Governance Fragmentation and Urban Spatial Expansion:
Evidence from Europe and the United States

Abstract

This study assesses the effects of urban governance structure on the spatial expansion of metropolitan areas. A more fragmented governance structure, represented by a high number of administrative units with decision power on land use per inhabitant, is expected to increase the competition between small towns in the suburbs of metropolitan areas to attract households and workers, which, in turn, induces more land uptake. We study empirically the relationship between administrative fragmentation and the spatial size of cities in a sample of 180 metropolitan areas in the contexts of the US and Europe in the period 2000-2012. Results shed light on the structural differences between the two broad regions and suggest that administrative fragmentation impacts positively on land uptake in both the United States and Europe, although to different extents.

Keywords:
Land take
Governance fragmentation
City size
United States and Europe

1 Introduction

Urban sprawl has become an increasingly common feature of modern cities in almost all regions of the world, although with substantial differences among geographical contexts and institutional settings. Nowadays, more than half of the world population lives in metropolitan areas, and the total urban population will approach 60% of the total by 2030 (UN DESA Population Division 2019), with significant impacts on land use, especially on the ecosystems and their capacity to provide essential services. This trend poses significant challenges to the management of cities.

The spatial expansion of cities occurs at the expenses of the environment with multiple effects such as the degradation of natural resources (Jaeger & Schwick 2014), the loss of soil biodiversity (Mcdonald et al. 2008, Turbé et al. 2010), the reduction of groundwater regeneration (Siedentop & Fina 2012), the interruption of ecosystem services supply (Mcdonald et al. 2008), and the loss of soil capacity to act as a carbon sink (Seto et al. 2012). Not surprisingly, many consider urban expansion as socially undesirable regardless of its determinants. Claims against low-density and spatially fragmented urban development, in particular, encouraged the adoption of measures to contrast land take, whose effectiveness has been an object of attention in empirical literature (Wassmer 2006). Few studies indicate, however, that even when containment policies are effective at the local level, their implementation may reach out the opposite outcome outside the specific implementation zone. For instance, Brueckner & Sridhar (2012) find that imposing urban land growth control generates urban development and sprawl outside the core in Indian cities. Similarly, results provided by Irwin & Bockstael (2004) suggest that the positive effect of land use policy implementation in an area may be outweighed by the development of land outside that area. This evidence suggests that the lack of coordination of planning policies among the authorities in the same area is an obstacle to the effectiveness of land containment policies and highlights, in turn, the crucial role of the governance of metropolitan cities. After all, as Glaeser & Kahn (2004) argue, eluding planning policies is easier in very fragmented and decentralised settings as developers can easily move to neighbouring places.

Existing research on the impact of urban governance fragmentation on sprawl provides evidence of a positive relationship. Carruthers & Ulfarsson (2002) base their analysis on a sample of US counties and find a positive statistical association between fragmentation and several indicators of urban sprawl. A similar exercise is carried out in Carruthers (2003), where the author finds a positive impact of fragmentation on the urban growth occurring at the fringe of the city, where density is at its lowest. Although Paulsen

(2014) includes institutional fragmentation among the causes of urban sprawl in US metropolitan regions, his conclusions do not point towards a clear understanding of the role of governance. To the best of our knowledge, in Europe, the only empirical study is conducted by Ehrlich et al. (2018), and it considers the correlation between measures of fragmentation and sprawl at the country level.

In the urban economics literature, the causes of sprawl are investigated with the Brueckner & Fansler (1983)'s model. The model conveys the insights of the Alonso-Mills-Muths (AMM) model of spatial structure (Alonso et al. 1964, Mills 1967, Muth 1969) into a regression equation of the total urbanised area on total population, median income, and proxy for transportation costs and farmland values to test for the validity of the AMM framework. Over the years, different works have confirmed the strength of this model implementing it on samples of US cities (McGrath 2005, Spivey 2008, Wassmer 2006, Paulsen 2012). This evidence on North American cities suggests that the four variables of the AMM model - namely population, income, transport costs and agricultural rents - explain 80% of the total variation in urban spatial size (Paulsen 2012). Similar results have been found for Europe (Oueslati et al. 2015) and for other regions of the world (Deng et al. (2008) and Song et al. (2014) for Chinese cities and Brueckner & Sridhar (2012) for Indian cities).

In this work, we propose an extension of the Brueckner & Fansler (1983)'s model that considers the fragmentation of metropolitan governance among the causes of urban sprawl. There are several reasons to expect a positive impact of fragmentation on urban sprawl, and they are clearly interrelated[1].

The first reason grounds on the Tiebout (1956)'s theory of "people voting with the feet". In fragmented and decentralised institutional settings, while households' location choice is determined by the tax/services combination, local authorities compete to attract them. If a local authority applies less restrictive land development policies to attract new households, this will result in more land take within the jurisdiction.

The second reason builds on the concepts of zoning or planning, which refer to the set of laws and regulations that control population density. To keep the residential values high, residents make pressures on local authorities to limit urban growth at the local level controlling the supply of land for new houses. The consequent high price of homes excludes some social classes from the market, creating a socio-economic context that may, in turn, affect the housing value positively. The proliferation of low-density zones impacts

[1]A critical review and a discussion of the economic aspects related to land use are provided in Fischel (2015).

aggregate urban growth positively.

