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Planning Institutions and Urban Spatial Patterns: Evidence from a Cross-National Analysis

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Abstract
This paper examines how national planning frameworks differ from each other and how those differences relate to patterns of urban development using an international cross section of metropolitan regions. We construct a composite index to measure institutional planning frameworks through objective criteria—restrictive versus permissive; binding versus nonbinding; nationally versus locally oriented—that enables comparison between (not within) countries. We also estimate a series of models to evaluate the relationship between institutional frameworks and patterns. The evidence suggests that a more centralized and coordinated planning framework produces more compact development, whereas a more decentralized and uncoordinated planning framework results in less compact development.

Keywords
planning institutions, land use, urban spatial structure, growth management, global context of planning

Abstract
Este documento examina cómo los marcos de planificación nacional difieren entre sí y cómo esas diferencias se relacionan con los patrones de desarrollo urbano que utilizan una sección transversal internacional de las regiones metropolitanas. Construimos un índice compuesto para medir los marcos de planificación institucional a través de criterios objetivos: restrictivos frente a permisivos; enlace frente a no enlace; orientado a nivel nacional frente a local, que permite la comparación entre (no dentro de) los países. También estimamos una serie de modelos para evaluar la relación entre los marcos y patrones institucionales. La evidencia sugiere que un marco de planificación más centralizado y coordinado produce un desarrollo más compacto, mientras que un marco de planificación más descentralizado y descoordinado resulta en un desarrollo menos compacto.

Keywords
Instituciones de planificacion, uso de la tierra, estructura espacial urbana, gestión del crecimiento, contexto global de la planificación

摘要
本文研究了国家规划框架之间的差异，以及这些差异如何与利用国际大都市区横截面的城市发展模式相关联。 我们构建了一个综合指数，通过客观标准来衡量制度规划框架——限制性与宽容性、有约束力与无约束力、以国家为导向与以地方为导向之间进行比较。 我们还预测了一系列模型来评估制度框架和模式之间的关系。 证据表明，更集中和协调的规划框架会产生更紧凑的发展，而更分散和不协同的规划框架会导致更不紧凑的发展。

关键词
规划机, 土地利, 城市空间结构, 发展管理, 全球规划背景

Researchers have made considerable progress in evaluating the goals of urban planning by looking, variously, at the assumptions on which it is based and the outcomes it yields. These gains have helped to clearly establish that institutions matter to the form of urban patterns and development. A wide-ranging literature has evolved to empirically gauge the extent to which a number of regulatory tools, policies, and institutions have been effective in determining the extent,

rate, and direction of urban spatial patterns (see, for example, Anthony 2004; Bengston, Fletcher, and Nelson 2004; Landis 2006; Nelson 1999; Paulsen 2014; Schmidt, Fina, and Siedentop 2017; Schmidt et al. 2020; Wassmer 2006). Many of these studies empirically model urban spatial patterns using a number of socioeconomic, geographic, institutional, and policy variables to test whether, and the extent to which, land-use regulations and growth management are effective. In doing so, they identify an appropriate research design that operationalizes urban spatial structure and creates a proxy for the restrictiveness of planning institutions and land-use regulatory policy. However, one readily notes that much of the empirical work on the efficacy of planning institutions and regulations is dated and the majority of this work is U.S.-based; none of the studies examine the relationship between planning institutions and land-use patterns from an international cross-sectional comparative perspective.

While the role of institutions has long been well understood (see, for example, Burby and May 1998) when viewed *within* particular planning frameworks, less understood is the role of institutions when viewed *across* alternative planning frameworks. North American, European, and Asian patterns of regional development have much in common, despite being governed by very different institutions. In fact, the institutional landscape, geography, and spatial scale of planning institutions and the implementation of land-use regulatory regimes are quite variable. Remaining unknown is how planning frameworks differ from each other and how those differences relate to regional development patterns: all else being equal, how do patterns vary with institutions?

Responding to the question, this paper explores spatial patterns of development across an international cross section of metropolitan regions between 2001 and 2014. The objectives of the work are as follows; first, to delineate a set of comparable metropolitan areas situated around the globe, based on the European Union (EU)-Organisation for Economic Co-operation and Development (OECD) definition of *functional urban areas* (see Dijkstra, Poelman, and Veneri 2019); second, to construct a classification-based index of institutional planning frameworks—restrictive versus permissive; binding versus nonbinding; nationally versus locally oriented—that enables comparison between (not within) countries; and third, to estimate a series of econometric models aimed at evaluating the relationship between alternative institutional frameworks and urban spatial patterns (defined here as urbanized land). We hypothesize that a highly institutionalized and coordinated land-use planning framework will produce more compact development, whereas a more decentralized and uncoordinated planning framework results in less compact development.[1]

The key contributions of this paper are as follows: first, to develop a composite index to measure national planning frameworks through objective and comparable criteria, and second, to explore the impact of alternative planning frameworks on urban spatial patterns through econometric analysis.

