Bolivia	La Paz	62.9	33.2	67.1	32.3	71.8	58.6
Brazil	Brasilia	62.0	79.8	65.2	50.2	82.6	69.0
	Rio de Janeiro	62.0	81.3	75.4	60.6	78.9	67.3
	São Paulo	62.0	75.0	80.7	61.1	70.4	70.0
	Porto Alegre	62.0	83.7	71.1	63.4	83.1	70.5
Chile	Santiago	67.1	76.4	81.2	59.4	50.8	86.8
Colombia	Bogota	36.2	52.5	71.2	56.6	87.0	86.0
	Medellin	36.2	51.6	52.9	61.1	86.1	85.2
Costa Rica	San Jose	72.7	61.3	74.3	71.9	76.9	81.4
Dominican Republic	Santo Domingo	45.4	42.5	23.9	35.0	77.1	71.5
Ecuador	Quito	58.0	43.0	51.4	59.8	90.3	85.8
El Salvador	San Salvador	35.4	44.8	37.7	53.5	64.5	84.1
Guatemala	Guatemala City	46.7	40.7	30.9	49.3	58.9	74.9
Guyana	Georgetown	57.1	35.8	33.1	50.8	79.5	73.5
Haiti	Port au Prince	3.8	4.0	11.6	23.3	56.8	44.0
Honduras	Tegucigalpa	39.6	37.1	55.9	42.5	57.2	75.7
Jamaica	Kingston	45.8	40.4	46.9	47.4	59.1	81.3
Mexico	Guadalajara	31.4	95.6	54.9	59.6	60.9	82.2
	Mexico City	31.4	94.2	77.8	55.8	62.5	82.1
	Monterrey	31.4	95.9	59.0	60.2	64.7	81.8
Nicaragua	Managua	39.5	37.2	40.2	64.9	73.7	78.7
Panama	Panama City	58.2	53.9	39.0	51.5	78.4	87.2
Paraguay	Asuncion	45.7	44.9	22.9	67.4	80.0	88.6
Peru	Lima	62.9	51.3	48.8	57.9	63.4	84.2
Uruguay	Montevideo	100.00	64.2	54.3	62.5	79.8	83.1
Venezuela	Caracas	38.96	36.6	78.1	57.8	47.2	66.3

Note: A score of 100 percent indicates that a city is the best performer.

Table B.35. Principal component analysis of composite index without ICT indicators

	Principal component					
Variable	*1*	*2*	*3*	*4*	*5*	*6*
Variance	2.7	1.2	0.9	0.6	0.4	0.2
Percent of variance explained	45.0	20.0	15.2	10.1	6.1	3.6
Cumulative percent of variance explained	45.0	65.0	80.2	90.3	96.4	100.0

Table B.36. Factor loadings of dimensions of composite index without ICT indicators			
	Factor		
Dimension	*1*	*2*	*3*
Smart Governance	0	0.7	0.4
Smart Economy	0.4	0	0.7
Smart Education	0	0	0.9
Smart Living	0.7	0.2	0.5
Smart Environment	0.2	0.8	–0.2
Smart Infrastructure without ICT	0.9	0.1	0

Note: Extraction method: principal components, Varimax rotation.

Table B.37. Weights of dimensions of composite index without ICT indicators	
Dimension	*Weight*
Smart Governance	0.1
Smart Economy	0.1
Smart education	0.2
Smart Living	0.1
Smart Environment	0.2
Smart Infrastructure without ICT	0.2