Institutional Fragmentation and Metropolitan Coordination in Latin American Cities
What Consequences for Productivity and Growth?

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Abstract

This paper provides empirical evidence on the impact of institutional fragmentation and metropolitan coordination on urban productivity in Latin American cities. The use of night-time lights satellite imagery and high-resolution population data allow the use of a broader definition of metropolitan area. Thus, metropolitan area consists of the urban extent that results from the union between the formally defined metropolitan area and the contiguous patches of urbanized areas with more than 500,000 inhabitants. The initial results suggest that the presence of multiple local governments within metropolitan areas generates opposite effects on urban productivity. On the one hand, smaller governments tend to be more responsive and efficient, which increases productivity. But, on the other hand, multiple local governments face coordination costs that reduce productivity.
Institutional Fragmentation and Metropolitan Coordination in Latin American Cities: What Consequences for Productivity and Growth?

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1 Introduction

Cities are central to the productivity and growth prospects of the Latin American and Caribbean region (LCR). The vast majority of the region’s output is generated in cities – Mexican cities generate 87 percent of gross value added (Kim and Zangerling, 2016), while Argentine cities contributed almost 80 percent of national GDP in 2007.¹ Yet it is unclear whether LCR’s cities are realizing their full potential – for the region’s major economies, GDP per capita levels are well below what one would predict based on their urbanization levels,² and recent policy reports by, for example, the McKinsey Global Institute have argued that cities in the region are being weighed-down by excessive diseconomies of agglomeration (Dobbs et al., 2011; Cadena et al., 2011).

According to the United Nations, Latin America and the Caribbean is the most urbanized region on the planet with 80% of its population living in cities (UN, 2012). The rapid urbanization of cities, together with the loss of density, has caused the expansion of cities beyond their administrative borders, absorbing surrounding urban areas and creating large urban extents (metropolitan areas) covering several administrative units. Since no local government has the tools to address all challenges and opportunities within a metropolitan area on its own, this form of urbanization poses new challenges to local authorities in terms of governance and integration. The way in which these large, multicity, urban extents manage aspects such as transportation, urban planning, infrastructure provision and other social and economic affairs, can make the difference between enjoying the benefits of prosperous economies of agglomeration or suffering the consequences of the diseconomies of agglomeration (Ahrend et al., 2014).

Unfortunately, there are two aspects that make it difficult for academics to make public policy recommendations for Latin American cities (LAC). First, the existing empirical evidence is mostly concentrated on metropolitan areas in developed countries; and second, there is supporting evidence in favor of the three models of metropolitan governance: The polycentrist model, which advocates

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¹ McKinsey Global Institute Cityscape database, version 1.1 (http://www.mckinsey.com/insights/urbanization/urbanworld).
² This conclusion is based on GDP per capita data from WDI and urban population share data from the UN’s World Urbanization Prospects (2014 Revision) database (http://esa.un.org/unpd/wup/). One issue that arises with the urban population data from the WUP database, however, is that it is based on official national definitions of urban areas, which differ from country to country. An important question to address, therefore, is the extent to which the apparent under-performance of LCR countries is driven by this inconsistent measurement of urban population shares. This will be addressed in another of the report’s background papers.
for the coexistence of multiple small and coordinated local governments; the centrist model, which argues that a single governance body takes advantage of reduced transactions costs and economies of scale and scope in providing public goods and services; and the regionalist view which recognizes the benefits of local governments while highlighting the importance of coordinated governance.

This paper will examine the interaction between local governance and economic performance, looking specifically at the effects of the fragmentation of functional urban areas across administrative entities. It will empirically test whether the economic performance of LAC is affected by the degree of institutional fragmentation that they exhibit. The paper will also seek to explore which, if any, of the different forms of metropolitan coordination observed in the region leads to a reduction of the penalties/advantages imposed by institutional fragmentation on economic performance. Finally, the paper explores whether results vary across city sizes (i.e. is there a specific threshold after which fragmentation penalties appear?) and whether they depend on the level of population concentration in a city’s center or the overall spatial population distribution across administrative units (i.e., does it matter if most of the metropolitan population is concentrated in the city center?).

Understanding these links is also important from a policy perspective. Improving the understanding of the strength and direction of these links can suggest whether national governments should support or incentivize metropolitan coordination mechanisms or entities, or whether they should support the consolidation of local governments. Further, there is also the question of whether national governments should support the fragmentation of local governments, or on the contrary, whether there are specific sectors (i.e. transport, environment, local economic growth) for which it makes sense to align fragmented local governments.

The rest of the paper is organized as follows. Section 2 provides a literature review. Section 3 presents the empirical models. Section 4 describes the source data. Section 5 presents the empirical results. Finally, section 6 presents our conclusions and ideas of future work.

2 Literature review

As mentioned by Nelson and Foster (1999), there exist three lines of thought when looking at the links between the governance structures of cities and their economic performance: polycentrist, centrist and regionalist. The polycentrist view is in line with Fisher’s argument in favor of dividing a
region into sub-regions to facilitate the planning and distribution of resources (Fischer, 1980). At the city level, the polycentrist view argues that institutional fragmentation of cities is equivalent to creating additional layers of decentralization, which can, in fact, enhance economic growth. This is thought to be achieved through two mechanisms. First, decentralized authorities are better informed of local needs and, therefore, can be more efficient in the provision of public goods (Ostrom, 2010). Second, increased competition between individual local governments constrains their ability to extract monopoly rents, thereby enhancing economic efficiency and, hence, economic growth (Stansel, 2005).

The second line of thought, the centrist, argues that the presence of multiple local governments within metropolitan areas may generate coordination failures that reduce efficiency in the provision of transport infrastructure and land use planning, and therefore affect economic performance (see Ahrend et al., 2014). Fragmentation may also reduce the metropolitan area’s ease of doing business because of the additional bureaucracy (Kim et al., 2014). According to Cheshire and Gordon (1996) and Feiock (2009), the presence of administrative boundaries within the functional region generates higher transaction costs and barriers to the diffusion of growth-promoting policies. As additional evidence in favor of the centrist view, Foster (1993) found a negative association between the proportions of population unincorporated to the metropolitan area and income growth.

Finally, the regionalist view can be seen as a middle way between the polycentrist and the centrist views. The regionalist view recognizes the benefits of local governments while highlighting the importance of metropolitan coordination defined as the efforts of governmental institutions to manage and solve problems in common between municipalities. According to Grassmueck and Shields (2010), more important than the existence of multiple local governments is the way in which they interact and perceive each other. Ahrend et al. (2014) found that the presence of a governance body that coordinates municipalities halved the penalty associated with fragmentation. Foster (1993) and Nelson and Foster (1999) also found empirical support for the regionalist view as a positive association between income growth and the presence of overarching decision-making mechanisms such as multi-jurisdictional, multipurpose regional governments. Also, the existence of single-purpose districts associated with large-scale infrastructure provision (e.g. water and wastewater systems) fosters income growth.
Regarding the measure of institutional fragmentation and metropolitan coordination, Table 1 and Table 2 present a summary of the variables commonly used in empirical studies. In Table 1 we classify the variables using the five categories proposed by Hendrick and Shi (2015). Based on the conceptualization of fragmentation as those urban extents that spread out over several, and independent, administrative units, the most common variables are those that measure the number of local governments included in the urban extent (sometimes standardized by population or land area). Other measures focus on the degree of concentration, the dominance relationship between the central city and the periphery. As considered by the centralist view, the potential drawbacks of having institutional fragmentation can be mitigated through proper channels of metropolitan coordination. This coordination can be reached via institutions (governance), coordinated planning and infrastructure (land use planning and mobility), the presence of overlapping governments with special of general purpose (provision of public utilities), or can be the result of tight linkages between the administrative units, which intensifies human interactions, generates spatial dependence, and facilitates coordination (functional region). Table 2 classifies the potential variables according to those proposed channels of coordination.