The rest of this paper is organized as follows. First, we introduce and describe our dataset, sample size, and unit of analysis. Second, we discuss and justify our composite index that measures the degree to which national planning frameworks are integrated and coordinated. We focus on the degree and amount of planning occurring at different levels of government and the degree of vertical integration and consistency between different government levels. As an example, we demonstrate how the scoring works for the United States and Germany, two rather distinct countries in terms of their planning frameworks. Next, we discuss two methods for creating a single composite index based on a variety of variables: a more subjective weighted index and a data-driven approach that uses multivariate analysis with optimal scaling (a principal components analysis for ordinal and categorical variables). We compare these different approaches to validate the index. Finally, we specify a number of models using the total urbanized area (in kilometers squared) for each metropolitan area as the dependent variable and a number of standard independent control variables. The models themselves consist of two cross-sectional models using our weighted composite index and two cross-sectional models unitizing the multivariate analysis with optimal scaling (for the years 2001 and 2014), as well as a panel framework. We also compare simulations for three different countries (Germany, the United States, the United Kingdom) to explore the role that national planning frameworks have on urbanized area.

Introduction of OECD Dataset

We use an extensive metropolitan dataset from the OECD, which, along with the EU (Eurostat and EC-DG Regio), has identified metropolitan areas based on a standard definition (identified as "functional urban areas," or FUAs) to overcome previous limitations to international comparisons of metropolitan areas. An FUA is composed of a city and its surrounding, less densely populated suburbs that have a high

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Table 1. Descriptive Analysis.

	N[a]	M	SD	Median	Minimum	Maximum
2001 Variables						
Total urban area[b]	536	328.867	590.454	151.5	10	6263
Population	536	1,105,128.8	2,390,169.7	470,840	159,258	33,172,680
Population density	536	400.805	444.806	253.7	13.3	3,060.2
GDP per capita[c]	536	35,116.961	10,942.986	34,219.5	6,093	76,664
Fragmentation	536	8.894	9.698	7.666	0.2	56.4
2014 Variables						
Total urban area	550	372.418	667.005	173.5	14	6718
Population	550	1,214,151.5	2,586,649	515,778	244,192	35,303,470
Population density	550	428.513	475.573	274.3	12.1	3565.4
GDP per capita	550	39,096.28	11,994.803	37,472	9623	88,562
Fragmentation	550	8.318	9.137	6.778	0.2	41.8
Planning framework variables						
Governance structure	550	0.462	0.499	0	0	1
Framework legislation	550	0.6	0.49	1	0	1
National level	550	0.758	0.978	0	0	3
Regional level	550	1.365	1.29	1	0	3
Metropolitan level	550	1.076	0.402	1	0	2
Local level	550	2.413	0.712	2	.5	4
Vertical coordination	550	0.775	0.843	1	0	2
Planning framework indices[d]						
Composite index	550	−0.474	1.341	−0.498	−2.198	1.434
MVAOS index	550	−0.513	1.342	−0.609	−2.139	1.531

Note: GDP = gross domestic product; MVAOS = multivariate analysis with optimal scaling; OECD = Organisation for Economic Co-operation and Development.

[a]We analyzed 28 OECD countries, 536 metropolitan areas in 2001, and 550 metropolitan areas in 2014. Fourteen metropolitan areas in 2001 were removed because of missing variable. The twenty-eight countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

[b]We used the total urban area in 2000 instead of 2001 because the latter is unavailable in the OECD dataset.

[c]GDP per capita 2001 is adjusted by purchasing power parity (PPP).

[d]We used seven planning framework variables as input variables to create the composite index and MVAOS indices.

degree of social and economic integration with the urban core, measured by commuting patterns (Dijkstra, Poelman, and Veneri 2019; OECD 2012). On the basis of this methodology, the OECD metropolitan database includes a set of annual variables (since 2001) for thirty-three OECD countries (plus Colombia) and a total of 628 functional urban areas with 250,000 people or more. The dataset includes relevant variables such as total population, population density, gross domestic product (GDP) per capita, and total urbanized land area, among others. European Countries account for the majority of countries in the dataset (twenty-six), North America has three (the United States, Canada and Mexico), South America has two (Colombia, and Chile), Asia has two (Japan and Korean), and Australia has one. The geographic distribution of FUAs is skewed: 162 are in the United States, 68 in Germany, 63 in Mexico, 53 in Japan, 46 in the United Kingdom, and 41 in France. Well over half the countries have five or less metropolitan areas. From this original dataset, we eliminated six countries because either they were represented by only one FUA or they lacked the key independent variables in regression. The cleaned dataset includes a total of 550 FUAs from twenty-eight countries and includes the following variables for 2001 and 2014: population, population density, GDP per capita, and a proxy for municipal fragmentation (a continuous variable measured as the number of municipalities per 100,000 inhabitants based on Bartolini 2015). See Table 1 for descriptive statistics.

Planning Institutions and Frameworks

While the existing literature on planning institutions, broadly defined here as those involved in the governance of land-use decision-making, is mainly qualitative and (often) subjective, a number of studies suggest that a wide variety of institutional arrangements and approaches that vary in terms of their scale and restrictiveness are instrumental in their effect on development patterns. Among other factors, the vertical and horizontal integration of policies in state, regional, and local plans and between adjacent planning authorities is an essential prerequisite for an effective land-use control (Wassmer 2006). In addition, growth management seems to be less effective in politically fragmented landscapes (Pendall

1999) and more effective within a more comprehensive institutionalized setting.

We compile a composite index to proxy the degree and extent to which a country's planning framework, referring here to the functions and services provided at different levels of government and the degree, is integrated. In doing so, we assume that in countries with greater vertical consistency requirements between levels of government, we would expect to find more efficient urbanization patterns, in terms of both the total spatial extent and population density, all else held equal. We organized our approach as follows. First, we assume that the planning framework should be more consistent across different governmental levels in countries with unitary governance structures, as it entitles more power to the central government, as compared with a federal system of governance. Second, we take into account the extent of planning functions and services occurring at different levels of government: national, subnational (i.e., region, province, or state), metropolitan, and local or municipal scale.

