[FC-05-043] First, Second, and Third Laws of Geography

Abstract

This entry describes the three key principles in Geography, referred to as the Laws of Geography. The first law was proposed by Tobler and manifests the spatial autocorrelation (dependence) of geographic variation, that is “near things are more related than distant things”. The second law was by Goodchild and addresses the spatial heterogeneity of the geographic variation, that is “uncontrolled variation” of geographic feature. The third law was proposed by Zhu and his colleagues and illustrates the geographic similarity of geographic variation, that is “The more similar the geographic configurations of two points (areas), the more similar the values (processes) of the target variable at these two points (areas)”, or the more similar in geographic configuration between two locations the more similar the outcomes between the two locations. These principles (laws) manifest the duality of geographic reality: spatial dependence/spatial heterogeneity, geographic similarity/geographic individuality. This duality calls for the integration of the nomothetic and ideographic approaches in geographic analysis.

Keywords: distance, spatial heterogeneity

Author & citation

Sui, D. and Zhu, A. X. (2024). The Geographic Information Science & Technology Body of Knowledge (2024 Edition), John P. Wilson (ed.). DOI: 10.22224/gistbok/2024.1.27.

Explanation

1. Nomothic vs Ideographic Traditions in Geography

Geography, like many other social sciences, grapples with the fundamental question of how best to understand the spatial patterns of human society, environmental systems, and the complexities of human-environment interactions. To contextualize the laws of geography, one should have a basic understanding of two primary approaches employed within geographical research: the nomothetic and the idiographic (Sui and Turner, 2022).

The Nomothetic Approach: Unveiling Universal Laws

Derived from the Greek word "nomos" meaning law, the nomothetic approach strives to identify general laws and patterns governing spatial phenomena across broad scales. It seeks to establish universal principles that explain the distribution, causes, and

consequences of geographical processes. This approach heavily relies on quantitative methods, employing statistical analysis, modeling and simulation, large-scale surveys, and geospatial data to identify correlations and generate generalizable knowledge.

For instance, nomothetic geographers might analyze migration patterns across continents, aiming to uncover the overarching factors influencing human movement based on economic opportunities, climate change, or political instability. This approach allows for the construction of predictive models to anticipate future trends and formulate policies based on these broader insights.

The Ideographic Approach: Unpacking the Uniqueness of Place

In contrast, the ideographic approach, derived from the Greek word "idios" meaning unique, focuses on the specific and distinctive characteristics of individual places and experiences. It delves into the intricate details that shape the character of a particular location or locale, emphasizing the unique cultural, historical, and environmental factors that contribute to its identity.

This approach often utilizes qualitative methods like ethnographic research, participant observation, and in-depth interviews to capture the nuanced perspectives and lived experiences of individuals within a specific locality. For example, an idiographic study might examine the impact of a local river on the social fabric of a village, exploring the unique cultural practices, resource utilization patterns, and community dynamics that revolve around this specific waterway.

The study of the first, second, and third law of geography obviously follows the nomothetic approach, but the second law of geography entails the necessity of the ideographic approach. To have a holistic understanding of geographic reality, we need both approaches in geographic research.

2. First Law of Geography and Spatial Autocorrelation

The first law of geography is about spatial autocorrelation. Spatial autocorrelation describes the fact that there is a relationship between the attribute values of a given geographic variable at two locations and the distance separating the two locations. In his classic paper, Tobler (1970) invoked “the first law of geography: everything is related to everything else, but near things are more related than distant things” for the first time in the literature. Tobler employed a spread function to parameterize population dynamics for the spatial units used in his movie. This invoked statement is now widely taken as Tobler’s First Law of Geography (or TFL) and marked the beginning of actually naming geographic principles as laws. Later in a separate paper, commenting on how to create continuous population surfaces based on census polygons, Tobler (1999) further elaborated the first law by giving the possible reasons for spatial autocorrelation, stating that “Philosophically, the phenomenon external to an area of interest affects what goes on in the inside (page 87).”