The scarcity of empirical studies, in addition to the differences found when taking different approaches and using different economic performance indicators, suggests that there is a need to further test the empirical links between the institutional fragmentation of cities and their productivity/economic growth. This paper makes multiple contributions to the literature. First, and foremost, it will allow for testing of whether existing findings for the US and other selected OECD countries also carry-over to countries in LAC. Second, the paper will allow for the testing of the robustness of results to different institutional fragmentation and institutional coordination measures. Third, it will allow for an assessment of whether existing metropolitan coordination measures are effective in helping to produce better economic outcomes. Finally, contrary to existing literature, most of the analysis will be supported by spatial data that are readily available at the global scale and for developing countries. This will allow the paper to contribute to the development of a methodology that can be easily replicated for other regions of the world.
Table 1. Measures of institutional fragmentation.

| Representation | Fragmentation Index (metro level) | Authors |
|----------------|-----------------------------------|---------|
| I. Size of region | Total number of local governments | Hendrick and Shi (2015); Hill (1974) |
| | Differences in population and area of municipalities | Barlow (1991) |
| II. Political fragmentation | Total local governments per capita | Hendrick and Shi (2015); Hill (1974) |
| | Total number of governments per 10,000 | Oakerson (1987); Post and Stein (2000) |
| | Number of administrative units per 50,000 persons | Ahrend et al. (2014) |
| | Proportion of unincorporated population | Foster (1993) |
| | Government per 100,000 persons | Hawkins (1971); Ahrend et al. (2014); Schneider (1989) |
| | Cities > 10,000 persons per 1 million MSA population | Morgan and Mareschal (1999) |
| | Number of suburban units with more than 10,000 persons, per 100,000 persons in the MSA. | Bollens (1986). |
| | Percent of Metro residents in suburbs with more than 10,000 people | Bollens (1986). |
| III. Spatial fragmentation | Total local governments per square mile | Hendrick and Shi (2015) |
| IV. Range of local governments | HH Index of percent of different types of local government | Hendrick and Shi (2015) |
| V. Suburban domination (or central city domination) | Percent of population not in central city | Hendrick and Shi (2015) |
| | Ratio of population in the city core to that in the periphery | Ahrend et al. (2014) |
| | Central-city population share | Morgan and Mareschal (1999) |
| | Percent of metropolitan population held within the borders of a central city | Savitch et al. (1993) |
| | Central-city area growth | Morgan and Mareschal (1999) |
| | Central-city elasticity | Rusk (1993); Blair et al. (1996) |
Table 2. Measures of metropolitan coordination.

| Representation | Fragmentation Index (metro level) | Authors |
|---------------|-----------------------------------|---------|
| I. Governance | Governance Body                   | Ahrend et al. (2014) |
|               | Age of the metropolitan area      | Nelson and Foster (1999) |
|               | Number of municipalities with the same political party | Pradenas (2006) |
| II. Land use plan and mobility | Percent of municipalities covered by integrated transport systems between municipalities and central city | Kim et al. (2014) |
| III. Coordination for special purpose | Percent of special purpose to general purpose governments | Hendrick and Shi (2015) |
|               | Number of general purpose units   | Goodman (1980) |
|               | Number of special purpose units   | Goodman (1980) |
| IV. Functional region | Percent of people working in the central city | Feria and Susino (2005) |
|               | Number of commuting from the municipalities to the central city | De Esteban (2009). |
|               | Percent of student population that go to the central city | Pradenas (2006) |
|               | Percent resident-job in central city | Pradenas (2006) |
|               | Number of telephone calls per month from the municipality to the central city must be four times greater. | Pradenas (2006) |

3 The Model

To estimate the relationship between institutional fragmentation and economic performance of cities, measured through city productivity, we follow the two-step empirical approach devised by Ahrend et al. (2014). The authors warn about the importance of accounting for individual sorting of highly skilled individuals into cities when estimating productivity differentials across urban areas (Combes et al., 2011). This is necessary in order to account for the tendency of more talented individuals to co-locate in cities that may lead to confounding agglomeration benefits with productivity increases from a more skilled workforce. Thus, in the first step, we use data from the Defense Meteorological Satellite Programs – Operational Linescan System (DSMP-OLS) nighttime lights (NTL) imagery to identify urban areas as well as survey-based micro-data for the period 2000-2014 to estimate productivity differentials across urban areas, net of individual and employment characteristics observables. The estimation on this first stage is then:

\[
\ln w_{it} = \lambda_0 + \sum_j \lambda_j L_j + \sum_e \eta_e \text{Dem}_{ie} + \sum_b \psi_b \text{Job}_{ib} + \varepsilon_{it},
\]

(1)
where $w_{it}$ is the real wage for individual $i$ at time $t$; $L_j$ are municipalities fixed effects; $Dem_{ie}$ is a vector of demographic characteristics, indexed by $e$, that include indicators of education; $Job_{ib}$ is a vector of job characteristic, indexed by $b$, that includes industry code and indicators of formality and job benefits; and $\varepsilon$ is an error term. The coefficient $\lambda_j$ captures the productivity differential across cities, after controlling by individual and employment characteristics.

In the second stage, we use the estimated productivity differentials, $\hat{\lambda}_j$, as the dependent variable in the following expression:

$$\hat{\lambda}_a = \delta a + \phi_c + \psi a + \varepsilon_a,$$

where $F$ is a vector of variables for institutional fragmentation; $C$ is a vector of variables for metropolitan coordination; $X$ is a vector of control variables, included the intercept; and $\varepsilon$ is the error term.

4 Data

4.1 Study region

In this work, we analyze Latin American and Caribbean metropolitan areas with more than 500,000 people in 2010 (Figure 1).
Figure 1. Location of identified metropolitan areas with more than 500,000 people in 2010 in Latin America and the Caribbean. The blue areas are the urban extent of the larger conurbation within each metropolitan area.

4.2 Metropolitan areas delineation from DMSP-OLS images

We use data from the Defense Meteorological Satellite Programs – Operational Linescan System (DMSP-OLS) nighttime lights (NTL) imagery to identify urban areas and metropolitan conurbations. The NTL data are based on nighttime imagery recorded by the Defense Meteorological Satellite Programs - Operational Linescan System (DMSP-OLS), and reports the recorded intensity of Earth’s
Nighttime lights products have high correlation to human activities (Hsu et al., 2015), and have been previously used for regional and global analysis of population modeling (Anderson et al., 2010; Lo, 2001), economic performance (Cao et al., 2016; Forbes, 2013), and urbanization (Cheng et al., 2016; Pandey et al., 2013; Sutton et al., 2006; Zhang and Seto, 2011; N. Zhou et al., 2015; Zhou et al., 2015).

There are two different nighttime light products from DMSP-OLS that can be used to delineate urban areas: the stable or ordinary product (NTL), and the radiance-calibrated (NTL RC) product. We decided to use the latter, since it is aimed to correct the saturation issue in bright areas such as city centers, where the NTL might be brighter, but the recorded digital number (DN) values are truncated at 63; and the RC product gives better correlations with socioeconomic variables than the stable products (Hsu et al., 2015; Ma et al., 2014). Another known issue of the DMSP-OLS products is the “overglow” effect: dim lighting detected from light in surrounding areas of cities because of the scattering of lights in the atmosphere (Wu et al., 2014). A novel deblurring process was applied to address the issue of over glow in the radiance-calibrated products. This process involves the use of two sequential filters, a standard deconvolution and the frequency of illumination maxima, to withdraw the light from the surroundings back and restacking it vertically on its source pixels at city centers (Abrahams et al., 2016).