We ranked functions and services based on whether the level of government provided only strategic guidelines or more detailed land-use plans for lower levels of planning to follow. We assume more detailed and integrated planning functions will result in more compact patterns. We also assume that interventions that are binding are more restrictive on lower levels of planning than those that are voluntary and will produce more compact spatial patterns. It is worth noting that we assume the functions and services are cumulative, meaning that a planning framework with higher score function includes lower functions by default. Finally, we examine the mechanisms, institutions, and procedures in place to ensure vertical integration and consistency between different government levels (beyond what is implied through planning hierarchy). Countries with more extensive policies and procedures in place to mediate conflicts and ensure consistency will result in more compact spatial patterns.

In summarizing across countries, we used the following sources: *Land-use Planning Systems in the OECD: Country Fact Sheets* (OECD 2017a) and *The Governance of Land Use in OECD Countries: Policy Analysis and Recommendations* (OECD 2017b), in addition to peer input and expert validation. We readily note that focusing on national level frameworks does not allow for subnational variation in institutional environments, but it does allow us to capture broad aggregate differences in the national environment for land-use planning.

Governance Structure

The countries consisted of either unitary ($n = 20$) or federal ($n = 8$) systems of government. In general, most countries have three to four levels of governments: the country level (federal/national government), an intermediate or subnational level (state/provincial, regional, or association of municipalities), and a local level (municipalities), each of which has its own land-use and spatial development plans. In operationalizing a country's governance structure, we code them either as 0, indicating a federal or quasi-federal system, or as 1, indicating a unitary form of government.

Framework Legislation

None of the federal countries enact binding framework laws for planning at the national level. Germany and Switzerland have national framework laws, but the subnational units are not bound by it and can create own framework laws that may deviate from the national one. In unitary countries, the national government has exclusive power to enact framework laws for planning, except Italy which delegates the power to enact framework laws to regional governments. Both unitary and federal governments delegate major powers for land-use planning to local level. The OECD survey on planning system suggests there is no large variation in planning frameworks between federal countries. This is counterintuitive, as we would expect that federal states have greater variation in subnational planning structures due to the ability of subnational units to enact framework laws. In describing whether or not the national government (or subnational governments) prepares framework legislation to structure the planning system, we code countries as either 0 (the subnational government prepares the framework legislation, indicating a more decentralized and diverse planning system) or 1 (the national government prepares the framework legislation (more integrated and centralized).

National-Level Planning

Of the twenty-eight countries, nineteen have national governments that prepare spatial or land-use plans, while the rest have no such responsibilities (four are unitary and five are federal). Some countries share their responsibility for plan making with lower level of governments. National and regional plans serve primarily as policy guidelines and strategic plans, and less than a third of them contain specific zoning or boundary plans. In terms of the content, most national-level plans provide a low degree of details and focus on general policy outlines (fifteen of nineteen). A majority of all national plans (twelve of nineteen) contain binding regulations for subnational-level planning by other public authorities. Most national-level plans cover a broad range of policy fields, including transportation, environment, housing, industry, commerce, and agriculture. In operationalizing the functions and properties of plans at the national or federal level, we use an ordinal scale as follows: 0 (*no functions or services*), 1 (nonbinding policy or strategic guidelines for lower tier planning), 2 (*binding policy or strategic guidelines for lower tier planning*), or 3 (*binding land-use plan guidelines for lower tier planning*).

Subnational Plans

This is perhaps the most diverse and flexible level of planning, and includes more formal state- or provincial-level

planning as well as regional-level planning initiatives. Twenty-three of twenty-eight countries use regional-level plans that contain general policy guidelines and elements of strategic planning. Of these, nine have more detailed land-use plans at the regional level. Of the twenty-three countries incorporating regional plans, only eighteen are binding on lower tiers of planning. Five countries have no regional-level planning framework or have only a few regions/states generating regional-level plans. For example, in Sweden only the Stockholm Region has adopted a Regional Spatial Plan, and in the United States only a minority of states have adopted state-wide plans.[2] Most regional plans are approved by regional governments, and the rest are approved by national governments. In describing the functions and properties of plans at the subnational level (state, regional, or subregional level), we use an ordinal ranking as follows: 0 (*no functions or services*), 1 (*nonbinding policy/strategic guidelines for lower tier planning*), 2 (*binding policy or strategic guidelines for lower tier planning*), or 3 (*binding land-use plan guidelines for lower tier planning*)

Metropolitan Plans and Inter-Municipal Plans

Dedicated metropolitan and inter-municipal plans are rare in the OECD, and in only seven countries are they frequently used. Examples include the *Metropolitan Area Plan* in Korea and the Territorial Coherence Plan in France (S*chema de Coherence Territoriale*) which, although not mandatory, are quite common due to government incentives. An additional fourteen countries have metropolitan plans in some metropolitan areas, and in some cases these are unique plans prepared only for a single metropolitan area (e.g., the "Finger Plan" for Copenhagen or the Budapest Priority Regional Plan). Seven countries have no planning-related government bodies existing at the metropolitan level (Ahrend, Gamper, and Schumann 2014; OECD 2014). Some are prepared and approved by the national government and others by metropolitan authorities. Most metropolitan and inter-municipal plans are binding for public authorities or the general public. We use the following ordinal ranking to describe the existence of land-use plans or government authorities with planning functionality at the metropolitan or inter-municipal level: 0 (*no planning-related government bodies exist*), 1 (*planning-related government bodies exist in some metro areas*), or 2 (*planning-related government bodies exist in all metro areas*).

