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Andersen, Rasmus Fonnesbæk

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It's the Geography, Stupid!

An Introduction to Geographical Information Systems in Political Science

Rasmus Fonnesbæk Andersen

Abstract

Much research in political science examines either countries or individuals. However, technological advances in geographic information systems (GIS) software and the ubiquity of geo-coded data in recent years have opened up the possibility of political science research that is attentive to (1) spatial aspects of political phenomena and (2) potential biases resulting from the dominance of country- and individual-based analysis in the discipline. In this article, I first present GIS and its possibilities for researchers (including existing, user-friendly GIS databases), and then show how GIS and spatial data have been used to examine the effects of artificial borders in Africa on civil war and development. Finally, I will offer my thoughts on how GIS can move forward political science in each of the traditional subfields of comparative politics, international relations and public administration.

1. Introduction

Modern political science has generally taken the sovereign state as well as individuals within one sovereign state as its natural units of analysis.¹ Does economic development lead to democracy? To find out, study correlations between income per capita and levels of democracy in as many of the world's countries as possible, preferentially over time. Does education lead to political tolerance? Study as many individuals as possible in a given country or across countries, and you will know. The field of international relations is basically founded on the premise that relations between sovereign states hold the only key to understanding patterns of peace and war.

Students of supranational organizations like the EU or scholars of postcolonial societies have voiced concerns over this preoccupation, noting that policy authority is increasingly devolved upwards and downwards from the sovereign state (Hooghe & Marks 2003) or that many national governments outside Western Europe and North America do not project their power over their

1 Notable early postwar exceptions are V.O. Key's *Southern Politics in State and Nation* (1949) and Robert Dahl's *Who Governs* (1961), while a later exception is Robert Putnam's *Making Democracy Work* (1993).

entire territories (Herbst 2000; Scott 2009). Likewise, recent research in political behavior has drawn attention to the local contexts and social networks in which individuals are embedded and which shape their political attitudes and participation (Gerber et al. 2008; Bond et al. 2010). More broadly, students of subnational politics and political methodologists have questioned both methodological individualism and methodological nationalism in urging conceptual attention to appropriate levels of analysis (Agnew 1996; Snyder 2001; Hilgers 2011; Harbers & Ingram 2014). But how can we avoid the pitfall of abandoning the goal of analysis and generalization and contenting ourselves with proclaiming immense complexity? I propose that one way to do so is to cultivate ‘spatial awareness’ – always trying to locate politics in space – and complement it with the tools furnished by Geographic Information Systems (or GIS).

By space, I mean geographic linkages between objects, units and actors of interest. The starting premise of linking data to space is that almost every type of information has a geographical referent. A country has borders existing in definite places, individuals move around in space, wars take place (also) in delimited spaces that troops, tanks or drones physically inhabit, and even rocket missiles have ranges that are limited in space. With regard to the challenges raised above, spatial awareness and GIS can help political scientists analyze subnational governments, peripheral territories that are only under partial central government control and the impact of local contexts and spatially proximate networks on individuals. As such, I will emphasize the potential for spatial awareness and GIS to advance political science in terms of theory-testing and to some extent also theory-building.

In this article I will first present GIS and its possibilities for researchers, including existing user-friendly GIS databases that allow for spatial representation of data without the need for technical savvy. Secondly, I will use the example of the Scramble for Africa and the artificial borders drawn at the Berlin Conference in 1885 to show how studies utilizing GIS have investigated large, otherwise intractable problems in social science. I will also use this example throughout the paper to illustrate the challenges and opportunities for research that spatial awareness grants us. I then offer my thoughts on how GIS can move forward the traditional political science subfields of comparative politics, international relations and public administration. Finally, I conclude that geography in political science is not only about using GIS to test existing theories, and that spatial awareness may also help our theory-building by making us more aware of geographical linkages in politics.

2. Everything is Spatial: GIS in Practice

Why should you care about Geographic Information Systems (GIS)? At the most basic level, what the technological advances in software and spatial data make

possible is the combination of otherwise incongruous types of data. This is relevant not only to the quantitative study of political phenomena: historians have been at the forefront of applying GIS methods to their work, constructing maps and visual representations to track networks, interactions and ways of seeing the world of elite actors, migrants, and social movements (Hillier & Knowles 2008; Gordon 2008; Dear et al. 2011; Bol 2013).