The third reason concerns the spillover effect. When planning policies are not coordinated at the metropolitan level, growth control instruments are less effective and, other things being equal, more land is taken. The extent to which an increase in fragmentation translates into urban growth depends, however, on the institutional and cultural context. In this respect, the main contribution of this paper to the literature is the comparison between EU and US metropolitan cities from an empirical point of view.

The empirical approach we propose is suitable for understanding the effect of metropolitan governance on land use and capturing any difference between the EU and the US. This is, however, the main limitation of the study, as the need to have a unified and tractable empirical framework imposes an oversimplifying representation of the actual relationship between governance and land-use in the two contexts. The oversimplification is reflected in the use of one indicator that is easy to compute in both contexts but not capable of expressing the institutional differences between the two. In general, it is beyond the scope of this paper to provide a comparative analysis of the two institutional frameworks and to reflect on how these differences may affect the relationship we look at. However, we attempt to give an overview in the next section based on the analysis of the existing studies. Nevertheless, admitting that these differences can be fully understood does not allow to convey them into one indicator.

For the empirical analysis this study relies on the OECD database of metropolitan areas. The advantage of this data source is that the metropolitan city, the unit of analysis, is defined in a consistent manner in both regions of the world. The database is publicly available on the OECD website and includes data on urban area and other socio-economic indicators for the metropolitan areas with more than 500,000 inhabitants in the OECD countries. At the date of access, data was available for the years 2000, 2006 and 2012. The governance fragmentation indicator is the average number of administrative units per hundred thousand population, which are the lowest levels of governmental unit.

Preliminary statistical comparison across different metropolitan areas in the OECD associates a lower number of administrative authorities to lower urban sprawl. We further explore this hypothesis by including the governance indicator in the AMM-based model regression, thus controlling for other determinants of the spatial size of cities. We also include an indicator of polycentricity to disentangle the simultaneous effect of the urban form and the governance structure on the spatial extent of cities.

Our empirical results confirm the hypothesis concerning the relationship between governance fragmentation and the spatial extent of cities for both

Europe and the US. After splitting the sample by population thresholds, we find that results are robust in both geographical areas but the magnitude varies among metropolitan areas of different sizes. Moreover, separating the European and the North American samples allows to unfold substantial structural differences in the determinants of the spatial size of metropolitan areas in the two contexts.

We find that, among others, the impact of governance fragmentation is significantly larger in the US compared to Europe. In general, we link this result to the higher decentralisation of planning policies in the US compared to Europe, especially to some northern European states that implement a more centralised approach to planning. In the US, the great power of local authorities on land management has favoured residential sorting and the process of zoning, resulting in more urban growth.

The remaining of the paper is structured as follows. The next Section 2 presents the differences between the institutional and regulatory frameworks concerning land use, planning policies and governance in Europe and the US. Section 3 describes the empirical approach and the data used. Results are illustrated and discussed in Section 4 and Section 5 concludes the work with final remarks.

2 Institutional Setting

Urban sprawl, defined as the low density and spatially dispersed urban growth at the borders of cities, is a feature generally associated with North American metropolitan areas. In 2011 the average density in European metropolitan areas was 3,452 pop/km^2 against a US figure of only 1,360 pop/km^2 (authors' calculations based on data employed in this study). It means that an American city of approximately the same population of a European one consumes about 2.5 times more land. This consumption of land appears substantial and excessive to many, and it has triggered several movements (i.e. the Smart Growth and the New Urbanism movements), which advocate for policies to reduce sprawl and urban expansion in general in American cities (Huang et al. 2007). Even in Europe, where cities are traditionally more compact, low-density and discontinuous urban development at the fringe has become the dominant trend of urban spatial expansion. Surprisingly, cities in which the population has been shrinking are also those in which the characteristics of urban sprawl are most marked (Guastella et al. 2019). In light of the negative effects of urban sprawl on the agricultural and natural environment and the disconnection between urbanisation and demographic trends, the more stringent actions against land take are now part of the policy debate in Europe (EEA-FOEN 2016), not only the US.

The differences between the US and the EU find their roots in the culture and history of the two continents. Firstly, the use of car now is the preferred form of urban mobility in the US, as landscape characteristics in many cities favoured the spreading of road infrastructures and also because gasoline prices have always been at their lowest compared to all other developed countries (The World Bank 2016). According to the Federal Highway Administration (2017), in 2017 Americans made 82.5% of their daily trips by car, 6% by public transport, 10.5% by foot and 1% by bike. Although Europe shares with the US similar levels of wealth and living standards, daily trips of European citizens have a higher proportion of *green* mode of transport in comparison, with about 70% by car, 13.2% by public transport, 10.5% by foot and 6.2% by bike (Eurostat 2017).

Secondly, several cultural aspects encouraged sprawl since the origins of North American towns. Specifically, a colonial characteristic consisted in the absence of city walls, which encouraged urban expansion. Colonialism also imposed weak city governments and limited city political power where cities were not granted chartered rights. Obligations were towards the colonial power rather than the city itself, which had the consequence of weakening cities' administrative powers (Gottdiener et al. 2014). Thirdly, planning regulations in the US are relatively recent (the cities that first adopted land use regulations are San Francisco (1880) and New York City (1916)) which, combined with cheap and abundant land, created the conditions for land speculators to widely exploit land around cities, hence promoting sprawl (Hilber & Robert-Nicoud 2009, Gottdiener et al. 2014, OECD 2017).