Deblurred DMSP-OLS RC annual composites for the years 1996, 2000 and 2010 were previously inter-calibrated and corrected for a multi-temporal analysis of urban form and city productivity in Latin America (Duque et al., 2017). In that work, the three nighttime images were used to delineate urban extents in each year for most of the Latin American and Caribbean cities that had more than 50,000 people in 2010. We used those delineated urban extents for the year 2010 to identify the metropolitan areas in the region. We consider the presence of a metropolitan area when more than one municipality or equivalent administrative unit intersects a single urban extent with more than 500,000 people in 2010. We use the administrative unit boundaries from the World Bank Latin American and the Caribbean Spatial Framework Database (Branson et al., 2016) for this purpose. Metropolitan area boundaries were obtained by aggregation of all of the administrative units that intersected the same urban extent. We verified each obtained metropolitan area with ancillary information from official sources to include those municipalities that are part of the official metropolitan area denomination but were not intersected by the urban extent. Figure 2 presents some
examples of identified functional areas: Mexico City (Mexico), Rio de Janeiro (Brazil), and Buenos Aires (Argentina).

Figure 2. Examples of functional areas. Urban extents extracted from 2010 nighttime images (in red), over the GHSL Built-up layer for 2014 (Freire and Pesaresi, 2015), with administrative boundaries (light purple). From left to right: Mexico City (Mexico), Rio de Janeiro (Brazil), and Buenos Aires (Argentina).

4.3 Estimated productivity differentials, $\lambda_j$

As presented in section 3, the first step to estimate the relationship between institutional fragmentation and economic performance of cities consists of extracting the productivity differentials between functional areas by extracting first the sorting effect that causes that more skilled workforce have a tendency to live in larger cities (Ahrend et al., 2014; Combes et al., 2011). The vector of coefficients $\lambda_j$ in equation 1, which becomes the dependent variable in the second stage (equation 2), was provided by Quintero and Roberts (2017) who studied the spatial variations in productivity premiums in 16 LAC countries. In their study, the authors use micro data on real hourly wage in the main occupation. As independent variables the authors use: (1) a vector of observable characteristics per worker (age, gender, marital status, years of education completed, and hours worked in the main occupation); (2) a vector of job characteristics that each worker occupies (sector, formal/informal status, and type of company –large private, small private, and public-); and (3) municipality fixed effects, which is our dependent variable, $\lambda_j$, in equation 2. All the collected data cover the period 2000-2014. We report the results with two types of $\lambda_j$ that we are calling $\lambda_j^{broad}$ and $\lambda_j^{narrow}$: $\lambda_j^{broad}$ controls for the effects of sorting including all employed wage-workers aged from 14 to 65; $\lambda_j^{narrow}$ controls for the effects of sorting including male wage-workers employed in the private sector and aged from 20 to 55.
4.4 Measuring institutional fragmentation and metropolitan coordination

Based on the literature desk review and the available data, we construct a database with a series of variables to characterize the functional areas included in this study, in terms of institutional fragmentation and metropolitan coordination. We use the administrative boundaries of local governments that conform the metropolitan areas and distributed population data to calculate institutional fragmentation measures using geoprocessing tools in ArcGIS. Administrative boundaries were obtained from OpenStreetMap\(^3\) (April 25\(^{th}\) 2017) and the World Bank LAC Spatial Database (Branson et al., 2016). We projected the administrative boundaries and the urban extents to the UTM coordinate system to calculate areas in square kilometers. Population counts at the administrative unit and urban extent levels were estimated using the Global Human Settlement Layer (GHS) distributed population grids produced by the Joint Research Centre (JRC) of the European Union (Freire and Pesaresi, 2015; Pesaresi et al., 2016). These layers show population counts for each pixel at 250 meters of spatial resolution, and were produced for the years 1975, 1990, 2000 and 2015. We used the 2000 layer to account for the population in that same year, and the 2015 layer as proxy for the population in year 2010.

Metropolitan coordination variables were obtained through a number of official information sources to account for the presence of a metropolitan governance body and public services single purpose districts (see Table A1). Tables 3 and 4 present the list of available variables for institutional fragmentation and metropolitan coordination respectively. The descriptive statistics are presented in Table A2.

4.5 Control variables

In order to isolate the predictive power of the variables describing urban form and to reduce omitted-variable bias, we include in the model a number of control variables including city size, locational variables, natural and urban amenities, as well as country fixed effects. A number of different data sources are used to compute control variables. Population data in gridded format for 2010 were

\(^3\) http://www.openstreetmap.org/copyright
obtained from the GHS layers. Natural amenities were calculated using several GIS layers: Water bodies were used to calculate dummy variables for location near the sea (coast). We used the 250 meters resolution raster MODIS Water Mask (Carroll et al., 2009) for this purpose. Finally, we used the Lloyd’s lists of maritime and fluvial ports to account for the presence of ports. Table 5 presents the control variables.
Table 3. Institutional fragmentation variables (vector F).

| Dimension       | Variable          | Description                                      | Data source for calculation                                                                 |
|-----------------|-------------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|
| I. Size of region | no_adminunits     | Number of administrative units_2010             | OpenStreetMap boundaries data (20170420) and the World Bank LAC Spatial Database (integrated in a new vector layer: administrative unit boundaries) |
| II. Political fragmentation | no_au_100th_2010   | Number of administrative units per 100,000 inhabitants_2010 | Administrative unit boundaries and population count at pixel level from GHS (GHS_POP_PW42015_GLOBE_R2015A_54009_250_v1_0 at 250 meters of spatial resolution). |
| III. Central city domination | cc_pop_2010       | Central-city population share_2010             | Administrative unit boundaries and population count at pixel level from GHS (GHS_POP_GP42015_GLOBE_R2015A_54009_250_v1_0) |

Table 4. Metropolitan coordination variables (vector C).

| Dimension       | Variable          | Description                                      | Data source for calculation                                                                 |
|-----------------|-------------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|
| I. Governance   | gov_body          | Presence of a governance body                    | See Table A1                                                                                 |
| II. Land use plan and mobility | its_cov           | Percent of municipalities covered by integrated transport systems between municipalities and central city (metro, bus) | See Table A1                                                                                 |
| III. Coordination for single purpose districts | spd_water | Existence of a single-purpose districts for water collection | See Table A1                                                                                 |
|                 | spd_energy        | Existence of a single-purpose districts for energy | See Table A1                                                                                 |
|                 | spd_waste         | Existence of a single-purpose districts for waste collection | See Table A1                                                                                 |
|                 | spd_sum           | spd_water + spd_energy + spd_waste               | See Table A1                                                                                 |
Table 5. Control variables (vector $X$).

| Dimension       | Variable    | Description                                      | Data source for calculation                                                                 |
|-----------------|-------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------|
| I. Size         | pop_2010    | Sum of population count within the urban extent   | Urban extents 2010 and population count at pixel level from GHS for 2015 (GHS_POP_          |
|                 | density     | pop_2010/ areac_ue2010_km2                       | GPW42015_GLOBE_R2015A_54009_250_v1_0)                                                       |
| II. Location    | pop_radio300km | Inhabitants in other FUAs within a 300 km radius | Urban extents 2010 and population count at pixel level from GHS for 2015 (GHS_POP_          |
|                 |             | of a city/1,000,000                               | GPW42015_GLOBE_R2015A_54009_250_v1_0)                                                       |
| III. Natural Amenities | coast_2010 | Dummy for location at the coast                   | MODIS Water Mask (Carroll et al., 2009) and urban extents from deblurred and corrected DMSP- |
|                 |             |                                                  | OLS NTL RC 2010 data.                                                                        |
| VI. Urban Amenities | port       | Dummy for port                                   | Lloyd’s List (http://directories.lloydslist.com)                                             |
5 Empirical results