Simply visualizing data in the form of maps and examining spatial patterns (and their dynamics and changes over time) in my own experience yields a greater understanding of any topic and allows for a quick and intuitive overview of many types of data. As Gary King put it, “Displaying data geographically helps because it connects a variable we wish to explain with numerous others coded on the same level of geography. Moreover, because most observers know the values of many of these variables without having to look them up, geographical displays are instantly recognizable and interpretable.” (1996: 161). While specific GIS software – most prominently ArcGIS – is essential for conducting independent and substantial research using spatial data, there exists a wealth of resources freely available, which allow for more informal spatial reasoning. The Center for Geographical Analysis at Harvard University has developed the open-source WorldMap platform in order to “lower barriers for scholars who wish to explore, visualize, edit, collaborate with, and publish geospatial information.”

Table 1. Selected digital, interactive maps from WorldMap

AfricaMap:	http://worldmap.harvard.edu/africamap/
ChinaMap:	http://worldmap.harvard.edu/chinamap/
Map of the Russian Empire:	http://worldmap.harvard.edu/maps/russianempire
ChicagoMap:	http://worldmap.harvard.edu/chicago/

Each of the digital maps in Table 1 contains spatially referenced information for different historical periods – such as the distribution of ethnic groups, languages, locations of armed conflict, slave ports (including the number of slaves exported), individual slave trade expeditions (including number of slaves, destination port, nationality of traders, year and date and more), and emitted light as recorded by satellite imagery (a strong proxy for income in Africa, see Henderson 2012) for the AfricaMap. The maps are easily constructed using point-and-click to show various layers of information alongside each other. Below, I will use the AfricaMap to illustrate the different forms that data can take in GIS because of the simplicity and richness of this particular map.

What GIS can help us do is to categorize the political objects that we deem to be of importance into types of spatial data that we can then relate to each other thanks to their common spatial referent of GPS coordinates. The four basic types of spatial data are (1) points (for instance landmarks such as churches,

the location of a battle or residence of an individual that we know something about from a survey or registry), (2) lines (such as infrastructure networks like roads, railroads or gas pipelines), (3) polygons (i.e. connected lines that enclose an area such as administrative units or countries) and (4) what are known as ‘rasters’ (meaning continuously varying information that is available for each point in a large area at a certain resolution, i.e. topography, emission of night-time lights, etc.).²

These datasets are each geocoded (using GPS coordinates) and packaged in ‘shapefiles’ that can be accessed in GIS software. Such shapefiles of various types of data are available online from various administrative agencies, international organizations and other scholars (for a partial overview, see the Wikipedia page “List of GIS data sources”).

Table 2. Types of spatial data

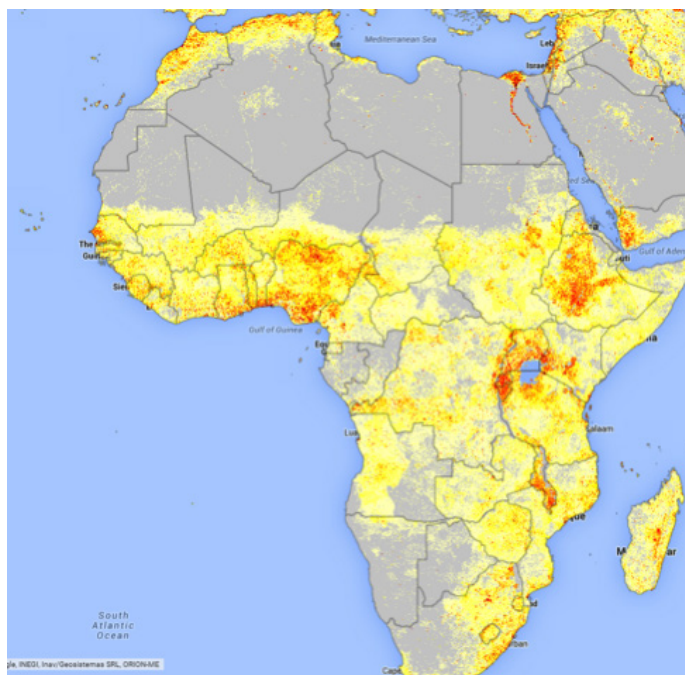
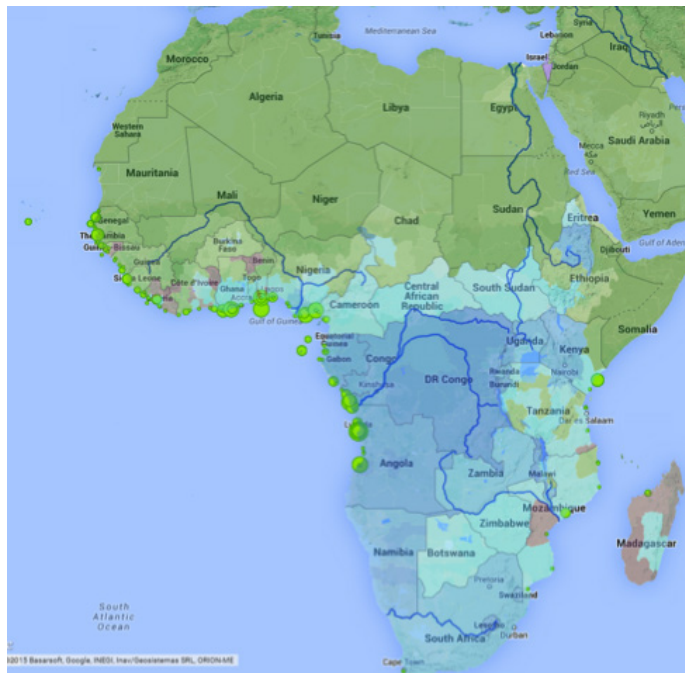
Points:	a GPS coordinate (city, building, site of battle, etc.)
Lines:	the sum of points directly between two GPS coordinates (river, road, gas pipeline, etc.)
Polygons:	the area enclosed by lines that connect each other (administrative units, lakes, etc.)
Rasters:	information available for each point in a given area at a certain granularity (light density, topography, temperature, etc.).