The first law of geography on spatial autocorrelation, even though without explicit proves and elaborations at the times when they were introduced, did capture an important aspect of geographic reality and have gained empirical support and validation across multiple fields of study (Goodchild, 2004; Sui, 2004; Otaiku, 2018; Leitner et al., 2018; Zhu et al., 2018). What entails in the first law of geography on spatial autocorrelation is actually the

theoretical foundation for geographic analyses and modeling, particularly with the development of geographic information systems and science (Longley et al., 2001). Spatial interpolation (such as kriging (Krige, 1951)), or geostatistics more broadly (Isaaks and Srivastava, 1989), is cited here as an example to illustrate this. Spatial interpolation provides an educated assessment about the status of a geographic variable at unsampled locations based on the conditions of that variable sampled at locations nearby. The influence of the sampled conditions on the assessment is based on the distance of each sample location to the location of assessment. The closer the sampled location the heavy the influence. Without spatial autocorrelation, assessments in such a way are impossible. The geographic literature contains various examples on the application of this law (See Mahuve and Tarimo, 2022; Mueller and Weiler, 2023; Yuan et al., 2018 for examples).

3. Second Law of Geography and Spatial Heterogeneity

The second law of geography is about spatial heterogeneity. Spatial heterogeneity refers to the varying nature of geographic features over time and space (Anselin, 1989). Similar to spatial autocorrelation, several law-like statements about spatial heterogeneity have been proposed to capture the different aspects of spatial heterogeneity of geographic reality. Goodchild (2004) introduced the "uncontrolled variation" of geographic features as a candidate for a Second Law of Geography. This “uncontrolled variance” can be perceived in two effects: the first order and second order effects. The first order effect is the variation of geographic features at a location over time and the second order effect is the variation in spatial autocorrelation between places, meaning that spatial autocorrelation, as captured in the First Law of Geography, can vary from location to location, from time to time, from feature to feature (Zhu, 2023).

Arbia, Benedetti, and Espa (1996), in discussion of the effects of the modifiable area unit problem (MAUP), described another dimension of spatial heterogenity, “everything is related to everything else, but things observed at a coarse spatial resolution are more related than things observed at a finer resolution’’. This statement suggests the smoothing effect of spatial aggregation or behavior of geographic feature across scales, which is similar to the Law of Scale Independence (LSI) proposed by Phillips (2022), “the law of scale independence (LSI) states that for any phenomenon that exists across a sufficiently large range of scales, there exists a scale separation distance at which the scales are independent with respect to system dynamics and explanation”. Both of these two laws emphasize the cross-scale nature of spatial heterogeneity of geographic features.

In examining the impacts spatially enabled digital devices on economic activities, Foresman and Luscombe (2017), discussed another aspect of spatial heterogeneity, “Things that know where they are can act on their locational knowledge. Spatially enabled things have increased financial and functional utility”. Although it focuses on impacts of the spatial location (geographic location) awareness on economic activities, this law really exemplifies the special effects of geographic location, referred to as “spatial is special”, capturing the importance of spatial context. Applications of location-enabled services in health services and disaster relief are other examples for this particular aspect of spatial heterogeneity (Boulos, 2003; Huang and Xu, 2014).

What is captured in these different laws on spatial heterogeneity does not suggest that geographic variation is out of order. Instead, it indicates that the forms and types of geographic variation is not universal, nor fixed. It is exactly this non-universal and non-fixed

forms of geographic variation gives birth to the complexity and diversity of geographic realm and makes the geographic world fascinating and interesting. This diversity and complexity act as one of the driving forces and motivation in advancing human civilization.

These different aspects of spatial heterogeneity as highlighted above provide new opportunities and new perspectives for geographic analysis, drives the development of the geography discipline, and helps us to better understand the geography world. For example, due to these different aspects of geographic variation, parameters in spatial analysis often are not taken as constants, rather taken as variables changing according to the types of geographic features, over time and over space as well as across scale of analyses. Understanding the various aspects of spatial heterogeneity allows us to understand and to traverse the geographic realm better.

4. Third Law of Geogrpahy, Geographic Similarity, and Beyond

The third law of geography captures the concept of geographic similarity which describes the causes of resemblance in geographic outcomes between locations through analogy. Zhu and his colleagues (2018), in examining the theoretical principles underpinning spatial prediction, proposed "The more similar the geographic configurations of two points (areas), the more similar the values (processes) of the target variable at these two points (areas)" as the Law of Geographic Similarity, and future elaborated and discussed in subsequent papers (Zhu et al., 2020; Zhu and Turner, 2022; Zhu, 2022; Zhu 2023).