Table 6 and Table 7 present the estimates of the relationship between metropolitan fragmentation/coordination and city productivity premium. The results are pretty similar in both cases. Following Ahrend et al. (2014) we report in the first column the positive and significant impact of population on productivity premium, which implies that productivity is higher in larger cities. In this regard Ahrend et al. (2014) reported estimated elasticities that range from 0.016 (for the United Kingdom) to 0.063 (for the United States). In our study, we obtained an estimated elasticity of 0.08 for LAC cities. We also report the coefficients associated to the logged population density (i.e., elasticity of productivity with respect to population) and surface (i.e., elasticity of productivity with respect to area). The results show that an increase in population, while holding the area constant, and an increase in area, while holding population density constant, both have a positive and statistically significant impact on productivity. Finally, the difference between these two coefficients indicates that an increase in area, while holding the total population constant, generates elasticities from 0.04 to 0.07. This range is 0.02 higher than the elasticity range reported by Ahrend et al. (2014), 0.02 to 0.05.

The block of indicators for institutional fragmentation is reported in column (3) of Table 6 and Table 7. The results show opposite effects from fragmentation: on the one hand, the negative and statistically significant coefficient for the logged number of administrative units indicates that the presence of multiple local governments affects economic performance because of factors such as higher transactions costs, barriers to the diffusion of growth promoting policies, and other coordination failures (which is consistent with the centralist view). But, on the other hand, the positive and statistically significant coefficient for political fragmentation (no_{au_{100th_{2010}}}) indicates that the presence of multiple local governments may lead to more responsive government to public needs (Nelson and Foster, 1999). Also, “smaller [local governments] make participation easier, make citizens feel more empowered and interested in their communities, and bring neighbors together” (Oliver, 2010, 65). Finally, the negative and statistically significant coefficient for cc_{pop2010_{ue}}, indicates that an increase in central city domination may affect economic performance.
The fourth column in Table 6 and Table 7 includes the block of variables for metropolitan coordination. None of the coordination variables appears significant, which does not provide evidence in favor of the convenience of the regionalist model. It is important to note that these results are conditioned to the variables used to measure the degree of metropolitan coordination. Finally, column five shows that the above conclusions remain the same after including a series of control variables.
### Table 6: Estimates of the relationship between metropolitan fragmentation/coordination and city productivity premium (OLS).

\[
Y = \text{City productivity premium (}\lambda_j^{broad}\text{)}
\]

| Variable                         | (1)     | (2)     | (3)     | (4)     | (5)     |
|----------------------------------|---------|---------|---------|---------|---------|
| ln(pop 2010)                     | 0.087***|         |         |         |         |
|                                  | (0.0274)|         |         |         |         |
| ln(density)                      | 0.070** | 0.223***| 0.230***| 0.190***|         |
|                                  | (0.0289)| (0.0591)| (0.0595)| (0.0521)|         |
| ln(area_km2)                     | 0.112***| 0.285***| 0.281***| 0.270***|         |
|                                  | (0.0310)| (0.0644)| (0.0647)| (0.0577)|         |
| ln(no_admunits)                  | -0.202***| -0.198***| -0.180***|         |         |
|                                  | (0.0666)| (0.0671)| (0.0589)|         |         |
| no_au_100th_2010                 | 0.197** | 0.196** | 0.168** |         |         |
|                                  | (0.0776)| (0.0777)| (0.0701)|         |         |
| cc_pop2010_ue                    | -0.369***| -0.329** | -0.214* |         |         |
|                                  | (0.1305)| (0.1362)| (0.1222)|         |         |
| gov_body                         | -0.043  | -0.050  |         |         |         |
|                                  | (0.0502)| (0.0451)|         |         |         |
| its_cov                          | 0.000   | 0.001   |         |         |         |
|                                  | (0.0006)| (0.0005)|         |         |         |
| spd_sum                          | 0.036   | 0.038   |         |         |         |
|                                  | (0.0272)| (0.0242)|         |         |         |
| pop_radio300km                   | 0.007***|         |         |         |         |
|                                  | (0.0017)|         |         |         |         |
| coast_2010                       | 0.062   |         |         |         |         |
|                                  | (0.0681)|         |         |         |         |
| Port                             | -0.082  |         |         |         |         |
|                                  | (0.0603)|         |         |         |         |
| Constant                         | 0.049   | -0.073  | -1.974**| -2.067**| -1.909***|
|                                  | (0.3812)| (0.3829)| (0.7885)| (0.7918)| (0.6988)|
| Country dummies                  | Y       | Y       | Y       | Y       | Y       |
| Observations                     | 73      | 73      | 73      | 73      | 73      |
| Adjusted R-squared               | 0.630   | 0.641   | 0.692   | 0.692   | 0.768   |

Note: Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
Table 7. Estimates of the relationship between metropolitan fragmentation/coordination and city productivity premium (OLS).

\[ Y = \text{City productivity premium (} \lambda \text{narrow}) \]

| Variable | (1) | (2) | (3) | (4) | (5) |
|----------|-----|-----|-----|-----|-----|
| ln(pop 2010) | 0.086*** | | | | |
| ln(density) | 0.066** | 0.229*** | 0.236*** | 0.202*** | (0.0322) (0.0649) (0.0656) (0.0568) |
| ln(area_km2) | 0.115*** | 0.301*** | 0.295*** | 0.276*** | (0.0345) (0.0707) (0.0713) (0.0629) |
| ln(no_adminunits) | -0.220*** | -0.214*** | -0.191*** | | (0.0733) (0.0739) (0.0642) |
| no_a100th_2010 | 0.204** | 0.203** | 0.171** | | (0.0853) (0.0856) (0.0764) |
| cc_pop2010_ue | -0.470*** | -0.423*** | -0.284** | | (0.1435) (0.1501) (0.1331) |
| gov_body | | -0.046 | -0.056 | | (0.0553) (0.0491) |
| its_cov | 0.000 | 0.000 | | | (0.0007) (0.0006) |
| spd_sum | 0.035 | 0.036 | | | (0.0299) (0.0263) |
| pop_radio300km | | | | | (0.0019) |
| coast_2010 | | | | | 0.062 |
| Port | | | | | -0.119* |
| Constant | -0.025 | -0.164 | -2.142** | -2.233** | -1.995** | (0.4251) (0.4264) (0.8666) (0.8724) (0.7613) |
| Country dummies | Y | Y | Y | Y | Y |
| Observations | 73 | 73 | 73 | 73 | 73 |
| Adjusted R-squared | 0.685 | 0.694 | 0.745 | 0.743 | 0.811 |

Note: Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6. Conclusions

This paper studies the impact of metropolitan fragmentation/coordination on economic performance of 73 metropolitan areas in the Latin America and Caribbean region. This contribution offers complementary evidence on the relationship between institutional fragmentation/coordination and economic performance, since most of the available literature in this topic is concentrated on developed countries.
Following the latest contributions in the literature, we implemented a two-step econometric approach in which we control for individual sorting of highly skilled individuals into cities. We also take advantage of recent developments in remote sensing science and free geospatial libraries to delineate urban extents and identify metropolitan areas in an automatic and highly standardized way, which guarantees comparability across LAC cities.

The available literature has not arrived to a definitive answer on this topic, and there is evidence in favor of the three potential models: polycentric, centralist and regionalist. Our results show that there may exist an optimal level of fragmentation in which the benefits of more responsive government are in balance with the higher costs associated to the presence of multiple local governments within the same functional area. This may indicate that in LAC cities the right model is somewhere in between the polycentric and the centralist governance structures. We found no evidence in favor of the regionalist view, since our results show that the presence of a governance body or integrated public services does not necessarily foster increased productivity.