Figure 1 shows the AfricaMap with three data sources overlaid on a simple terrain from Google: points, i.e. green bubbles that represent slave ports scaled in size by how many slaves were exported from them (Trans-Atlantic Slave Trade Database 2010), blue lines showing major rivers (Natural Earth Project 2013), and colored polygons showing religious composition across first-level administrative units in African countries in 2005 (World Religion Database 2008). For the latter, darker green areas have a higher percentage of Muslims, darker blue more Christians and darker red more tribalists. The slave trade data have been used in a number of studies to examine the effects of the slave trade on present-day economic development and social characteristics such as trust (Nunn 2008; Nunn & Wantchekon 2011), distance to major rivers could provide a relevant control variable in many different types of studies, and research using GIS has also tried to explain why certain parts of Africa are predominantly Muslim, while in others Protestant and Catholic missionaries succeeded in spreading the gospel (Michalopoulos et al. 2012; Nunn 2010). Figure 2 shows instead the Landscan raster dataset which uses census data and satellite images of light density at night (detecting light from human settlements) to obtain fine-grained and precise information on population density across Africa (Landscan

2 Using GIS in 3D adds a third dimension to X-Y coordinates, which will not be covered here (see for instance Dell 2010). Geometrical GIS objects (points, lines and polygons) are sometimes called vectors and contrasted to the pixel-based raster data.

2010). As such, darker areas on the map are more densely populated. In section 3.1, I will review research of the effect of ethnic partition by country boundaries in Africa using some of these data.

Figure 1 and 2. AfricaMap with polygons (country borders and World religion data-base), points (slave ports) and lines (major rivers) and AfricaMap with polygons (country borders) and raster (population density)



Geocoding data of these four types (i.e. adding spatial information to them) then allows the computation of relations between them. This usually means joining information from other 'layers' than the one representing the unit of analysis with which one is concerned.

If the unit of analysis is polygons such as administrative units, then points (measuring the number of battles in a civil war for instance) may be counted within the territory of a given polygon, a variable may be constructed coding for whether or not a line (such as a road or river) traverses the polygon, and the average of a raster (such as topography or altitude) may be calculated for all polygons. We may also calculate which other polygons overlap with the administrative unit we are interested in, such as parliamentary constituencies. If the unit of analysis is points, like surveyed individuals based on residence, then the soil type (polygon) in the place in which the individual lives may be joined to the individual, as goes for the distance from the individual to a country border (line of a polygon) or highway (line), or the average density of light emitted at nighttime in a 25 kilometer radius from the individual (raster). Joining information from other points to a point can be done in a number of ways: the distance from the individual's residence to the closest school, for instance, or the number of schools in a certain radius from the surveyed individual. Likewise, lines or 'rasters' may be related to other data of their own type or the three other forms of data.