The Third Law of Geography links the similarity in outcome of a geographic variable between two locations to the similarity in the geographic configurations at these two locations, that is, similar geographic configurations lead to similar geographic outcomes. This law employs analogy in explaining the nature of geographic variation. If the processes leading to the geographic outcome at one location are known, this location can be used as an "exemplar" in assessing the outcome at a different location whose geographic configuration is similar.

What makes this law geographic is its emphasis on "geographic configuration." Zhu and Turner (2022) outlined the three key components in the constitution of geographic configuration. The first is the list of geographic variables used to characterize the geographic configuration at a location. These variables need to be related to the prescribed geographic variable; thus, this list is dependent on the prescribed variable under concern. For example, the set of geographic variables used to define the geographic environment for occurrence of a specific type of crimes would be different from those for assessing the suitability of a particular wildlife. The relationship between these variables and the prescribed variable is not necessarily causal, but covarying. Thus, these geographic variables are often referred to as "covariates". The second component is the order (relative importance) and the combination of the values from these covariates. The third is the spatial structure (spatial arrangement) of the conditions from these covariates around the location of interest or within the area of interest. It is this spatial arrangement that makes the third law geographic (Zhu and Turner, 2022; Zhu 2023).

Analogy based on geographic configuration is an important concept in the Third Law of Geography. It allows one to focus on the role of individual known examples (samples) in the process of geographic assessment. What captured in the Third Law might be the reason that geographers seek out "exemplars" or "representative samples" to study geographic

phenomena so that they can be used as analogy for assessing geographic outcomes at unvisited locations with similar geographic environments (configurations).

The third law provides a completely different way for geographic analysis. The majority of existing geographic analysis is based on the statistical average model. The average model computes the “average” condition (the mean value or mean relationship) from a set of samples and this average condition is then used to assess the geographic outcomes at unvisited locations. Under the Third Law of Geography assessment of geographic outcomes at unvisited locations is accomplished by evaluating the similarities in geographic configuration between the unvisited location and the individual known samples (examples). This allows the more “similar” examples to play more important roles in the assessment and thus, the individuality of the local conditions (or detail spatial variations) can be better captured. In addition, confidence (uncertainty) associated with the assessment can be obtained by analyzing these similarities. If the similarities are low, then the quality of the assessment is low, otherwise, high. Applications of the Third Law of Geography in spatial predication, uncertainty quantification and sample quality assessment, spatial data bias mitigation, have shown that this new way of analysis is effective (Zhu et al., 2015; Zhang et al., 2019; Zhu et al., 2019; Liu et al., 2020).

The fact that the Third Law of Geography emphasizes the general principle but the approach it takes is based on uniqueness of individual samples, make it a good example of the integration of nomothetic and ideographic ideology in geographic analysis.

5. The Duality of Geographic Reality: Bridging the Divide

While the nomothetic and ideographic approaches differ in their focus and methodology, they are not mutually exclusive because of the duality of geographic reality – dependence/heterogeneity, similarity/individuality. A rich understanding of geographical phenomena often emerges from the interplay between the nomothetic and the idiographic (Sui and Kedron, 2021).

Nomothetic insights provide a foundational framework for understanding broader spatial patterns, while idiographic investigations enrich this framework by revealing the specificities and nuances that shape the lived experiences within these patterns. This synergy allows geographers to move beyond generalizations and appreciate the unique character of individual places within the context of broader trends.

Both the nomothetic and idiographic approaches offer valuable tools for comprehending the complexities of geography. Recognizing the strengths and limitations of each approach allows geographers to create a more nuanced and comprehensive understanding of the human-environment relationship across various scales and contexts. By embracing both the universal and the unique, geographers can paint a richer picture of the world, revealing the intricate tapestry woven from the interplay of broad patterns and individual experiences.

6. Summary

Ultimately, we need both nomothetic and ideographic approaches, which are manifested in the three laws of geography discussed in this entry. Together these three general principles cover the unique aspects of the nature of geographic variation: spatial autocorrelation, spatial heterogeneity, and geographic similarity. We hope that it is shown through this presentation that geographic epistemology contains both nomothetic vs. ideographic

ideology but in much more integrated or complement way than these terms imply. As shown above, the first law's spatial dependence is only completed when complemented by the second law's heterogeneity, and vice versa. The third law links similarity (generality) with individuality (uniqueness) together, an explicit statement about the need for integrating the two ideologies in geographic analysis.

References

Anselin, L. (1989). What is Special About Spatial Data? Alternative Perspectives on Spatial Data Analysis (89-4). UC Santa Barbara: National Center for Geographic Information and Analysis.