Besides these reasons, another pivotal factor that influences urban expansion is the fragmentation of decision centres. In both Europe and the US, local governments are elective bodies endowed with legislative power on land use and care about political consensus. The objectives of a local government are multiple, but keeping the price of houses at the desirable level is undoubtedly among the most important. This objective can be achieved through zoning, which, maintaining density low, has the aim to constrain the housing supply and, in a minor but still relevant measure, to segregate upper-class and lower-class residents (Albouy & Ehrlich 2018). As a result of zoning, the real estate properties capitalise land-use restrictions into the rent price and market values, and the competition among municipalities leads to an income-based segregation (Shertzer et al. 2018). The core difference between the two systems is that the US legislation allows for much greater decentralisation of decision compared to the EU, especially in the northern European countries which have a consolidated tradition of centralised planning (Mills et al. 2006).

The US is a country of 50 states, where each state has the power to decide on land use allocation and to set the rules for land transformation. While municipalities can put several constraints through zoning, density control, and growth boundaries, states cannot interfere in planning policies. This kind of decentralised institutional setting favours the competition among municipalities. However, although local authorities have full control over land-use policies but not on budget policies, they depend on the state for their budget policies. This distribution of powers causes competition to be played on land development (Mills et al. 2006).

The EU is a union of member states where each state has its land-use regulation, that is usually the result of the interaction of different levels of government. While municipalities have decision power on land allocation in all member states, the decisions on land-use change are usually taken under a more general regulatory framework defined at a higher level. Whether this level is the central government or the regional one depends on the internal institutional setting of each member state. These diverse regulatory frameworks cover a wider range of issues connected to land-use stemming from transport to environment, housing to economic development in the case of national or federal plans (OECD 2017). There are also limited cases of regional or metropolitan plans, which reach a higher degree of detail.

Not all countries, however, have recognised metropolitan authorities. In some cases, in fact, there is not even a coincidence between the morphological aspect of the metro area and its boundaries (Guastella & Pareglio 2017). Even for countries where there are, these authorities have not a recognised power on land use and can only coordinate planning policies. In these cases, municipal plans are the only binding plans.

To conclude, although parallelisms between the two regions are common in the academic community, the sharp contrasts make the two areas allegedly hard to compare. The differences between the two institutional contexts are too many and too large to be summarised in a way that allows to understand how the administrative fragmentation influences land-use. This paper acknowledges the risks of over-simplifications implicit in the choice of using the same measure of administrative fragmentation that, applied to the two contexts, reflect very diverse phenomena. In this respect, the empirical part of the work that comes in the next sessions should be understood as a preliminary effort to measure macro differences in the dynamics of the relationship between governance and urban sprawl.

3 Econometric Model and Data

To measure to what extent the fragmentation of governance affects land use consumption in the United States and Europe we estimate the standard city size model (Brueckner & Fansler 1983) with the following equation:

$$\begin{aligned} UA_{it} = \beta_{0i} + \beta_1 POP_{it} + \beta_2 GDPPC_{it} + \\ + \beta_3 LOCGOV_{it} + \beta_4 POLY_{it} + \gamma_t + \varepsilon_{it}, \end{aligned} \tag{1}$$

where UA_{it} is the urbanised land (km^2) in metropolitan area i on year t (where t takes the values of 2000, 2006 or 2012). Total population (POP) and the average income ($GDPPC$) represent the AMM model's independent variables that explain the expansion of cities. The traditional Brueckner & Fansler (1983)'s model also assumes that farmland price at the edge of the city and unitary transportation costs affect the optimal spatial size of the city and include indicators for these two variables in the reduced-form equation. Nonetheless, proxies for these variable are observed for the two regions considered in this work in a sufficiently consistent manner that would allow their inclusion in the model. Their omission causes a potential estimation bias which is worth discussing here. In particular, all the studies using this empirical specification either excluded transportation costs or used proxy variables leading to inconsistent result (Paulsen 2012) and the exclusion of this variable from the model is not expected to cause severe problems. The omission of agricultural land prices is source of mispecification. However, in absence of valid proxy variable, the inclusion of city specific effects β_{0i} is expected to capture the *between-cities* systematic differences in built-up area size due to the connection between the urban and the rural environments. Rather than making an a-priori assumption about the correlation of these effects with the independent variables, we test this correlation empirically. The term γ_t represents time-specific effects for the three years of observation. The last term, ε_{it} represents the idiosyncratic disturbance element. The model is expanded with the governance fragmentation indicator ($LOCGOV$, which is the number of local governments per hundred thousand inhabitants.) to test for the hypothesis that the associated coefficient β_3 is positive and statistically different from zero[2].

Finally, we add the indicator of polycentricity ($POLY$) to control for any possible deviation from the monocentric structure assumed in the AMM model on which the Brueckner & Fansler (1983)'s empirical specification grounds.

[2]We do not have information about alternative uses of land at the city level which could be used to account for topological limitations to urban sprawl.

Metropolitan area data are drawn from the OECD Metropolitan Area Database for the years 2000, 2006 and 2012[3]. We extract data for North American and European metropolitan areas. The two regions account for 180 metropolitan cities with population above 500 thousand: 70 metropolitan cities are located in the US and 110 in Europe.