These are the fundamental building blocks of GIS and spatial analysis. Knowing these types of data allows one to make sense of the vast majority of studies in social science utilizing GIS, including the ones presented above, and the example I turn to in the following section.

3. Geography in Political Science: Then and Now

The focus of political science on individuals and countries, to the exclusion of geography and space, is a postwar phenomenon. The founders of academic American political science at Johns Hopkins University in the late 19th century were schooled in 'Old Institutionalism' focused on the geographical transmission of ideas and institutions, which produced for instance the well-known Turner Thesis (Turner 1893) of the American frontier (see Ethington & McDaniel 2007: 135–7). With the behavioral revolution and the systematic collection of survey data and national-level data, however, geography slid out of the political science mainstream. While engaging and theoretically fruitful, these works of 'old institutionalism' and other literatures such as comparative historical sociology ultimately were weaker in conclusively and systematically establishing their findings and eliminating alternative hypotheses than most of the quantitative work that became possible (see for instance critiques of comparative historical sociology by Geddes [1990] and King et al. [1994]). Yet today, newer

studies utilizing the GIS tools enumerated above can help social science provide systematic and triangulating tests of the accounts of the vital questions asked by 'old institutionalism' and comparative historical sociology and geography in politics, more broadly.

I will now show how – using GIS and these four types of geocoded data – new research has tested the effect of African borders on the wellbeing of the continent's citizens, as the borders have been argued to be artificial and poor for stability and development. I will take care to highlight the role played by spatial data in answering this otherwise difficult research question.

3.1 THE SCRAMBLE FOR AFRICA AND ARTIFICIAL BORDERS

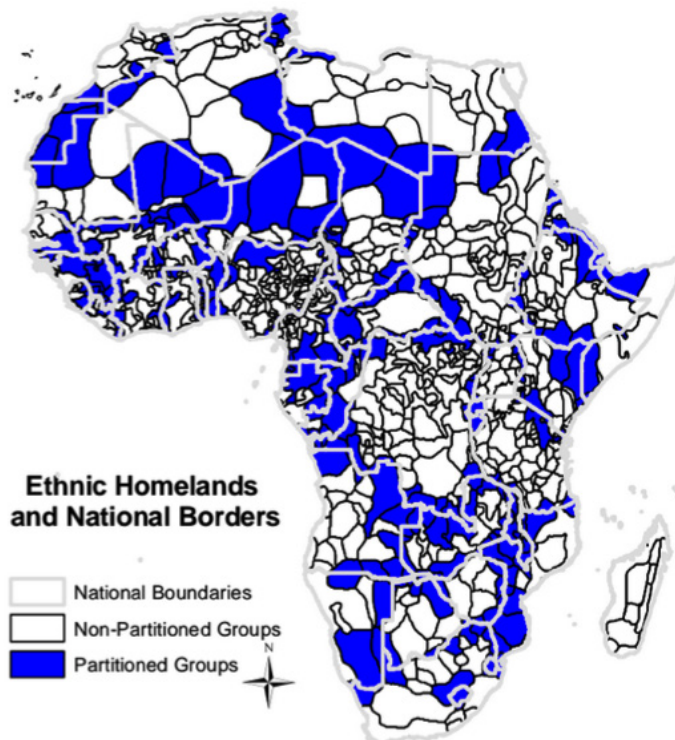
In addition to colonial rule (Acemoglu et al. 2001) and the slave trade (Nunn 2008), one of the causes of Africa's poverty and proneness to war, civil war and violence highlighted by Africanist historians is the imposition of unsuitable borders by European powers (Thomson 2010). Beginning at the Berlin Conference in 1884–5, arbitrary borders were drawn, and many have proven remarkably persistent up until today. Historians have argued that this has hindered the development of cohesive nation-states and led to ethnic strife (Horowitz 1985): if an ethnic group is partitioned, then its members may agitate for reunion with their ethnic brethren across the border, and in a conflict its members may be able to retreat and regroup on the other side of the national border, which may make them more of a threat to other ethnic groups or the national government. However, historians and political scientists have not been able systematically and conclusively to establish this finding. In an age of secessionism and of the emergence of new states such as South Sudan, the effects of the location of borders are therefore a question of very high substantive academic and policy interest.