Local-Level Planning

Most of the countries in the OECD dataset have some form of local- or municipal-level planning. We operationalized this variable as follows: 0: *no functions or services*; 1: *prepare local land-use plans for all or most municipalities (except for small rural areas)*; 2: *prepare highly detailed land-use plans and zoning ordinances for high-priority areas* (e.g., major urban areas, high-density areas); 3: *prepare strategic policies and general land-use guidelines for the entire municipality* (e.g., comprehensive plans or equivalent plans), 4: *prepare specific plans that facilitate high-density and compact development*. To capture some of the nuances of local planning practice, we took off half a point if the strategies, policies, or land-use plans are only partially implemented and we took off half a point if local land-use plans or comprehensive plans are not legally binding to sublevel plans or landowners.

Vertical Coordination

Nineteen of twenty-eight countries have a hierarchical planning system. A formal hierarchical planning system may be very restrictive and leave little freedom to local government (e.g., Israel), or it may create some possibilities for lower government to influence the higher level government such as the "counter-flow principle" in Germany which includes both a vertical consistency requirement on lower levels of planning *and* a mandate that local planning to be involved in state and regional planning processes. Alternatively, higher level plans may not provide restrictive binding force to lower level, leaving more flexibility to local governments. Local governments in the United States have wide latitude to act, while in the Netherlands, the national and provincial governments may override the local plans if found to be in noncompliance with higher level plans. Many countries have consultation requirements, which requires that other level governments need to be informed and allowed to provide comments. The basic form of consultation requirement is similar to the stakeholder involvement process. Some countries require the approval of land-use plans by higher level of governments to guarantee the local plan's conformity with higher level plans. We operationalize specific vertical coordination across levels of government (in addition to the formal hierarchical planning system) as follows: 0 (*no other formal mechanisms for vertical coordination*), 1 (*the existence of instruments and institutions that provide consultation and a platform for information sharing and conflict mitigation across levels of government*), and 2 (*the existence of stronger instruments and institutions that supervise the compliance of lower plans to higher level plans*).

For the sake of illustration, we will highlight the scoring of the United States and Germany in Table 2 to better demonstrate how the index works. These two countries are illustrative; although they are both federal systems of government, they are quite divergent in how land-use planning is organized. The United States is generally more decentralized and less integrated with a municipal-level fragmentation and competition, while planning in Germany is mediated through a vertically integrated and consensus-oriented institutional framework (Schmidt and Buehler 2007). We readily acknowledge that this scoring system does not capture subnational variation in how planning is structured and

Table 2. Side-by-Side Comparison of Scoring for Germany and the United States.

Variables	Germany	The United States
Governance structure	Score 0: Federal	Score 0: Federal
Framework legislation	Score 1: Federal and state governments have overlapping legislative authority in spatial planning matters. The federal can pass laws related to spatial planning (*Raumordnungsgesetz*), while the states (*Länder*) are granted divergent rights (Organisation for Economic Co-operation and Development [OECD] 2017a).	Score 0: States have the authority to regulate land use, but all states have, to a large degree, delegated this authority to local governments through state constitutions and statutes (OECD 2017a)
National-level planning	Score 1: Framework strategies (*Leitbilder der Raumordnung*) exist at the national level, but they do not have legally binding effects on lower tier planning (OECD 2017a)	Score 0: No national-level spatial plans exist in the United States (OECD 2017a)
Subnational-level planning	Score 3: States (Länder) are the primary planning authorities in Germany. State development and regional plans are quite diverse, providing land-use regulation in some states or serving as a coordinating role in others (OECD 2017a)	Score 0: Only twelve states have adopted state-wide plans, typically strategic plans. In some states, the plans are legally binding and local governments must comply with them (OECD 2017a)
Metro level planning	Score 1: Metropolitan plans (both formal and informal ones) exist in some states (*Länder*, e.g., Berlin-Brandenburg or Mecklenburg-Vorpommern) (Ahrend, Gamper, and Schumann 2014)	Score 1: Councils of Governments are voluntary associations of local governments that function as a forum for regional policy exchange (Ahrend, Gamper, and Schumann 2014; OECD Regional Outlook 2014)
Local level planning	Score 3: Preparatory Land-use Plans cover the entire municipality. They outline general strategies and specifies permissible land-use types. Binding Land-use Plans are prepared where necessary for urban development (OECD 2017a).	Score 2: Local governments have a large degree of autonomy to control land use within their jurisdictions. Fifteen states prepare nonbinding comprehensive plans that guide strategic planning and the preparation of zoning ordinances.[a] Most local governments adopt zoning ordinances (only eight states require it), which contains map-based and text-based regulations of land use (OECD 2017a).
Vertical coordination	Score 2: Counter-current principle (*Gegenstromprinzip*); a special procedural instrument that involves regional and local actors to identify and mediate potential conflicts over land use (OECD 2017a; Rodrigo 2009)	Score 0: In some metropolitan areas, metropolitan planning organizations have an advisory role to local and state governments and focus on the co-ordination of policies between them (OECD 2017a)

organized (e.g., there is quite a bit of variation between U.S. states), a significant constraint as this is often the level at which institutions have a direct effect on land-use decisions. In addition to the difficulty of capturing the diversity of subnational approaches in a standardized and meaningful scoring system, we argue that our index is trying to operationalize the degree to which national planning frameworks and institutions are integrated and coordinated, not the specific planning authorities and competencies of the various levels of government. The resulting model should therefore be narrowly interpreted as it cannot be used for differentiating between individual metropolitan regions and specific spatial planning regulations in place at this level. See the appendix for a summary of results for all OECD countries included in the dataset.