The OECD Metropolitan Area Database provides information about population, urban area, GDP, polycentricity and territorial organisation for metropolitan areas with more than 500,000 inhabitants. Consistently with a long tradition of empirical literature testing the AMM model (among others, Brueckner & Fansler (1983), Spivey (2008), Paulsen (2012) and Oueslati et al. (2015)), the outcome variable used in this study is the total urbanised area, defined as the land area (km^2) covered by buildings or infrastructures for urban (residential, industrial and commercial) use. The European sample includes metropolitan cities belonging to 20 countries out of the 28 in the European Union[4].

The OECD designed a methodology to allow for a comparison across functional urban areas of similar size across countries. A functional urban area is an urban agglomeration with a continuously built-up urban core and surrounding areas also known as commuting region (Ahrend et al. 2014). The OECD defines a city core as a cluster of neighbouring cells of 1 km^2 with a density of at least 1,500 population per km^2. Furthermore, to account for polycentricity, two city cores are combined into a single metro area if the share of the workers that live in one city core and commute in a second city core is above 15% (OECD 2019).

Figure 1 about here

Figure 1 shows the distribution of the cities in the dataset and provides visual information on their size in terms of population. We set two thresholds to distinguish between large (L) and extra large (XL) cities in the US and

[3]Data were extracted on March 2018, when the OECD provided built-up area data from different sources for the EU and the US. For the US, the National Land Cover Database (NLCD) was used in its different versions: 2001, 2006 and 2011. For Europe, the source is the CORINE Land Cover in years 2000, 2006 and 2012. For the purpose of this study, we match 2001 and 2011 US data with 2000 and 2012 EU data, respectively. It is worth noting that we estimate our models for the two regions separately. Our aim is to simplify the interpretation of results without hindering their validity. Recently, the OECD uniformed the methodologies worldwide to make data more comparable. Although they added more and smaller cities to the dataset as well as more years, they removed information on polycentricity and administrative organisation, which are pivotal to this study.

[4]The following eight countries are excluded: Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Luxembourg, Malta and Romania.

in Europe. Whereas large metro areas correspond to those with population between 500 thousand and one million in EU, in the US large cities are those with population up to 1.5 millions. This distinction in thresholds depends on the fact that on average American metro areas are larger than European ones[5].

Table 1: Summary statistics.

	United States†			**Europe**		
Year	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.
UA - Urbanised area (km^2)						
2000	1,640.15	1,350.39	70	375.96	360.79	110
2006	1,725.37	1,411.73	70	386.67	366.9	110
2012	1,788.97	1,454.59	70	448.48	402.88	110
POP - Population (thousand)						
2000	2,146.86	2,835.32	70	1,443.10	1,579.77	110
2006	2,279.51	2,934.02	70	1,490.59	1,664.75	110
2012	2,433.91	3,052.25	70	1,548.34	1,765.28	110
GDPPC - GDP per capita						
2000	50,405.11	11,173.76	70	34,371.34	10,149.83	110
2006	55,144.55	11,473.26	70	38,386.89	10,091.78	110
2012	54,389.98	12,718.99	70	38,589.78	10,009.94	110
LOCGOV - Local governments per 100,000 population						
2000	5.21	5.13	70	7.84	10.07	110
2006	4.92	4.88	70	7.56	9.61	110
2012	4.64	4.64	70	7.28	9.16	110

† For the US, the values of urbanised area for years 2000 and 2012 actually are the values for years 2001 and 2011, respectively. The values of GDP per capita for year 2000 are the values of GDP for year 2001.

Table 1 provides detailed summary statistics, by region and year of observation, about the dependent variable (urbanised area), the two main variables of the AMM model (total population and per capita GDP), and the variable of interest in this study, which is the number of local governments per hundred thousand inhabitants.

Looking at the urbanised area, the average US metropolitan area used to be more than four times larger than the European counterpart in 2000.

[5] Table A.1 in the Appendix shows that the final results are robust to the choice of the threshold if allowed to vary by 100 or 200 thousand population below and above the chosen limit.

Table 2: Number of metropolitan areas by polycentricity indicator and 2012 population size.

Size	Monocentric	Polycentric	Total
United States			
$< 1.5m$ (L)	39	0	39
$\geq 1.5m$ (XL)	29	2	31
Total	68	2	70
Europe			
$< 1m$ (L)	53	8	61
$\geq 1m$ (XL)	33	16	49
Total	86	24	110

Although the relatively more rapid growth of urbanised area in European cities allowed the gap to shrink in 2012, the difference between the two regions remained substantial. Consistently with urbanised area figures, the population values are also greater for the US cities where, on average, the population is less than double the European average. In fact, the most significant difference between the two regions is notably the land consumption per inhabitant, that remains relatively higher in the US. As expected, GPD per capita[6] is also higher in the sample of US metropolitan cities.

The fragmentation of governance in a metropolitan area is measured as the number of governments per hundred thousand inhabitants. The variable provides quantitative information on the level of the administrative fragmentation of the metropolis (Bartolini 2017). Governance fragmentation appears to be lower in the US, with on average 5 local governments per hundred thousand inhabitants against an average of almost 8 in Europe. This indicator changes little over time due to the fact that variation is introduced only by the changes in population over the years, whereas the number of local governments remains fixed across the relatively short period of time observed in this study, between 2000 and 2012.