In order to study the effects of ethnic partition and implicitly the effect of this particular pernicious European influence on Africa, Stelios Michalopoulos and Elias Papaoiannou (forthcoming) examine conflict in the areas traditionally inhabited by split ethnic groups, the involvement of partitioned ethnic groups in ethnic conflict as well as the living standards and educational attainment of individuals belonging to partitioned ethnic groups. To do this, they combine a large number of data sources using the GIS toolbox described in section 2.

In order, first, to find out which ethnic groups were partitioned and which were not, they first use spatial data on the locations and borders of mid-19th century 'homelands' of ethnic groups collected by ethnographers and missionaries [polygons] and present-day country borders [polygons] to determine that 229 of these ethnic homelands are partitioned by one or more present-day country borders, while 596 are not (see figure 3). They are also able to show that ethnic and precolonial characteristics pertaining to the ethnic groups in question (such as precolonial kingdoms, major cities, sites of major battles,

family structure, etc.) do not predict whether an ethnic homeland is split by a border or not. This makes sense insofar as European border-drawers were making these decisions *without* local knowledge, far away from the African areas concerned. The only things that predict split are the size of an ethnic homeland and the presence of major lakes in the territory of an ethnic homeland.

Figure 3. Partitioned and non-partitioned ethnic homelands (from Michalopoulos & Papaioannou, forthcoming)



However, because Michalopoulos & Papaioannou want to conduct within-country comparison, they use as their unit of analysis not the ethnic homelands, but rather the ‘country-ethnic area’ (i.e. the part of a given ethnic homeland in a given country). Of these there are 1212 in 49 countries [polygon]. Using spatially disaggregated data from the Armed Conflict Location & Event Data Project (ACLED) on violent events from 1997 to 2013, measured at the specific location of the violent event [point], Michalopoulos & Papaioannou can assign these to the country-ethnic area in which they take place. As such, they show that ethnically partitioned country-ethnic areas experience more battles between armed actors (state or non-state) and one-sided violence against civilians than other country-ethnic areas *in the same country* – also when examining only country-ethnic areas close to borders. The differences are strikingly large: the prevalence of conflicts with one or more deaths is estimated to be between 40 and 60 percent higher in the homelands of partitioned ethnicities (2015: 18). Equally, there

is a (generally smaller) spill-over effect to country-ethnic areas adjacent to split ethnicities. Michalopoulos & Papaioannou also use data from the ACLED on the conflict actors to show that government forces, rebels and militias and especially external government forces are more likely to engage in violence in partitioned country-ethnic areas. This backs up qualitative research indicating that foreign governments are especially likely to invade areas with large populations belonging to an ethnic group on the other side of the country border. Michalopoulos & Papaioannou also link the split ethnic groups to the Ethnic Power Relations (EPR) dataset (Wimmer et al. 2009) to show that groups that are partitioned by country borders are more likely to be victims of government discrimination and implicated in ethnically based civil wars.

Finally, Michalopoulos & Papaioannou examine individual outcomes using household data [points] from the Demographic and Health Surveys (DHS) containing location of residence and reported ethnicity. Matching this data to the split groups allows them to show that individuals identifying with partitioned ethnic groups have lower living standards, less access to public goods such as running water and electricity, and lower levels of education. Because they know where these respondents live, Michalopoulos & Papaioannou can also show that this is the case both for those living inside split homelands and for those outside them. Crucially, no matter where members of partitioned groups live, they appear to be disadvantaged, while members of non-partitioned groups who live in partitioned country-ethnic areas are not disadvantaged by it. In this way, their findings partly challenge Africanists who suggest that ethnic partitioning is responsible for poverty in general in Africa: country-ethnic areas of partitioned groups do *not* have lower income per capita measured by emitted night lights recorded by satellite imagery [raster].

As such, it seems that traditional Africanist historiography overwhelmingly had it right in emphasizing borders splitting ethnic groups in explaining civil wars and violence episodes in Africa, and further that the economic effects of this European heritage appears present *only* for citizens who belong to partitioned groups. In beginning to answer this question, Michalopoulos & Papaioannou have also provided us with a creative, new research design that will likely lead to more research that will enable us to understand ethnic partitioning, conflict and African history even better. But many possibilities remain to test even *the same* question by leveraging spatial thinking and data: Michalopoulos & Papaioannou look at contemporary borders, but do not in fact trace the development of African borders from 1885 until today (see also section 4.1 for the problems this poses for the results in the paper). Which ones changed, and which did not? Were early borders that partitioned groups more likely to change later than those which did not? While answers to these questions are unlikely substantially to change the findings in this research project, there is still much we do not know.