In compiling a single composite index based on this analysis, we used both a subjective weighting and a data-driven approach. We first created a composite index based on a simple weighting system using normalized *z*-scores for each of the variables, given each of them has a different weighting based on our interpretation as to their significance: governance structure (5%), framework legislation (10%), national-level planning (15%), subnational-level planning (15%), metropolitan-level planning (15%), municipal-level planning (25%), and vertical coordination (15%). To correct for potential subjectivity inherent in the weighted approach and to provide an additional validation, we also used a data-driven approach using a multivariate analysis with optimal scaling (MVAOS), a nonlinear principal components analysis for ordinal and nominal variables introduced by Gifi (1990) and Michailidis and de Leeuw (1998). The basic idea of MVAOS is to transform the original ordinal or nominal variables to a numerical scale by minimizing a loss function so that the normal principal components analysis can be applied. This process is called optimal scaling. The transformations are computed along with a principal components analysis to maximize the variance explained by each component (Rossiter 2020).

The resulting scores are presented side by side for ready comparison in Figure 1. The results are fairly similar and validate what we were expecting to find: the United States, Canada, and Australia have "less" coordinated planning frameworks, while Germany, Switzerland, and the Netherlands have "more" coordinated planning frameworks.

Econometric Analysis

We specified three separate models—two that are estimated as single-year (2001, 2014) cross-sections and a third that pools the two years and is estimated in panel form—to explain the outcome of urban growth.[3] All these models account for metropolitan-level effects (i.e., population size)

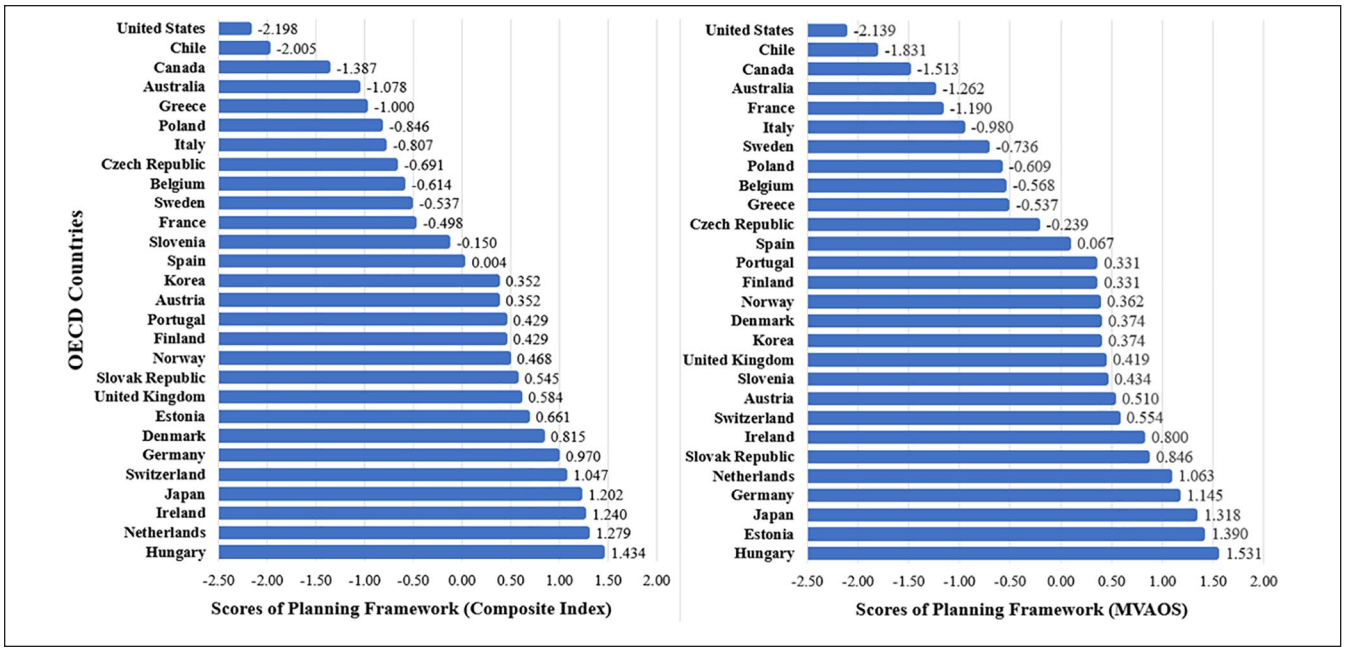

Figure 1. Planning Institutions index using weighted composite approach (left) and multivariate analysis with optimal scaling (right).

and country-specific effects (i.e., the institutional framework for planning). The panel specification includes unobserved random effects. Because the analysis involves metropolitan areas from all around the world, the model specification is *general*, designed to accommodate variation in land use globally—not to accommodate *special*, idiosyncratic, within-country variation.