In line with previous contributions we found that economic performance increases with city size. While evidence for OECD countries indicates that doubling city size may increase economic performance between 2% and 5% (Ahrend et al., 2014); for LAC cities, we found an impact that ranges from 4% to 7%.

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## Appendix

### Table A1. Data sources.

| ISO | Central City | gov_body | spd_Water |
|-----|--------------|----------|-----------|
| ARG | Salta        | Ministerio del Interior | Aguas del Norte |
| ARG | Buenos Aires | Región Metropolitana de Buenos Aires y del Conurbano Bonaerense | Águas Bonaerenses |
| ARG | Cordoba      | Gobierno de la Provincia de Córdoba | Aguas Cordobesas |
| ARG | Mendoza      | Mendoza Gobierno |  |
| ARG | Rosario      | Gobierno de Rosario | Gobierno de Santa Fe |
| ARG | Tucuman      | Observatorio de Fenómenos Urbanos y Territoriales | Ministerio del Interior |
| BOL | Cochabamba   | Gaceta Oficial del Estado Plurinacional de Bolivia | Servicio municipal de agua potable y alcantarillado sanitario (SEMAPA) |
| BOL | La Paz       | Ministerio de Autonomías | Empresa Pública Social del Agua y Saneamiento S.A. (EPSAS) |
| BOL | Santa Cruz   |  | Autoridad de Agua Potable y Saneamiento Basico |
| BRA | Aracaju      |  |  |
| BRA | Belém        | Procuraduría General del Estado de Pará | Agência Reguladora Municipal de Água e Esgoto de Belém |
| BRA | Belo Horizonte | Agencia Região Metropolitana de Belo Horizonte | Companhia de Saneamento de Minas Gerais – COPASA |
| BRA | Brasilia     |  | Companhia de Saneamento Ambiental do Distrito Federal |
| BRA | Campinas     | Gobierno de Sao Paulo | Sociedade de Abastecimento de Agua S/A - Sanasa |
| BRA | Cuiaba       | Portal Transparencia | Departamento de Água e Esgoto de Várzea Grande -DAE. |
| BRA | Curitiba     | Coordenacao da Regiao Metropolitana de Curitiba (COMEC) | Companhia de Saneamento do Paraná -Sanepar- |
| BRA | Florianopolis| Gobierno de Estado de Amazonas | Companhia Catarinense de Águas e Saneamento -Casan- |
| BRA | Fortaleza    | Secretaria do Desenvolvimento Local e Regional | Companhia de Água e Esgoto do Ceará -CAGECE- |
| BRA | Joao Pessoa  | Estado do Paraiba | Companhia de Água e Esgotos da Paraíba -CAGEPA- |
| BRA | Joinville    |  |  |
| BRA | Londrina     | Empresa Paulista de Planejamento Metropolitano (EMPLASA) | Companhia de Saneamento do Paraná -Sanepar- |
| BRA | Maceio       | Empresa Paulista de Planejamento Metropolitano (EMPLASA) | Companhia de Saneamento de Alagoas |
| BRA | Manaus       | Gobierno de Estado de Amazonas | Grupo Aguas do Brasil |
| BRA | Natal        |  | Companhia de Saneamento de Minas Gerais – COPASA |
| BRA | Porto Alegre | Associação dos Municípios da Região Metropolitana de Porto Alegre - Granpal | Companhia Riograndense de Saneamento -Corsan- |
| BRA | Recife       | Consejo de Recife | Companhia Pernambucana de Saneamento -Compesa- |
| BRA | Ribeirao Preto |  | GS Inima Brasil |
| BRA | Rio de Janeiro | Asamblea Legislativa de Rio de Janeiro | Companhia Estadual de Águas e Esgotos -CEDAE- |
| BRA | Salvador Bahia |  | Companhia de Águas e Esgotos de Rondônia -Caerd- |
| BRA | Santos       | Agência Metropolitana da Baixada Santista (AGEM) | Companhia de Saneamento Básico do Estado de São Paulo S.A. -Sabesp- |
| BRA | Sao Jose Dos Campos | Consejo Metropolitano de San José de los Campos | Portal Saneamento Basico |
| BRA | Sao Luis     |  | Companhia de Saneamento Ambiental do Maranhão -CAEMA- |
| BRA | Sao Paulo    | Empresa Paulista de Planejamento Metropolitano (EMPLASA) | Companhia Estadual de Águas e Esgotos do Rio de Janeiro (CEDAE) |
| BRA | Sorocaba     | Empresa Paulista de Planejamento Metropolitano (EMPLASA) | Prefeitura de Sorocaba |
| BRA | Teresina     | Instituto Brasileiro de Geografia e Estatistica | Águas e Esgotos do Piauí S.A. -Agespia- |
| BRA | Vitoria      | Instituto Jones dos Santos Neves (IJSN) | Companhia Espírito Santense de Saneamento -Cesan- |

*Continue next page*
Table A1. Data sources (cont.)

| ISO | Central City | gov_body | spd_Water |
|-----|--------------|----------|-----------|
| CHL | Santiago     | Biblioteca del Congreso Nacional de Chile | Aguas Andinas |
| COL | Barranquilla | Área Metropolitana de Barranquilla | Triple A S.A. |
| COL | Bogotá       | Supervisoria de Servicios Públicos Domiciliarios | |
| COL | Bucaramanga  | Área Metropolitana de Bucaramanga | Supervisoria de Servicios Públicos Domiciliarios |
| COL | Cali         | | Aguas de Palmira S.A. |
| COL | Cucuta       | Área Metropolitana de Cucuta | Plan Departamental de Agua de Norte de Santander |
| COL | Medellín     | Área Metropolitana Valle de Aburrá | Empresas Publicas de Medellín (EPM) Aguas |
| COL | Pereira      | Área Metropolitana Centro Occidente | Supervisoria de Servicios Públicos Domiciliarios |
| CRI | San José     | Ministerio de Viviendas y Acountamientos Urbanos | Instituto Costarricense de Acueductos y Alcantarillados |
| DOM | Santo Domingo | | Coordinación de Agua y Alcantarillado (CAASD) |
| ECU | Guayaquil    | | Interagua |
| GTM | Guatemala    | | Municipalidad de Guatemala |
| GTM | Quetzaltenango | | Empresa Municipal de Agua y Alcantarillado "Virgen Guadalupe del Sur" (EMAPAVIGS) |
| MEX | Chihuahua    | | Junta Municipal de Agua y Saneamiento de Chihuahua |
| MEX | Cuernavaca   | | Sistema de conservación, agua potable y saneamiento de agua de Temixco, Morelos (SACPSATM) |
| MEX | Tuxtla Gutiérrez | | Sistema Municipal de Agua Potable y Alcantarillado (SMAPA) |
| MEX | Aguascalientes | | Compañía de servicios públicos de agua en Aguaasclientes (CAASA) |
| MEX | Cancún       | | Aguakan S.A. de C.V. |
| MEX | Ciudad de México | | Comisión Nacional del Agua (CONAGUA) |
| MEX | Guadalajara  | | Sistema Intermunicipal de los Servicios de Agua Potable y Alcantarillado (SIAPA) |
| MEX | Mérida       | | Junta de Agua Potable y Alcantarillado de Yucatán |
| MEX | Monterrey    | | Servicios de Agua y Drenaje de Monterrey -SADAM- |
| MEX | Morelia      | | Comité de Agua Potable y Alcantarillado del Municipio de Tarimbaro - Comapat- |
| MEX | Puebla       | | Concesiones Integrales Puebla |
| MEX | Querétaro    | | Comisión Estatal de Aguas Querétaro |
| MEX | Saltillo     | | Aguas de Saltillo |
| MEX | San Luis Potosí | | Compañía de servicios públicos de Agua -INTERAPAS- |
| MEX | Tampico      | | Comisión Municipal de Agua Potable y Alcantarillado -COMAPA- |
| MEX | Toluca       | | Secretaria de Desarrollo Metropolitano Valle de Toluca |
| MEX | Torreon      | | Sistema Municipal de Agua y Saneamiento -SIMAS - |
| MEX | Veracruz     | | Comisión del Agua del Estado de Veracruz (CAEV) |
| PAN | Ciudad de Pánama | | Autoridad Nacional de Servicios Públicos -ASEP- |
| PER | Arequipa     | Municipalidad distrital de Pucusana | Servicio de agua potable y Alcantarillado de Arequipa S.A. (SEDAPAR) |
| PER | Lima         | Municipalidad distrital de Pucusana | Servicio de agua potable y Alcantarillado de Lima S.A. (SEDAPAL) |
| PER | Trujillo     | Plan de Desarrollo Territorial de Trujillo (PLANDET) | Servicio de agua potable y Alcantarillado de la Libertad -SEDALIB S.A- |
| PRY | Asunción     | | Empresa de Servicios Sanitarios del Paraguay S.A. (ESSAP) |
| SLV | San Salvador | Oficina de la Administración de El Salvador (OPAMSS) | Administración Nacional de Acueductos y Alcantarillados (ANDA) |