4. Advancing Political Science: Spatial Awareness and GIS

After outlining the concrete tools of GIS and showing an example of its innovative use to address one of political science's great questions, here I offer my thoughts on how spatial awareness and GIS can further political science as a discipline. I then give a number of specific examples of questions and topics in each of the three traditional subfields of comparative politics, international relations and public administration that I believe spatial thinking and GIS could help address.

4.1 THEORY TESTING, DATA AND RESEARCH DESIGNS

Political scientists' preoccupation with the sovereign state and atomic individuals not only increases the risk that we miss out on interesting political phenomena in between them, but also may carry implications for the validity of the results we find. By allowing for new tests of existing theories GIS can help improve the quality of our analysis and inference and thus hold the potential for political science to progress.

Firstly, it can do this by allowing the integration of data sources. As emphasized in section two of this article, space is a common denominator of almost all types of data and thus allows for integrating otherwise incongruent datasets by common spatial referents. If the units of analysis of different datasets are not compatible, they can often be made so by the addition of geocodes. In the example of the Scramble for Africa, the existing, non-geocoded Ethnic Power Relations dataset (Wimmer et al. 2009) was linked with the dataset of partitioned ethnicities constructed by Michalopoulos & Papaioannou using GIS. Furthermore, many of the new data sources referred to as 'Big Data' are recorded with spatial information such that for instance google searches and some social network activity may be linked to a specific place (see Stephens-Davidowitz [2013] and Jamal et al. [2015]). Historical sources – such as information at the city-level, census records or historical borders – are often also possible to geocode at relatively low cost or effort. In this way, more data may be brought to bear on our theories to adjudicate between competing theories.

Secondly, GIS and spatial thinking can help political science advance by making possible new research designs to test our theories. Conducting subnational analysis is much more straightforward with GIS, and complementing or moving beyond the cross-country and cross-country time-series research design can help improve the validity of our causal inference on macro-political phenomena for a number of reasons: Countries are inherently very difficult to compare in a manner that is sufficiently attentive to their particularities. Comparing subnational political units holds a great many potentially unobserved factors constant

across the units of analysis, lessening the risk of omitted variable bias (Snyder 2001; Pande & Udry 2005). By using geocoded datasets or geocoding existing datasets ourselves, we add spatial information that can be used for new research designs both within and between countries (such as natural experiments based on geographical discontinuities or precise instrumental variables, etc.). Again using the example of the Scramble for Africa, Michalopoulos & Papaoiannou create a new unit of analysis for their study by combining two shapefiles containing polygon data: the country-ethnic area, i.e. the part of an ethnic homeland contained in a given country. This then allows them to compare areas within the same country that were historically inhabited by a split and a non-split group, something that would have otherwise been impossible.

Such new research designs enabled by GIS can help to ameliorate the threats to inference originating from what geographers call the 'Modifiable Areal Unit Problem' (or MAUP): the challenge posed by the aggregation of local data into higher-order units for statistical analysis (Openshaw 1983). The basic intuition of the problem is that summary values for a given variable of higher-order units are highly influenced by the specific choice of boundaries if there is local variation in the variable. This holds because the areal units (countries, provinces, municipalities) are modifiable; political scientists who work on the subject of gerrymandering in political districts are acutely aware of this phenomenon. As Alesina & Spolaore put it, in social science "[...] borders themselves are treated as part of the geographical landscape, like coasts or mountains. However, national borders are not a natural phenomenon; they are human-made institutions [...]" (2005: 2). This introduces yet another disadvantage of country-level analysis: for any factor that has substantial, territorial within-country variation, MAUP potentially biases results – and when countries split up or amalgamate, MAUP is also one of the reasons that this may change our findings. Thus, MAUP may confound any potential causal relationship analyzed across sovereign states if the causal processes that produce the specific number of sovereign states and the territorial extent of these states at a given time are also correlated with the independent or dependent variable. What this means, essentially, is that conclusions about causal relationships reached by comparing countries may be misleading or outright wrong whenever we study variables that are plausibly also related to breakdown, amalgamation or emergence of sovereign states – most obviously colonialization, state capacity, federalism, secessionist sentiment, etc. at the domestic level and peace, war, free trade regimes, etc. at the international level.³ Even in the

3 Studying the processes of state formation and recognition, both eminently territorial, in history and today can help us determine which variables to worry about in relation this type of confounding. An example is Coggins's book-length study of which secessionist movements are elevated to the status of states and admitted into the international community of states after World War II, finding that support from great powers in the international system is crucial (Coggins 2014).