In specifying the model, we chose to not to include fixed effects and an accompanying set of parameters on those fixed effects. Fixed effects account for idiosyncratic, or *special* (case-specific), parametric influences while at the same time acknowledging ignorance of the particulars of those influences. The parametric shifts of a fixed-effects specification would be colinear with the parameters of interest—namely those on the planning indices—and get in the way of obtaining efficient, unbiased estimates of them. Instead, the random-effects approach (as the name implies) capture random shocks that are unobserved by the model and/or unknowable. These effects are not estimated parameters, they are disturbances (e.g., political upheaval, natural disasters, and/or any other random shock) that may have positively or negatively, as the case may be, impacted metropolitan development patterns between 2001 and 2001 (see Greene 2000).

We use the total urbanized area (in kilometers squared) as the dependent variable and a number of standard independent control variables: population, population density, GDP per capita (as a proxy for income), municipal fragmentation, and the different planning institution indices. The models themselves consist of two cross-sectional models using our weighted composite index (for the years 2001 and 2014), two cross-sectional models unitizing the multivariate analysis with optimal scaling (for the years 2001 and 2014), and a panel framework. The results of the weighted composite index (2001 and 2014) and the MVAOS index (2001 and 2014) cross-sectional models are presented in Table 3. The composite index displays the expected sign indicating a negative relationship between the degree of institutionalization and urbanized land area, and the size of the coefficient remains remarkably similar for both time periods. This suggests that more integrated planning frameworks produce more compact urban form (although, as mentioned in the earlier footnote, there is some endogeneity in the model).

For the multivariate analysis with optimal scaling analysis, we find remarkably similar results in terms of the direction and size of the coefficients, and the value of the adjusted goodness of fit. Unlike the weighted composite model, the population density variable is significant. Keeping in mind that the dependent variable (urbanized area) is measured in kilometers squared, all else being equal, an increase in the index score by a unit of 1 (i.e., more institutionalized) would be associated with a 9.9 to 11.5 percent decrease in urbanized area, a result that remains consistent between both models and time periods. Within the composite index model, the difference between the 2001 and 2014 coefficients suggests that the marginal land consumption per "unit" of our planning framework index score decreased 0.74 percent. Within the MVAOS model, the coefficient indicates that one additional index score is associated with a decrease in nearly a percentage point (from 9.89% to 10.42%) of urbanized land area. The role that planning frameworks play in creating more compact urban development appears to be increasing over time; they are becoming more important.

Finally, in addition to the cross-sectional models, we also estimated our models in a panel framework using a

Table 3. Cross-Sectional Models Using Both Weighted Composite and MVAOS Index Dependent Variable: Log(Total Urban Area).

	(1) 2001 Composite index	(2) 2001 MVAOS	(3) 2014 Composite index	(4) 2014 MVAOS
Log(Population)	0.9251***	0.9346***	0.9026***	0.911***
	(0.0208)	(0.0202)	(0.0222)	(0.0218)
Log(Population Density)	−0.0575**	−0.0721***	−0.0447	−0.0581**
	(0.0261)	(0.0248)	(0.028)	(0.0269)
Log(Municipal Fragmentation)	0.1292***	0.1279***	0.1603***	0.1576***
	(0.015)	(0.0152)	(0.0178)	(0.0179)
Log(GDP per capita)	0.5498***	0.5439***	0.5174***	0.5164***
	(0.0563)	(0.056)	(0.0775)	(0.0769)
Composite Index	−0.1156***		−0.1082***	
	(0.0166)		(0.0171)	
MVAOS Index		−0.1042***		−0.0989***
		(0.0155)		(0.0158)
Constants	−12.8273***	−12.8079***	−12.3122***	−12.3345***
	(0.5725)	(0.5676)	(0.7608)	(0.7528)
Observations	536	536	550	550
R^2	.8438	.8419	.8178	.8163

Note: Robust standard errors are in parentheses. MVAOS = multivariate analysis with optimal scaling; GDP = gross domestic product.
*$p < .1$. **$p < .05$. ***$p < .01$.

Table 4. Panel Framework Estimation Dependent Variable: Log(Total Urban Area).

	Composite Index	MVAOS
Log(Population)	0.9139***	0.9219***
	(0.0563)	(0.0590)
Log(Population Density)	−0.0970**	−0.1086***
	(0.0395)	(0.0417)
Log(Municipal Fragmentation)	0.1324**	0.1294*
	(0.0673)	(0.0676)
Log(GDP per capita)	0.3292***	0.3285***
	(0.0139)	(0.0103)
Planning Framework index	−0.1035***	−0.0958***
	(0.0252)	(0.0233)
Constant	−10.1611***	−10.1918***
	(0.6797)	(0.6669)
Observations	1086	1086
R^2	.7471	.7458

Note: Robust standard errors are in parentheses. GDP = gross domestic product.
*$p < .1$. **$p < .05$. ***$p < .01$.

random-effects estimation strategy (Table 4). Whereas cross-sectional estimates compared across time measure changes in the average land consumption rates of a "typical" FUA, panel estimates measure the marginal effect of an explanatory variable on the dependent variable. The advantage of using a panel model is that it is able to fix potential biases that occurred in cross-sectional models, such as unobserved time-invariant regional characteristics that affect both earlier and later time periods. The panel estimation demonstrates a high degree of significance for all variables, and similar direction and size of the coefficients, although slightly lower adjusted R^2. The panel estimated coefficient on the index is similar compared with the cross-sectional estimates, suggesting that an increase in one unit of our planning framework index score would decrease the size of the urban area by approximately 10 percent for both the weighted composite and MVAOS Index.