As modern cities increasingly become more polycentric, the number of urban cores in a metropolitan area in studying the relationship between governance fragmentation and the spatial extent of cities. To simplify the interpretation of this information we convey it in a dummy variable taking value equal to 1 when the metropolitan structure shows more than one core and 0 otherwise. In contrast with the other variables, the indicator of polycentricity does not exhibit variability over time in either region and its distribution is reported separately in Table 2.

[6]GDP per capita is expressed in US dollars, at 2010 constant prices.

Table 2 shows that polycentricity seems to be a characterising feature of European cities. In fact, in the US there are no polycentric cities with population below 1.5 millions. A monocentric urban structure characterises larger metropolitan areas as well, with only two cities in a sample of 31 featuring a polycentric urban structure. Polycentrism characterises European cities to a much larger extent. Considering smaller ($< 1m$) metropolitan areas only, in Europe there are 8 polycentric cities in a sample of 61 and the share increases significantly in larger metropolitan areas. Polycentricity is measured in terms of population density and a polycentric metropolitan area is such if it has more than one highly densely populated core.

Among other mechanisms, this paper analyses the impact of the degree of polycentricity of a metropolitan areas on urban land growth. However, a concern might be raised regarding the endogenous nature of polycentricity. This issue can be addressed comparing the time frame of action of these polycentricity versus urban land. As explained above, the former variable represents a characteristic of a city that does not vary over the time span of this study (13 years). Therefore, while it is possible to investigate the effects of this characteristic on land use, urban land growth does not have an impact on the number of cores of a city in the short- to medium-run.

3.1 Effects by city size

A factor that may moderate the effect of governance on urbanisation is the size category of the metropolitan area. Some recent studies introduce a population size cutoff and test the monocentric model for the different size categories. Spivey (2008) finds that the largest US cities are a better sample for testing the standard AMM model for monocentric cities. In another study, Paulsen (2012) introduces a city size cutoff at 500 thousand population and investigates the difference in growth patterns across small or large areas. He finds that in bigger metropolitan regions the elasticity of urbanised land area with respect to population is lower than in smaller cities.

The vast majority of the studies that find evidence of differential growth dynamics by city size exclusively look at North American metropolitan areas. To the best of our knowledge, this study is the first that explores the effect of governance on urban expansion comparing cities of different sizes in two regions, North America and Europe. We introduce an indicator for large (L) and extra large (XL) metropolitan areas, provided that the dataset includes exclusively areas with more than 500,000 inhabitants.

As shown in Table 1, there are substantial differences in population size between the United States and Europe, where the former holds on average a population 50% larger than the latter. To account for this contrast, as we mentioned in the previous section, we select two different size cutoffs. For the United States, L and XL correspond to metropolitan areas with population between 500 thousand and 1.5 millions or equal and above 1.5 millions, respectively. For Europe, L and XL correspond to metropolitan areas with population between 500 thousand and 1 million or equal and above 1 million, respectively[7].

In order to clarify whether the structural differences between US and European cities are due to either the institutional context, metropolis size or both, we estimate the following equation, for the US and for Europe.

$$\begin{aligned} UA_{it} &= \alpha_i + \beta X'_{it} + \lambda_t + \epsilon_{it}, \\ \text{with} \quad \beta &= \beta_1 size_{it} + \beta_2(1 - size_{it}) \end{aligned} \tag{2}$$

where X is a vector of POP, $GDPPC$, $LOCGOV$ and $POLY$, which are the same of equation (1). The coefficient β is a linear combination of the coefficients β_1 and β_2, where the former represents the coefficients for XL areas and the latter for L areas. This is due to the fact that these coefficients are interacted with an indicator of size, $size_{it}$, and its linear transformation, $1 - size_{it}$. The indicator $size_{it}$ is equal to 1 for XL metropolitan areas and equal to 0 for L areas, therefore $1-size_{it}$ is equal to 1 for L metropolitan areas and equal to 0 for XL areas. The dummy variable $size_{it}$ varies with time (although by a small degree) by definition, since it is built on population, which changes over the years. The term λ_t represents time effects for the same three years of observation: 2000, 2006 and 2012. The last term, ϵ_{it}, represents the error element.

4 Results and Discussion

The empirical specification adopted in this paper allows for city-specific effect in a panel data setting. Preliminary tests on the correlation between these effects and the independent variables are run to discriminate between the two most common specifications of the individual effects, the fixed effects (FE) and the random effects (RE). In this context, the standard procedure is to run the Hausman test that compares the coefficient sets of the two specifications to establish whether this difference is statistical significant. The nature of our data impedes proceeding this way as far as the $POLY$ variable does not vary over time, causing the related coefficient to drop in the

[7]As we mentioned previously, Table A.1 in the Appendix reports robustness tests on the choice of these cutoffs.

Table 3: Estimated effects of urban governance on urban land use, by geographical region.

	United States	Europe
POP	0.493***	0.202***
	(0.038)	(0.010)
GDPPC	0.010**	0.005***
	(0.005)	(0.002)
LOCGOV	10.275	2.275***
	(10.618)	(0.821)
POLY	-2092.779*	-41.571
	(1190.211)	(37.106)
Intercept	74.945	-88.018*
	(193.997)	(45.331)
Time effects	✓	✓
Observations	210	330
Adjusted R^2	0.879	0.865

Cluster-robust standard errors in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

FE specification only, not in the RE one, and producing coefficient vectors of different lengths that are not comparable with the Hausman test. We, instead, rely on the Mundlack-Chamberlain device (Mundlak 1978, Chamberlain 1982) to estimate the FE specification.