(primarily subnational) study by Michalopoulos & Papaioannou, MAUP could pose a problem: if ethnic partitioning (their independent variable) or civil war (one of their dependent variables) mattered for how many sovereign states emerged in Africa and where their borders came to lie, then their results may be biased. This would in fact appear very likely. South Sudan and Eritrea are Africa's two newest states which both came into being following particularly vicious civil wars with ethnic components. If borders have been moved to *less* conflict-prone areas and towards aligning with ethnic boundaries since 1884, then the partitioned ethnicities analyzed by Michalopoulos & Papaioannou given current boundaries may experience less conflict than would have been case without endogenous border displacement, and their estimate of the effect of ethnic partitioning on conflict may be biased downwards (i.e. *smaller* than the true causal estimate).

In addition to helping us solve these problems with much existing (primarily cross-country) research by facilitating subnational analysis, natural experiments and geographical regression discontinuity designs, using GIS software with certain types of geocoded data also allows us to perform cross-country analysis holding political units constant over time, instead of allowing them to change endogenously. As such, GIS would also allow Michalopoulos & Papaioannou to run their analyses on ethnic partitioning using only the borders that have not changed since 1885, since 1914, and since 1960, and to see whether their results are the same. For many types of research, GIS can even help us construct 'virtual countries' to use as complementary units of analysis, i.e. dividing the world into a number of squares, calculating values for relevant variables for them and performing analyses at this level of analysis (Michalopoulos 2012; Abramson 2014; Alesina et al. forthcoming).

However, GIS obviously cannot solve every problem of causal inference. Furthermore, certain types of GIS-assisted analysis contain risks of their own: in subnational analysis, for instance, processes of diffusion between subnational political units with relatively permeable borders make the assumption of the independence of causal processes taking place internally in units without outside influence even less tenable than in cross-national studies (see Imke & Harbers 2014 for ways to address this problem statistically). Additionally, it is not always warranted to conduct analysis at the lowest possible level of aggregation (such as the municipality) if the phenomenon studied is intimately tied to, or takes place at, a higher level of aggregation (such as at the provincial level or in the capital city). The spatial projection of power and linkages between different places can also be difficult to analyze using GIS. Edward Gibson distinguishes between the *site* (territorial arena) and *scale* (territorial reach) of political action because "goals pursued in one geographic location are often means toward objectives in other locations." (2013: 16). When site and scale are the same location, meaning that political action is directed at an outcome

in the same location as that in which the political action takes place, a variable or causal relationship is easily 'geo-operationalized', i.e. tied to a single geographical referent. But when this is not the case, 'geo-operationalizing' a variable or a causal relationship requires more reflection, and in these cases they often should not be solely reduced to a single geographical referent. In the case of ethnic partitioning and conflict, for instance, much relevant conflict caused by this division could take place *outside* the historical homelands of the ethnic group in question, for instance if separatists motivated by grievances related to the partitioning of their ethnic group undertake terrorist attacks in the capital city [site] to pressure influential national policymakers to change policy in the area where the partitioned group lives [scale].⁴

Despite these limitations, the new research designs made possible by GIS thus allow us to test political science theories in a way that is less vulnerable to omitted variable bias and MAUP biases rooted in how our units of analysis come about. This in turn should make political science more accurate in its explanations.

4.2 GIS AND COMPARATIVE POLITICS, INTERNATIONAL RELATIONS AND PUBLIC ADMINISTRATION

The example of Michalopoulos & Papaioannoy's work on the Scramble for Africa is easily translated to much of comparative politics at the micro- and macro-levels. Just to give a few examples, in comparative politics geographically informed studies of party systems, ethnic relations, public goods provision, multilevel governance, and election fraud all present great potential and are beginning to be published (for recent examples, see Ichino & Nathan 2013 and Dinesen & Sønderskov 2015).