Continue next page
Table A1. Data sources (cont.)

| ISO | Central City | spd_Energy | spd_Waste_e |
|-----|--------------|------------|-------------|
| ARG | Salta | Empresa Distribuidora de Electricidad de Salta S.A. (EDESA) | Ministerio del Interior |
| ARG | Buenos Aires | Compañía Administradora del Mercado Mayorista Eléctrico (CAMMESA) | Coordinación Ecológica Área Metropolitana Sociedad del Estado (CEAMSE) |
| ARG | Cordoba | Empresa Provincial de Energía de Córdoba | Logística Urbana S.A. (LUSA) |
| ARG | Mendoza | Empresa Mendocina de Energía -Emesa- | Limpieza Metropolitana S.A. E.S.P. (LIME) |
| ARG | Rosario | Empresa Provincial de la Energía de Santa Fe | Limp AR Rosario S.A. |
| ARG | Tucuman | Ministerio del Interior | Ministerio del Interior |
| BOL | Cochabamba | Empresa de Luz y Fuerza Electrica Cochabamba (ELFEC) | Servicio Municipal de Agua Potable y Alcantarillado COCHABAMBA |
| BOL | La Paz | Distribuidora de Electricidad La Paz (DELAPAZ) | Empresas pública social de Agua y Saneamiento EPSAS |
| BOL | Santa Cruz | Compañía Eléctrica Central Bulo Bulo S.A. | Autoridad de Fiscalización y Control Social de Agua Potable y Saneamiento Básico AAPS |
| BRA | Aracaju | Grupo Energisa | Prefectura de Rio de Janeiro |
| BRA | Belém | BELEM BIOENERGIA BRASIL | Prefectura Municipal de Belém |
| BRA | Belo Horizonte | Compañía Energética de Minas Gerais | Agencia Região Metropolitana de Belo Horizonte -RMBH- |
| BRA | Brasilia | Compañía Energética de Brasilia | Gobierno de Brasilia |
| BRA | Campinas | Compañía Paulista de Força e Luz | MB Ingeniería y Medio Ambiente |
| BRA | Cuiaba | Centrais Elétricas Matogrossenses (CEMAT) | Prefectura Cuiabá |
| BRA | Curitiba | Compañía Paranaense de Energia | Ares do Paraná |
| BRA | Florianopolis | Centrais Elétricas de Santa Catarina S.A. (Celesc) | Prefectura de Florianópolis |
| BRA | Fortaleza | Compañía de energía sostenible- Ener Brasil | Grupo Taborda |
| BRA | Joao Pessoa | Energisa | Marquesi Ambiental |
| BRA | Joinville | Centrais Elétricas de Santa Catarina S.A. (Celesc) | Ambiental |
| BRA | Londrina | Compañía Paranaense de Energia | Colecta e destinacao do resíduos BIOACCESS |
| BRA | Maceio | Eletrobras | Consorcio público de saneamento básico da bacia hidrográfica do Rio Dos Santos |
| BRA | Manaus | Eletrobras Amazonas Energia | Manaus Limpia |
| BRA | Natal | Biomassa BR | Banco de Brasil |
| BRA | Porto Alegre | Energia Proyectos e Investigación | Prefectura de Porto Alegre |
| BRA | Recife | Grupo privado electrico do Brasil- Neoenergia | Grupo recolección de residuos sólidos (RELIMA SOLVÍ) |
| BRA | Ribeirao Preto | Compañía Paulista de Força e Luz | Koleta Ambiental S.A. |
| BRA | Rio de Janeiro | Enel Green Power Brasil | Compañía Municipal de Limpieza Urbana |
| BRA | Salvador Bahia | Compañía de Eléctricidade do Estado da Bahia | Koleta Ambiental S.A. |
| BRA | Santos | Compañía Paulista de Força e Luz | Total Waste Management AMBIENTAL BRASIL |
| BRA | Sao Jose Dos Campos | EDP Energias do Brasil | Urbanizadora Municipal -URBAM- |
| BRA | Sao Luis | Novus Energia Sao Luis | Coleta de Oleo de Frita Indama |
| BRA | Sao Paulo | Enel distribuciao S.A | Resíduos e gestão ambiental Utresas |
| BRA | Sorocaba | Votorantim Energia | Prefectura de Sorocaba |
| BRA | Teresina | Electrobras Distribuição Plaui | Prefectura Municipal de Teresina |
| BRA | Vitoria | Interconexión Eléctrica S.A. E.S.P. - ISA - | Vitoria Ambiental |

Continue next page
Table A1. Data sources (cont.)