The procedure assumes correlated random effects and requires estimating a pooled model with unit-specific mean values of time-varying variables. The F-test on the joint significance of coefficients related to the unit-specific mean variables is used to test the null hypothesis of zero correlation between the effects and the explanatory variables. The results of this test in our case do not allow rejecting the null hypothesis of uncorrelated random effects and we, therefore, opt for the RE specification.

Table 3 shows the results of the estimated panel regressions described in equation (1). The model can explain substantially the variation in urbanised area, as the adjusted R^2 is high for both the United States and Europe. In both cases about 95% of the total variance is explained, which is a considerable result given that only three variables are used in the explanatory part of the model. The result is not new and is consistent with previous empirical literature Paulsen (2012). This analogy confirms the fact that the stylised monocentric Alonso-Mills-Muth model indeed captures well the main drivers of urban spatial expansion.

Looking at the estimated coefficients, an increment by thousand population is linked with an increase of around 50 or 20 hectares of urbanised land in a North American or European city, respectively. To check whether these estimates on population and urbanisation are qualitatively relevant, we match them with existing results. For the US region, we use the results of the study by Paulsen (2012), which analyses a sub-sample of cities with population above 500 thousand. Provided that our sample includes only those areas, we are able to supply a meaningful comparison of estimates. Paulsen (2012) estimates an increment of 8,341 square foot (ft^2) of urban land per person. Converting our estimate of 0.493 km^2 extra urban land per thousand inhabitants, we obtain an increment of 5,306 ft^2 of urban land per person. The difference in these estimates is 3,035 ft^2, which corresponds to 282 m^2.

We do the same for the region of Europe and we use the study by Oueslati et al. (2015) as a means of comparison. Although their study uses data on European cities, they include all cities without referring to their size. We translate their findings on elasticity of urban land with respect to population into a square foot change per person. Using the sample mean population and urban area provided by the authors we obtain an increment of around 697 ft^2. In our study, the estimate of 0.202 km^2 for the European population of Table 3 is converted into 2,174 ft^2 extra urban land per person. The difference between our and Oueslati's estimates is 1,477 ft^2, which corresponds to about 137 m^2.

These different values for North American and European cities are relatively large compared to the estimates found in the existing literature. They correspond to the 36% and 20% change compared the US and EU estimates, respectively. To justify this large change we estimate our model of equation (1) without the indices of governance (not reported here) to match the new estimates on population against the values given by the literature, which are lower than ours. This reduced model returns smaller coefficients on population for both regions, which suggests that the dissimilar estimates are due to the different models used in the literature. For instance, besides the various selection of explanatory variables, Oueslati et al. (2015) report their results in terms of elasticities, thus complicating the comparison of results.

Another factor that might influence these relatively large discrepancies is the difference in samples, particularly for Europe (Oueslati et al. 2015) where the existing literature does not split cities by size, pooling all metro areas together.

The other estimated values reported in Table 3 refer to GDP per capita and the two indices of governance. As expected, urban land grows with GDP, where the United States experience an increment of one hectare for each one point-increase of GDP per capita. Our results also show that Europe has a correspondent growth half the size. More specifically, an extra point of GDP per capita is associated with an additional half a hectare of consumed urban land.

For the United States, the governance fragmentation variable does not seem to contribute to the model of urban land use. The *POLY* variable, although statistically significant at the 90% level, is negative as expected. US metropolitan areas with more than one city core consume less urban land compared to cities with only one core. To put this result into scale, it is worth recalling that the portion of polycentric cities in the US accounts for only the 3% of the total (i.e. 2 out of 70 areas, see Table 2).

For Europe, whereas the coefficient of the polycentricity indicator is not statistically significant, the index of fragmentation is positive and significant at the 99% level. For this region, one extra local government per hundred thousand population is associated with about 2 km^2 (or about 230 hectares) of further urban land.

This result shows that, in Europe, an increase in the number of local governments leads to urban land growth. This is confirmed by other studies, where high values of this measure are usually associated with a worse allocation of land (Bartolini 2017). Ahrend et al. (2014) use the same OECD data of this study and find a correlation between better governance and reduction of urban sprawl. However similar to our conclusions, they use a different definition of "good" governance. They define it as the presence of metropolitan governance bodies, which often include multiple municipalities. These governance units as the lowest levels of government that deal with metropolitan-wide matters, such as regional economic development, transportation and spatial planning and they find it is associated with a reduction of urban sprawl (Ahrend et al. 2014). Our study goes beyond this kind of indicators and looks at the relationship between the number of local governments and urban land growth to find that an extra administrative entity increases urban land consumption.

Table 4 reports the estimates by region and city size of model (2). If the adjusted R^2 were already high in the estimations reported in Table 3, here we find even higher values. Accounting for size-related structural heterogeneity, this model explains 96% and 94% of the variation for the regions of United States and Europe, respectively.

For both the US and Europe we find significant structural differences between groups of metropolitan areas of different sizes based on Anova tests

Table 4: Estimated effects of urban governance on urban land use with indicators for two levels of the metropolitan area size, by region.