To extend the analysis, we compare actual mean value of urbanized land area versus predicted mean value of urbanized land area for both the United States and Germany for both time periods (see Figure 2). The predicted urbanized area is calculated based on the regressions using the composite index as the key variable of interests (columns 1 and 3, Table 1)

The model slightly overpredicted the values for Germany and underpredicted (with a larger error) the values for the United States for both time periods. In general, they do not deviate much from the actual value, and we can conclude the

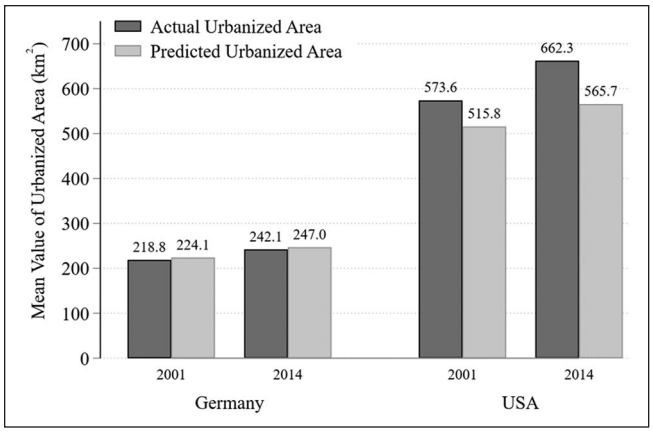

Figure 2. Predicted value versus the actual values of Total Urban Area for the United States and Germany, 2000 and 2014.

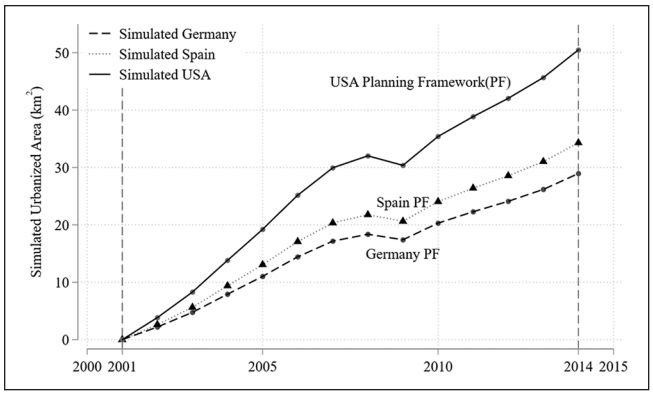

Figure 3. A simulation of urban expansion in terms of the planning frameworks in the United States, Germany, and Spain.

model performed well. One observation is that Germany witnessed a moderate increase in urbanized area of roughly 25 km^2, while the United States saw an increase of nearly 90 km^2 between 2001 and 2014.

Finally, we examine how much of this increase can be attributed to the different planning frameworks. To do so, we construct a dataset of the control variables[4] for each year between 2001 and 2014 for all available FUAs from the OECD statistics of metropolitan area.[5] Using this dataset and the regression coefficients obtained from column 1, Table 3, we simulated three urban growth scenarios for the planning framework of the United States, Germany, and Spain, respectively. We selected Spain because it is closer to the middle of the institutional framework indices, while the United States and Germany are positioned at opposite ends. Figure 3 shows the simulation result of three scenarios using the same aggregated OECD dataset. We normalized the urbanized area in 2001 to zero so that the different scenarios have the same starting point, and it is easier to observe how urban growth patterns differ due to the disparities in the planning frameworks. Our simulation predicts that the average total urbanized area would increase by over 50 km^2 by 2014 if the U.S. planning framework is adopted, increase by 35 km^2 under the Spain scenario, and increase by 27 km^2 under the Germany scenario. The growth trends are consistent with the magnitude of the institutional framework indices we created, and it further demonstrates that a less constrained planning framework (like the one in the United States) contributes significantly to urban expansion and urban sprawl. In contrast, a more regulated framework such as in Germany and Spain can better contain urban expansion.

Conclusion

This paper has sought to explain how variations in national planning institutions more broadly and planning frameworks more specifically impact urban spatial patterns at the metropolitan scale across OECD countries. To answer this question, we created a composite national planning framework for all countries using objective criteria and based on the planning functions and services occurring at different levels of government and the degree of vertical integration and consistency between different government levels. In compiling the index, we used both a more subjectively weighted index and a data-driven model based on MVAOS, a nonlinear principal components analysis for ordinal and nominal variables. We then specified a number of functional models for two time periods using both forms of composite indices, using both cross-sectional and panel estimate frameworks.

One of the major contributions of this work is the creation of a composite index to compare planning frameworks across a number of different institutional environments. This output can be used by other researchers interested in comparing planning institutions. This is not without its shortcomings, however. One problem is that some of the functions and services are spatially heterogeneous, meaning that they may exist in certain countries and not in others. For example, the role of preparing a regional land-use plan may be assumed by the state government, and therefore may not appear as an additional level of planning. Second, planning functions and services are not necessarily cumulative, meaning that the national government may assume some responsibilities (i.e., preparing framework legislation), but may lack jurisdiction over more basic functions, that is, preparing policy/strategic guidelines. Three countries, France, Spain, and Sweden, present this problem.

We acknowledge that the causal relationships between institutions and land-use patterns run both ways. Nevertheless, based on our remarkably consistent results, the evidence suggests that more institutionalized and coordinated land-use planning system will produce more compact development, whereas more decentralized and uncoordinated planning system results in less compact development. The models suggest that an increase in one unit of our planning framework index score (ie more institutionalized) would decrease the size of the urban area by approximately 10 to 11 percent.