In the field of international relations, questions such as the relationship of supra-national organizations to sub-national regions desiring autonomy, the use of strategic maps by diplomats and policy-makers, of national minorities in border regions and the risk of war and many others are equally amenable to the use of GIS. Here as well, disciplinary trends such as the publication, by the *Journal of Conflict Resolution* in December 2014, of a special issue entitled "Bridging Micro and Macro Approaches on Civil Wars and Political Violence: Issues, Challenges, and the Way Forward" using GIS, indicate that a 'spatial turn' is taking place.

In contrast, the research so far done in the sub-discipline of public administration has perhaps been touched the least by the possibilities unleashed by GIS. This near-absence of research in public administration using GIS is

4 Including this type of conflict is another advantage to Michalopoulos & Papaioannou of linking their data to the EPR dataset, which records ethnic conflict involving a given group no matter where it takes place (2015: 29).

somewhat paradoxical: in real-life administration at municipal, provincial and national levels GIS tools are ubiquitous and used in planning to determine the locations of new schools, hospitals, roads and other types of infrastructure. Equally, they are used to manage existing infrastructure and improve local public service provision.⁵ Furthermore, a large literature in public administration is concerned with analyzing governance and policy networks of bureaucrats and agencies (O'Toole 1997; 2014), which are highly conditioned by geographical distance. Taken together, this implies that there is a large potential for such studies, that quite possibly there is 'low-hanging fruit' to be picked in the field of public administration, and that scholars could benefit from embracing a spatial mindset and the tools of GIS.

5. Conclusion

In this article, I have argued that all political actors and political action are ultimately grounded in geographical space. For this reason, political science can progress further if we as its practitioners adopt a spatial mindset and avail ourselves of the possibilities inherent in geographic information systems for testing existing theories in new ways. While comparative politics and international relations are beginning to incorporate space in their analyses, its potential is, however, still underexplored and research public administration is notably lagging behind. Therefore, I have highlighted an example of geographically informed research that I believe advances political science and given examples of where we still have work to do on which GIS can be of assistance.

In furthering political science, I have laid my emphasis on the possibilities furnished by GIS to test existing theories through new data and new research designs. However, I believe spatial awareness may also help us as political scientists in theory-building: firstly, in theoretically incorporating political phenomena that our focus on countries and individuals have concealed, and secondly in theoretically integrating hierarchical linkages between actors at local, intermediate, national and international levels as well as horizontal linkages between actors at the same levels. This would make our theories more complete and likely also more accurate.

Applying this methodology to the example of the Scramble for Africa for the last time, thinking about a number of questions may make our theory of the long-run effects of European-imposed borders more complete: local conflict and inequality are likely shaped by subnational political contexts, so how do subnational civil servants and political officials (elected or appointed) seek to

5 See for instance "The Mayor's Geek Squad", *The New York Times*, March 23rd 2013, on the use of GIS data in New York City's Office of Policy and Strategic Planning under previous mayor Michael Bloomberg.

prevent or, conversely, to stoke the flames of conflict? How does local government mitigate or exacerbate ethnic inequality? And what interests do national governments have in shaping these local governance outcomes? Another question concerns the drawing of *subnational* boundaries. Do these follow ethnic boundaries, and when they do, does this make conflictual outcomes in partitioned ethnicities more or less likely? In Ethiopia since 1994, the introduction of ethno-federalism meant the redrawing of subnational first-level administrative boundaries in accordance with the locations of large ethnic groups (including the Eastern-most Somali regional state), providing subnational political leaders with institutional resources that may in part be used in conflicts. This happened after a destructive civil war, but from 1998–2003 and again from 2006–2009, Ethiopian-Somali conflict raged both within and outside Ethiopian territory (Kefale 2013).

Although the Ethiopian boundaries are likely more ‘natural’ in having been negotiated gradually between the indigenous Abyssinian kingdom and various European powers, thinking spatially about political action in between the individual and the national level and linkages between national and local political officials, as well as between local political officials and individual citizens, may help us to locate some of causal mechanisms that connect ethnic partitioning and conflict.

Contemporary politics are inextricably linked with space and geography, as has been explored by historians, area specialists and qualitative scholars directly and indirectly since the infancy of political science. Yet, the possibilities unlocked by GIS allow quantitative scholars to enrich such detailed, narrative research with systematic testing and let qualitative scholars add yet another source of information to their in-depth accounts of complex political phenomena. In addition to empirical and theoretical advances, an increased appreciation of geography may then also further better integration between quantitative and qualitative research in political science.

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