	United States		Europe	
	L	XL	L	XL
POP	0.851***	0.449***	0.204***	0.192***
	(0.103)	(0.042)	(0.072)	(0.012)
GDPPC	0.001	0.011	0.001	0.007***
	(0.002)	(0.010)	(0.001)	(0.002)
LOCGOV	14.746***	45.350*	1.735***	4.712*
	(5.383)	(23.513)	(0.462)	(2.559)
POLY	.	-1860.802*	1.348	-85.536
		(1076.211)	(21.837)	(61.500)
Intercept	27.559	-1644.905	25.412	-158.787
	(128.235)	(1308.272)	(60.559)	(111.090)
Time effects	✓		✓	
Observations	210		330	
Adjusted R^2	0.961		0.943	

Cluster-robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Note: L and XL refer to the size of the metropolitan area. For the United States, L and XL correspond to cities with < 1.5 and ≥ 1.5 million population, respectively. For Europe, L and XL correspond to cities with < 1 and ≥ 1 million population, respectively.

(not reported). For both, we find that the average land consumption is bigger in smaller (L) metropolitan areas. This evidence supports the argument that smaller cities are relatively less efficient in allocating land. This is probably due to the greater availability of non-urban land to be converted and to the lower institutional attention to the issues related to land-take.

Compared to the results of Table 3, not only does the difference between the two regions remain significant, but, after accounting for size-related heterogeneity, it also widens especially in cities of smaller size. As a result, in the sample of US metropolitan areas with less than 1.5 million inhabitants, the marginal land consumption estimate is four times larger than the estimate for the sample of European metropolitan areas with less than 1 million inhabitants. Splitting by size, the income effect becomes statistically insignificant in all models except for the case of very large cities in Europe.

Results concerning administrative fragmentation also significantly differ across size groups and areas. For both regions, the larger the city the bigger the effect of a marginal increase of the number of administrative units on the total land consumption. For extra large cities the estimated marginal consumption of land per new municipality is about three times bigger that the one estimated in large cities. In addition, comparing the results of the two models, whereas for North American cities fragmentation does not contribute to explain urban land growth, adding a city size interaction term changes the scenario.

To our knowledge this is the first study that compares metropolitan areas of different sizes from different regions. We find that population size moderates the effect of governance on urban land growth. For both regions, the US and Europe, an increase in administrative fragmentation is associated with an increase in urbanisation at different magnitudes depending on the city size. Furthermore, results report a significant variation of the effect intensity between the two regions. This is in line with the fact that this study uses a single variable to describe governance fragmentation, which is a complex phenomenon that cannot be easily described and it is hardly comparable between Europe and the United States.

5 Conclusion

Not only does urban sprawl affects the environment adversely, limiting the functioning of its ecosystems, but also it affects human health as a consequence of increasing traffic, congestion, and air pollution. The call for a more compact model of urban development found only incomplete responses from local policy makers. Moreover, not all these responses demonstrated as efficient as they were thought, causing sometimes undesired results. For instance, urban containment policy is a standard approach to contrast the sprawling of cities. However, evidence shows that containment tools are effective in limiting urbanisation inside the administrative boundaries while creating leapfrog development outside. More in general, policies that limit the expansion of urbanised area have not only direct effects on relevant areas but also on neighbouring areas. The lack of coordination in planning policies can therefore be responsible for its low effectiveness.

The coordination of planning policies is not easy to achieve. It requires setting up agreements on the limits to impose to urban area conversion as well as on the tools to enforce these agreements. It also requires an integration of different policies, typically planning and transport. The coordination gets more complex as the number of municipalities in a metropolitan area gets larger. Furthermore, the extent to which an increase in fragmentation translates into urban growth depends on the institutional and cultural context.

This study compares the effects of governance fragmentation in metropolitan areas from two regions, Europe and North America, distinguishing between large and extra large cities. The two regions feature different characteristics, such as population and size of urbanised area. US cities are larger and less dense, on average, primarily for historical and cultural reasons. Metropolitan areas diverge as well in terms of administrative fragmentation, which we find higher in Europe compared to the US. These differences impact on the relationship between administrative fragmentation and the spatial size of cities.

The evidence in this paper shows that a greater administrative fragmentation is associated with a larger amount of urbanised area consumed, other things being equal. This is true for both areas, the US and Europe, but to different extents. We find that the spatial size response to a one unit increase in the number of administrative centres per hundred thousand population is estimated between eight and ten times larger in US cities compared to European ones.

According to the evidence in this paper, lowering the number of administrative centres with decision power on land use may result in lower spatial expansion and less sprawl of metropolitan areas. Larger cities in particular are expected to benefit the most from this administrative transformation.

To conclude, a reduction of urban sprawl can be encouraged through reforms aimed at reducing the number of decision units. Such reforms have the potential to impact land consumption in different manners, lowering the competition between municipalities and improving the coordination of planning policies at different levels, for instance. As a result, a better coordination of policies is expected to benefit the effectiveness of traditional urban containment instruments.