Moreover, all model specifications indicated that the impact of planning frameworks on urbanized land area increased between 2001 and 2014, although only slightly. We also find that our models perform well, explaining more than 75 percent of the variation in urbanized land area, similar to other studies (McGrath 2005; Paulsen 2012; Schmidt et al. 2020).

As mentioned, we are aware of the constraint in the study, namely that subnational variation is not captured by the model (each country receives only one score). We readily note that focusing on national-level frameworks does not allow for subnational variation in institutional environments, but it does allow us to capture broad aggregate differences in the national environment for land-use planning. For example, in the United States, subnational variation in planning institutions occurs at the level of the states (see DeGrove 2005) as well as at the metropolitan level (see Puentes, Martin, and Pendall 2006), so we would expect the degree to which planning is integrated to differ not only between states but also between individual metropolitan areas. Clearly this is an area for future research to create a more nuanced and robust understanding of how planning institutions impact spatial development patterns.

Appendix

Planning Framework Scores for Each OECD Country.

Country	Governance structure	Framework legislation	National planning	Regional planning	Metropolitan planning	Vertical coordination	Local planning
Australia	0	0	0	0	2	1	2.5
Austria	0	0	1	3	1	2	3.0
Belgium	0	0	0	3	1	1	2.5
Canada	0	0	0	2	1	0	2.5
Chile[a]	1	1	0	1	0	0	0.5
Czech Republic	1	1	2	2	0	0	1.5
Denmark	1	1	2	2	2	0	3.0
Estonia	1	1	2	3	0	1	3.0
Finland	1	1	2	2	1	1	2.0
France	1	1	0	1	2	0	2.0
Germany	0	1	1	3	1	2	3.0
Greece[b]	1	1	2	1	0	0	1.5
Hungary	1	1	3	3	0	2	3.0
Ireland	1	1	1	2	2	2	2.5
Italy	1	0	0	2	1	1	2.0
Japan[c]	1	1	1	3	1	1	4.0
Korea	1	1	2	2	1	0	3.0
Netherlands	1	1	2	2	1	2	3.0
Norway	1	1	1	1	2	1	2.5
Poland[d]	1	1	1	1	1	0	1.5
Portugal	1	1	2	2	1	1	2.0
Slovak Republic	1	1	2	3	0	2	1.5
Slovenia	1	1	3	0	0	1	2.5
Spain	0	1	0	3	1	1	2.5
Sweden	1	1	0	0	2	1	1.5
Switzerland	0	1	1	3	2	2	2.0
United Kingdom	1	1	3	0	1	2	2.0
United States[e]	0	0	0	0	1	0	2.0

Note: OECD = Organisation for Economic Co-operation and Development.

[a]We assigned a half point to Chile's local planning framework because while there are several partly overlapping land-use plans existing at the municipal level, they are not comprehensive for the entire country.

[b]Greece implemented a major planning framework reform in 2016. But we adopted the old land-use planning system to develop the indices due to the research period (2001–2014). We assigned a 1.5 to Greece's local planning framework because local governments often lack the enforcement power to dismantle illegally constructed buildings which have become a serious issue.

[c]Japan has local *Location Optimization Plans* (Landscape Plans and Compact City Plans) that target compact and high-density urban development.

[d]We assigned a 1.5 to Poland's local planning framework because many municipalities do not have comprehensive zoning plans, and local plans are rarely constrained by the national-level plans.

[e]State legislations in fifteen U.S. states require municipalities to prepare a comprehensive plan. Most local governments adopt zoning ordinances, although only eight states require local governments to do so.

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Notes

1. Although we identify a specific causal relationship between institutions and land-use patterns, we acknowledge that planning institutions have emerged and evolved in regions and countries long after their land-use and ownership patterns (as well as systems of governance) developed in ways that are largely path-dependent. Consequently, the causal relationship runs both ways.
2. The number of states that have adapted state-wide plans may vary depending on how broadly or narrowly interpreted but generally include Oregon, Florida, New Jersey, Maine, Rhode Island, Vermont, Georgia, Maryland, Washington, and Hawaii.
3. All three models take the general form $u_i = f(\boldsymbol{m}_i, \boldsymbol{c}_i, \rho_i)$, where i indexes metropolitan areas and observed urban land area, u_i, is a function of metropolitan- and country-level variables, $\boldsymbol{m}_i$ and $\boldsymbol{c}_i$, plus the composite planning index, ρ_i. The implementation of this function takes on two different forms, corresponding to the single-year and panel specifications:

$$\ln(u_i) = a_1 + \alpha_1 \cdot \ln(\boldsymbol{m}_i) + \alpha_2 \cdot \ln(\boldsymbol{c}_i) + \alpha_3 \cdot \rho_i + \varepsilon_i \quad (1)$$

and

$$\ln(u_{it}) = \beta_1 + \beta_1 \cdot \ln(\boldsymbol{m}_{it}) + \beta_2 \cdot \ln(\boldsymbol{c}_{it}) + \beta_3 \cdot \rho_i + \varepsilon_{it} + \mu_i \quad (2)$$

4. The control variables are population density, population, municipality fragmentation, and gross domestic product (GDP) per capita.
5. The dataset is available at https://stats.oecd.org/Index.aspx?DataSetCode=CITIES

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