Arbia, G., Benedetti, R., & Espa, G. (1996). Effects of the MAUP on image classification. Geographical Systems, 123-141.

Boulos, M.N.K. (2003). Location-based health information services: a new paradigm in personalised information delivery. Int J Health Geogr 2, 2.

Foresman, T. and Luscombe, R. (2017). The second law of geography for a spatially enabled economy. International Journal of Digital Earth. 10 (10): 979–995.

Goodchild, M. F. (2004). The Validity and Usefulness of Laws in Geographic Information Science and Geography. Annals of the Association of American Geographers, 94(2):300–303.

Huang, Q. and Xu, C. (2014). A data-driven framework for archiving and exploring social media data. Annals of GIS, 20:4, 265-277

Isaaks, E.H., and Srivastava, R.M. (1989). An Introduction to Applied Geostatistics, Oxford University Press, New York.

Jing, L., Zhu, A.-X., Rossiter, D. G., Du, F., and Burt, J. (2020). A trustworthiness indicator to select sample points for the individual predictive soil mapping method (iPSM). Geoderma, 373: 114440.

Krige, D.G. (1951). A statistical approach to some basic mine valuation problems on the Witwatersrand. Journal of Chemical, Metallurgical, and Mining Society of South Africa, 52, 119–139.

Leitner, M., Glasner, P., & Kounadi, O. (2018, February 26). Laws of Geography. Oxford Research Encyclopedia of Criminology.

Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2001). Geographic Information System and Science (1st Edition). England: John Wiley & Sons, Ltd.

Mahuve, F. E., & Tarimo, B. C. (2022). Integrating fuzzy set function into floating catchment area measures: a determination of spatial accessibility of service points. Annals of GIS, 28(3), 307–323.

Mueller, A. G., & Weiler, S. (2023). Spatial Models of Travel Behavior and Land Use Restriction. Journal of Sustainable Real Estate, 15(1).

Otaiku, A. A. (2017). The Evaluation of Laws of Geography. International Journal of Research in Geography (IJRG) 4(4): 12-21.

Phillips, J. D. (2022). The Law of Scale Independence. Annals of GIS, 28(1), 15–29.

Sui, D. Z. (2004). Tobler's First Law of Geography: A Big Idea for a Small World? Annals of the Association of American Geographers, 94(2), 269–277.

Sui, D. Z., & Kedron, P. (2021). Reproducibility and Replicability in the Context of the Contested Identities of Geography. Annals of the American Association of Geographers, 111(5), 1275-1283.

Sui, D., & Turner, M. (2022). General theories and principles in geography and GIScience: Moving beyond the idiographic and nomothetic dichotomy. Annals of GIS, 28(1), 1–4.

Tobler W. (1999). Linear pycnophylactic reallocation comment on a paper by D. Martin. International Journal of Geographical Information Science, 13(1), 85–90.

Tobler, W. R. (1970). A Computer Movie Simulating Urban Growth in the Detroit Region. Economic Geography 46: 234–240.

Yuan, Y., Wei, G., & Lu, Y. (2018). Evaluating gender representativeness of location-based social media: a case study of Weibo. Annals of GIS, 24(3), 163–176.

Zhang, G., & Zhu, A.-X. (2019). A representativeness-directed approach to mitigate spatial bias in VGI for the predictive mapping of geographic phenomena. International Journal of Geographical Information Science, 33(9), 1873–1893.

Zhu, A. X. (2022). On the Third Law of Geography. In: Li, B., Shi, X., Zhu, AX., Wang, C., Lin, H. (eds) New Thinking in GIScience. Springer, Singapore.

Zhu, A. X. (2023). "On the Three Laws of Geography", Geographic Education (Chinese), No. 1 (2023), pp. 1-7.

Zhu, A. X., & Turner, M. (2022). How is the Third Law of Geography different? Annals of GIS, 28(1), 57–67.

Zhu, A.X., G. Lv, C.Z. Zhou, C.Z. Qin (2020). "Geographic Similarity: The Third Law of Geography?" Journal of Geo-Information Science, Vol. 22, No. 4, pp: 673-679.

Zhu, A.X., Liu, J., Du, F., Zhang, S.J., Qin, C.Z., Burt, J., Behrens, T. and Scholten, T. (2015), Predictive soil mapping with limited sample data. Eur J Soil Sci, 66: 535-547.