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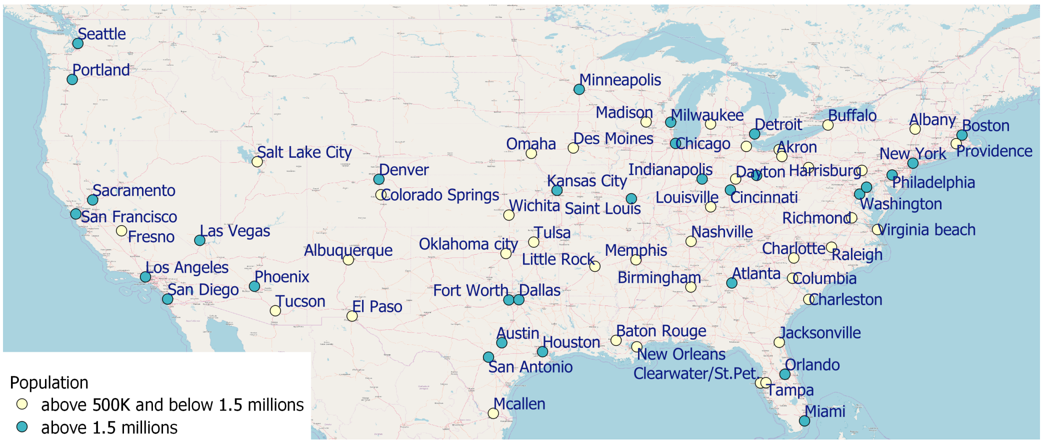

(a) *United States*

(b) *Europe*

Figure 1: Location of metropolitan areas included in this study, by population size.

A APPENDIX

Table A.1: Estimated effects of urban governance on urban land use in US and EU with different size thresholds.

United States	$\gamma_{US} - 200K$		$\gamma_{US} - 100K$		γ_{US} =*1500K (main)*		$\gamma_{US} + 100K$		$\gamma_{US} + 200K$	
	L	XL	L	XL	*L*	*XL*	L	XL	L	XL
POP	0.880***	0.454***	0.874***	0.452***	*0.851****	*0.449****	0.826***	0.444***	0.809***	0.441***
	(0.125)	(0.040)	(0.117)	(0.041)	*(0.103)*	*(0.042)*	(0.088)	(0.042)	(0.080)	(0.042)
GDP	0.001	0.011	0.001	0.011	*0.001*	*0.011*	0.001	0.011	0.001	0.011
	(0.002)	(0.009)	(0.002)	(0.009)	*(0.002)*	*(0.010)*	(0.002)	(0.010)	(0.002)	(0.010)
LOCGOV	14.340**	46.614**	14.536***	44.461*	*14.746****	*45.350**	14.374***	49.475**	14.062***	55.192**
	(5.418)	(22.489)	(5.477)	(23.136)	*(5.384)*	*(23.513)*	(5.214)	(23.904)	(5.025)	(22.710)
POLY	.	-1872.492*	.	-1868.587*	.	*-1860.802**	.	-1842.108*	.	-1833.759*
		(1088.172)		(1083.697)		*(1076.211)*		(1060.581)		(1053.990)
Intercept	-16.405	179.515	-2.719	211.675	*0.236*	*229.328*	27.402	255.401	52.202	289.804
	(157.134)	(406.211)	(154.861)	(452.576)	*(140.706)*	*(499.999)*	(133.408)	(516.889)	(131.463)	(524.070)
Time effects	✓		✓		✓		✓		✓	
N	210		210		*210*		210		210	
adj. R^2	0.961		0.961		*0.961*		0.962		0.963	

Europe	$\gamma_{EU} - 200K$		$\gamma_{EU} - 100K$		γ_{EU} =*1000K (main)*		$\gamma_{EU} + 100K$		$\gamma_{EU} + 200K$	
	L	XL	L	XL	*L*	*XL*	L	XL	L	XL
POP	0.108	0.194***	0.293***	0.193***	*0.204****	*0.192****	0.279***	0.193***	0.293***	0.193***
	(0.127)	(0.012)	(0.084)	(0.012)	*(0.072)*	*(0.012)*	(0.066)	(0.013)	(0.056)	(0.013)
GDP	0.000	0.007***	-0.000	0.007***	*0.001*	*0.007****	0.001	0.007**	0.001	0.007**
	(0.001)	(0.002)	(0.001)	(0.002)	*(0.001)*	*(0.002)*	(0.001)	(0.003)	(0.001)	(0.003)
LOCGOV	190.985***	435.631**	167.402***	479.542*	*173.503****	*471.157**	209.377***	572.705*	221.661***	710.288*
	(47.907)	(209.547)	(50.926)	(242.903)	*(46.157)*	*(255.889)*	(52.832)	(315.370)	(57.442)	(378.700)
POLY	21.121	-85.488	16.182	-88.967	*1.348*	*-85.536*	-4.471	-93.925	-5.608	-101.180
	(20.542)	(54.407)	(19.418)	(55.607)	*(21.837)*	*(61.500)*	(25.062)	(69.137)	(25.540)	(71.799)
Intercept	136.739**	-127.584**	40.446	-142.241**	*56.270*	*-123.169*	-27.321	-147.757	-34.518	-156.562
	(67.642)	(60.548)	(66.739)	(68.840)	*(63.804)*	*(84.979)*	(68.066)	(103.561)	(57.468)	(107.274)
Time effects	✓		✓		✓		✓		✓	
N	330		330		*330*		330		330	
adj. R^2	0.944		0.944		*0.943*		0.943		0.943	

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$