| ISO | Central City     | spd_Energy                                      | spd_Waste | c   |
|-----|------------------|------------------------------------------------|-----------|
| CHL | Santiago         | Enel Distribución Chile S.A.                   | Sistema Nacional de Información Ambiental de Chile (SINIA) |
| COL | Barranquilla     | Comisión de Regulación de Energía y Gas        | Edumas    |
| COL | Bogotá           | Grupo Energía de Bogotá                        | ASEO Internacional S.A. |
| COL | Bucaramanga      | Comisión de Regulación de Energía y Gas        | Proactiva |
| COL | Cali             | Celsia S.A. E.S.P                              | Proactiva |
| COL | Cucuta           | Centrales Eléctricas del Norte de Santander S.A E.S.P (CENS) | Grupo Sala |
| COL | Medellín         | Empresas Publicas de Medellín (EPM)            | Emvarias  |
| COL | Pereira          | Superintendencia de Servicios Públicos Domiciliarios | Asopereira |
| CRI | San José         | Instituto Costarricense de Electricidad (ICE)  | Empresas Berthier EBI de Costa Rica S.A. |
| DOM | Santo Domingo    | Comisión Nacional de Energía                   | Ecoservis Dominicana |
| ECU | Guayaquil        | Empresa Energía Publica                         | Puerto Limpio |
| GTM | Guatemala        | Empresa Eléctrico de Guatemala S.A. (EEGSA)    | Info Ciudad |
| MEX | Chihuahua        | Comisión Federal de Electricidad               | Naciones Unidas |
| MEX | Cuernavaca       | Comisión Federal de Electricidad               | Aseca S.A. |
| MEX | Tuxtla Gutiérrez | Comisión Federal de Electricidad               | Limpia y Aseo Público Municipal Tuxtla |
| MEX | Aguascalientes  | Comisión Federal de Electricidad               | Aguascalientes Gobierno de Estado |
| MEX | Cancún           | Comisión Federal de Electricidad               | Solución integral de residuos sólidos cancún (SIRESOL) |
| MEX | Ciudad de México | Comisión Federal de Electricidad               | Dirección General de Servicios Urbanos |
| MEX | Guadalajara      | Comisión Federal de Electricidad               | Ayuntamiento de Merida |
| MEX | Mérida           | Comisión Federal de Electricidad               | General Ambiental |
| MEX | Monterrey        | Comisión Federal de Electricidad               | Biosistem Mexico S.A de C.V. |
| MEX | Morelia          | Comisión Federal de Electricidad               | Biosistem Mexico S.A de C.V. |
| MEX | Puebla           | Comisión Federal de Electricidad               | Gen Industrial S.A. de C.V. |
| MEX | Querétaro        | Comisión Federal de Electricidad               | Gobierno Saltillo |
| MEX | Saltillo         | Comisión Federal de Electricidad               | Promotora Ambiental |
| MEX | San Luis Potosi | Comisión Federal de Electricidad               | Desechos Basuras y Servicios SA |
| MEX | Tampico          | Comisión Federal de Electricidad               | General Ambiental |
| MEX | Toluca           | Comisión Federal de Electricidad               | Recicladora Siderúrgica de la Laguna S.A. de C.V. (RESILASA) |
| MEX | Torreon          | Comisión Federal de Electricidad               | Secretaria de Medio Ambiente y Recursos Naturales (SEMARNAT) |
| PAN | Ciudad de Pánama | Empresa de Transmisión Eléctrica S.A.          | Panama Waste Management (PWM) |
| PER | Arequipa         | Sociedad Electrica del Sur Oeste S.A. (SEAL)   | Relima Solvi |
| PER | Lima             | Responsabilidad Social y Desarrollo Sostenible | Municipalidad metropolitana de Lima |
| PER | Trujillo         | Distribuzione S.A.                             | PROMAS Servicios Ambientales |
| PRY | Asunción         | Administracion Nacional de Electricidad (ANDE)  | Dirección Nacional de Contrataciones Públicas |
| SLV | San Salvador     | AES El Salvador Energia                        | Ministerio de Medio Ambiente y Recursos Naturales |
### Table A1. Data sources (cont.)

| ISO | Central City | **its cov** | port |
|-----|--------------|-------------|------|
| ARG | Salta        | Sociedad Anónima del Estado de Transporte Automotor - SAETA | Lloyd's List |
| ARG | Buenos Aires | Ferrocarriles Metropolitanos Area Metropolitana de Buenos Aires | Lloyd's List |
| ARG | Cordoba      | Transporte automotor municipal sociedad del estado | Lloyd's List |
| ARG | Mendoza      | Mendoza Gobierno | Lloyd's List |
| ARG | Rosario      | Instituto Nacional de Estadística y Censos de la República Argentina (INDEC) | Lloyd's List |
| ARG | Tucuman      | Ministerio del Interior | Lloyd's List |
| BOL | Cochabamba   | Banco Interamericano de Desarrollo | Lloyd's List |
| BOL | La Paz       | La Paz Bus | Lloyd's List |
| BOL | Santa Cruz   | Centro de Estudios para el Desarrollo Urbano y Regional (CEDURE) | Lloyd's List |
| BRA | Aracaju      | Grupo Parvi | Lloyd's List |
| BRA | Belém        | Instituto de Pesquisa Econômica Aplicada (IPEA) | Lloyd's List |
| BRA | Belo Horizonte | Compañía Brasileira de Trens Urbanos | Lloyd's List |
| BRA | Brasilia     | Secretaria de Estado de Distrito Federal | Lloyd's List |
| BRA | Campinas     | Empresa Metropolitana de Transportes Urbanos de São Paulo | Lloyd's List |
| BRA | Cuiaba       | República Federativad Brasil | Lloyd's List |
| BRA | Curitiba     | Urbanização de Curitiba URBS | Lloyd's List |
| BRA | Florianopolis | Consórcio Fénix | Lloyd's List |
| BRA | Fortaleza    | Omnibus do Fortaleza Fortalbus | Lloyd's List |
| BRA | Joao Pessoa  | Companhia Brasileira de Trens Urbanos | Lloyd's List |
| BRA | Joinville    | Gidion Transporte e Turismo Ltda y Transtusa | Lloyd's List |
| BRA | Londrina     | Encontro Nacional da Anpege | Lloyd's List |
| BRA | Maceio       | Companhia Brasileira de Trens Urbanos | Lloyd's List |
| BRA | Manaus       | Departamento Nacional de Infraestrutura de Transportes | Lloyd's List |
| BRA | Natal        | Companhia Ferroviaria del Nordeste, CFN | Lloyd's List |
| BRA | Porto Alegre  | A Fundação Estadual de Planejamento Metropolitano e Regional - Metropplan | Lloyd's List |
| BRA | Recife       | Companhia Brasileira de Trens Urbanos CBTU | Lloyd's List |
| BRA | Ribeirao Preto | Red Ferroviaria Federal Sociedad Anónima | Lloyd's List |
| BRA | Rio de Janeiro | Metrorio | Lloyd's List |
| BRA | Salvador Bahia | Empresa Metropolitana de Transportes Urbanos | Lloyd's List |
| BRA | Santos       | Empresa Metropolitana de Transportes Urbanos | Lloyd's List |
| BRA | Sao Jose Dos Campos | Universidade de Taubaté - UNITAU | Lloyd's List |
| BRA | Sao Luis     | Secretaria Municipal de Trânsito e Transporte Sao Luis | Lloyd's List |
| BRA | Sao Paulo    | Companhia Brasileira de Trens Urbanos | Lloyd's List |
| BRA | Sorocaba     | Empresa Metropolitana de Transportes Urbanos | Lloyd's List |
| BRA | Teresina     | Mobilitade Urbana Sustentável (Mobilize) | Lloyd's List |
| BRA | Vitoria      | Instituto de Pesquisa Econômica Aplicada (IPEA) | Lloyd's List |
Table A1. Data sources (cont.)

| ISO | Central City | its cov                              | port                        |
|-----|--------------|--------------------------------------|-----------------------------|
| CHL | Santiago     | Empresa de los Ferrocarriles del Estado (EFE) | Lloyd's List                |
| COL | Barranquilla | Departamento Nacional de Planeación  | Lloyd's List                |
| COL | Bogotá       | Sistema Integrado de Transporte Bogotá | Lloyd's List                |
| COL | Bucaramanga  | Metrolínea                           | Lloyd's List                |
| COL | Cali         | Metrocali                            | Lloyd's List                |
| COL | Cucuta       | Área Metropolitana de Cúcuta          | Lloyd's List                |
| COL | Medellín     | Metro de Medellín                    | Lloyd's List                |
| COL | Pereira      | Área Metropolitana Centro Occidente  | Lloyd's List                |
| CRI | San José     | Instituto Costarricense de Ferrocarriles (Incofer) | Lloyd's List                |
| DOM | Santo Domingo| Metro Santo Domingo                  | Lloyd's List                |
| ECU | Guayaquil    | Metrovia                             | Lloyd's List                |
| GTM | Guatemala    | Municipalidad de Guatemala           | Lloyd's List                |
| GTM | Quetzaltenango | Sistema de Registro Fiscal de Vehículos | Lloyd's List                |
| MEX | Chihuahua    | Gobierno de Chihuahua                | Lloyd's List                |
| MEX | Cuemavaca    | Secretaría de Movilidad y Transporte | Lloyd's List                |
| MEX | Tuxtla Gutiérrez |                                    | Lloyd's List                |
| MEX | Aguascalientes | Gobierno de Aguascalientes         | Lloyd's List                |
| MEX | Cancún       | Marítima Isla Mujeres S.A.           | Lloyd's List                |
| MEX | Ciudad de México | Ferrocarriles Suburbanos        | Lloyd's List                |
| MEX | Guadalajara  | Sistema de Tren Eléctrico urbano (SITEUR) | Lloyd's List                |
| MEX | Mérida       | Yucatan-Sistema Integral de Transporte Urbano | Lloyd's List                |
| MEX | Monterrey    | Transmetro Monterrey                | Lloyd's List                |
| MEX | Morelia      |                                      | Lloyd's List                |
| MEX | Puebla       | Rutapuebla                          | Lloyd's List                |
| MEX | Querétaro    |                                      | Lloyd's List                |
| MEX | Saltillo     | Gobierno de Coahuila                | Lloyd's List                |
| MEX | San Luis Potosi | Secretaría de comunicaciones y transporte | Lloyd's List                |
| MEX | Tampico      | Turutadirecta                       | Lloyd's List                |
| MEX | Toluca       |                                      | Lloyd's List                |
| MEX | Torreón      | El Siglo de Torreón                 | Lloyd's List                |
| MEX | Veracruz     | Gobierno de Veracruz                | Lloyd's List                |
| PAN | Ciudad de Pánama | Metro de Panamá                     | Lloyd's List                |
| PER | Arequipa     | Municipalidad Provincial de Arequipa | Lloyd's List                |
| PER | Lima         | Protransporte                        | Lloyd's List                |
| PER | Trujillo     | Transporte Metropolitano de Trujillo | Lloyd's List                |
| PRY | Asunción     | Ministerio de Obras Publicas y Comunicación | Lloyd's List                |
| SLV | San Salvador | SUBES El Salvador                   | Lloyd's List                |
Table A2. Descriptive statistics.

| Variable               | n  | p25 | Median | p75 | Mean  | Std. Dev. | Min   | Max   |
|------------------------|----|-----|--------|-----|-------|-----------|-------|-------|
| $\lambda^broad_j$     | 73 | 0.84| 1.02   | 1.28| 1.05  | 0.30      | 0.12  | 1.65  |
| $\lambda^narrow_j$    | 73 | 0.91| 1.12   | 1.43| 1.16  | 0.36      | 0.17  | 1.88  |
| pop_2010              | 73 | 902,390.50 | 1,573,563.00 | 2,922,544.00 | 2,699,436.00 | 3,698,464.00 | 203,131.10 | 21,200,000.00 |
| density               | 73 | 276.17 | 506.37 | 905.83 | 819.88 | 902.17 | 18.08 | 4217.76 |
| no_adminunits         | 73 | 4.00 | 7.00   | 15.00| 12.26 | 12.41     | 2.00  | 76.00 |
| no_au_100th_2010      | 73 | 0.30 | 0.49   | 0.77 | 0.66  | 0.59      | 0.02  | 3.29  |
| cc_pop2010_ue         | 73 | 0.31 | 0.50   | 0.63 | 0.48  | 0.20      | 0.07  | 0.87  |
| gov_body              | 73 | 0.00 | 1.00   | 1.00 | 0.53  | 0.50      | 0.00  | 1.00  |
| its_cov               | 73 | 0.00 | 57.89  | 100.00 | 50.51 | 44.11    | 0.00  | 100.00 |
| sd_p_sum              | 73 | 1.00 | 1.00   | 2.00 | 1.34  | 0.85      | 0.00  | 3.00  |
| pop_radio300km        | 73 | 1.10 | 5.00   | 12.97| 9.64  | 11.72     | 0.00  | 43.55 |
| coast_2010            | 73 | 0.00 | 0.00   | 1.00 | 0.40  | 0.49      | 0.00  | 1.00  |
| port                  | 73 | 0.00 | 0.00   | 1.00 | 0.40  | 0.49      | 0.00  | 1.00  |

Table A3. Correlation matrix

| Variable               | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
|------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| $\lambda^broad_j$     |     |     |     |     |     |     |     |     |     |      |      |      |      |
| $\lambda^narrow_j$    | 0.9635* | 1   |     |     |     |     |     |     |     |      |      |      |      |
| pop_2010              | 0.2702* | 0.2535* | 1   |     |     |     |     |     |     |      |      |      |      |
| density               | -0.2407* | -0.2453* | 0.5129* | 1   |     |     |     |     |     |      |      |      |      |
| no_adminunits         | 0.3112* | 0.3383* | 0.6523* | 0.1673 | 1   |     |     |     |     |      |      |      |      |
| no_au_100th_2010      | 0.099 | 0.1064 | -0.2613* | -0.2811* | 0.3111* | 1   |     |     |     |      |      |      |      |
| cc_pop2010_ue         | -0.0931 | -0.1423 | 0.024 | -0.0375 | -0.2978* | -0.3172* | 1   |     |     |      |      |      |      |
| gov_body              | 0.2411* | 0.2446* | 0.2475* | 0.1643 | 0.3095* | 0.0848 | -0.0765 | 1   |     |     |      |      |      |

*Indicates significance at the 0.05 level.
| Variable                  | its_cov (9) | sdp_sum (10) | pop_radio300km (11) | coast_2010 (12) | port (13)   |
|--------------------------|-------------|--------------|---------------------|-----------------|-------------|
|                         | 0.4804*     | 0.4951*      | 0.0562              | -0.0561         | 0.138       |
|                         |             |              | 0.138               | -0.1966         | 0.0683      |
|                         |             |              |                     |                 | 0.2482*     |
|                         |             |              |                     |                 | 1           |
|                         |             |              |                     |                 |             |
|                         | 0.1662      | 0.075        | -0.0893             | -0.1575         | 0.0531      |
|                         |             |              | 0.0531              | 0.1306          | -0.0905     |
|                         |             |              |                     |                 | 0.0533      |
|                         |             |              |                     |                 | 0.1031      |
|                         |             |              |                     |                 | 1           |
|                         |             |              |                     |                 |             |
|                         | 0.227       | 0.2252       | 0.0914              | 0.0192          | 0.1659      |
|                         |             |              |                     | 0.0825          | -0.1059     |
|                         |             |              |                     |                 | 0.0813      |
|                         |             |              |                     |                 | -0.0544     |
|                         |             |              |                     |                 | 0.0352      |
|                         |             |              |                     |                 | 1           |
|                         |             |              |                     |                 |             |
|                         | 0.1255      | 0.1678       | 0.0871              | 0.1957          | -0.0285     |
|                         |             |              |                     |                 | -0.1038     |
|                         |             |              |                     |                 | -0.0021     |
|                         |             |              |                     |                 | -0.0277     |
|                         |             |              |                     |                 | 0.1957      |
|                         |             |              |                     |                 | -0.1629     |
|                         |             |              |                     |                 | -0.0777     |
|                         |             |              |                     |                 | 1           |
|                         |             |              |                     |                 |             |
|                         | 0.0384      | 0.0513       | -0.0698             | 0.133           | -0.1035     |
|                         |             |              |                     |                 | 0.0913      |
|                         |             |              |                     |                 | -0.0067     |
|                         |             |              |                     |                 | 0.0284      |
|                         |             |              |                     |                 | 0.1455      |
|                         |             |              |                     |                 | -0.0308     |
|                         |             |              |                     |                 | -0.1197     |
|                         |             |              |                     |                 | 0.7712*     |
|                         |             |              |                     |                 | 1           |