International Journal of Research in Geography (IJRG)
Volume 4, Issue 4, 2018, PP 12-21
ISSN 2454-8685 (Online)
http://dx.doi.org/10.20431/2454-8685.0404002
www.arcjournals.org

The Evaluation of Laws of Geography

Ayodele A. Otaiku*

Doctoral Student, Nigerian Defence Academy, Faculty of Arts & Social Science,

Department of Geography/Environmental Management, Kaduna, Nigeria

***Corresponding Author:** *Doctoral Student, Nigerian Defence Academy, Faculty of Arts & Social Science, Department of Geography/Environmental Management, Kaduna, Nigeria.* **Email:** *otaiku.ajayiayodele@nda.edu.ng, aotaiku@gamil.com.* **Mobile:** *+234 8033721219*

Abstract: *Geography simply is a science by virtue of the fact that it is a truth-seeking discipline whose raw materials consist of empirical observations seeking to make law-like statements. A law should be unrestricted in its application over space and time. It is thus a 'universal statement' of unrestricted range. This suggests at least one important criterion for distinguishing a law. A key concept in this respect is that laws must be proven through objective procedures and not accepted simply because they seem plausible. A valid law must predict certain patterns in the world, so that having developed an idea about those patterns; the researcher must formulate them into a testable hypothesis 'a proposition whose truth or falsity is capable of being asserted'. Four types of laws which have relevance for human geographer: Cross-sectional laws; Equilibrium laws; Dynamic laws and Statistical laws. Positivist-led geography has wider application of laws for successful and fruitful analysis of geographical phenomena together with spatial patterns. There are two alternative routes to explanation, or which are followed in establishing a scientific law 'induction' and 'deduction'. Tobler's First Law (TFL) was a product of the quantitative revolution of the 1960s, and efforts to turn geography into a nomothetic science stated that 'everything is related to everything else, but near things are more related than distant things'. Spatial analysis, and indeed life itself, would be impossible. Less well known is his (Tobler) second law, which complements the first: "The phenomenon external to an area of interest affects what goes on inside". Others scholars have offered up their versions of this law examples include: "Ecology" "Cognitive geography" "Political behaviour" and "Financial". The primary task of scientific method is to explain empirical phenomena, now encapsulated in geographic law and illuminated by advanced in geomatic science. TFL forms the conceptual foundation for the entire field of geostatistics and its cousins in other disciplines.*

Keywords: *Quantitative Revolution; Spatial Science; Scientific Methods; Laws of Geography and Empirical Observations*

1. Background

Geography has ancient historical origins that trace to Greece, Rome, North Africa, and Southwest Asia? Martin (2005).The growth of geographical thought in fifteenth and sixteenth century Europe, which built on those traditions, was deeply intertwined with the colonial project. Three key Enlightenment figures-Immanuel Kant, Alexander von Humboldt, and Carl Ritter- developed geography as a science of space, which proved crucial to its inclusion as a discipline in modem universities, including those in the United State (Hartshorne,1959).Despite this relatively parallel growth in student interest, geography and law came to occupy very different places in the U.S. academy over the first half of the twentieth century. In addition to belonging in both of the increasingly balkanized social and natural sciences, geography made intellectual choices that marginalized it. At the end of the nineteenth and beginning of the twentieth century, many leading U.S. geographers had embraced environmental determinism, which argues that the physical environment controls socio-cultural development (Semple,1911). As environmental determinism came under attack in the 1920s and 1930s, the discipline turned to regional and morphological approaches, which became devalued in broader mid-century U.S. academic discourse. This trend continued for twenty more years, even as the beginnings of a postmodern turn emerged in the U.S. academy Murphy (2006)**.** Neil Smith notes that geography was endangered at Harvard, for example, because of the "lack of clear intellectual terrain and set of goals" and "the alleged low calibre of geographical scholarship "by Smith (1987).

The quantitative revolution was a paradigm shift that sought to develop a more rigorous and systematic methodology for the discipline of geography. It came as a response to the inadequacy of regional geography to explain general spatial dynamics. The main claim for the quantitative revolution is that it led to a shift from descriptive (idiographic) geography to an empirical law-making (nomothetic) geography. The quantitative revolution occurred during the 1950s and 1960s and marked a rapid change in the method behind geographical research, from regional geography into a spatial science (Gregory et al., 2009). In the history of geography, the quantitative revolution was one of the four major turning-points of modern geography- the other three being environmental determinism, regional geography and critical geography. The quantitative revolution had occurred earlier in economics and psychology and contemporaneously in political science and other social sciences and to a lesser extent in history.

2. THE QUANTITATIVE REVOLUTION

The quantitative revolution responded to the regional geography paradigm that was dominant at the time. Debates raged predominantly (although not exclusively) in the U.S., where regional geography was the major philosophical school. In the early 1950s, there was a growing sense that the existing paradigm for geographical research was not adequate in explaining how physical, economic, social, and political processes are spatially organized, ecologically related, or how outcomes generated by them are evidence for a given time and place. A growing number of geographers started to express their dissatisfaction with the traditional paradigm of the discipline and its focus on regional geography, deeming the work as too descriptive, fragmented, and non-generalizable. To address these concerns, early critics such as Ackerman (1945) suggested the systematization of the discipline. Soon thereafter, a series of debates regarding methodological approaches in geography took place. One of the first illustrations of this was the Schaefer vs. Hartshorne debate in 1953 *Exceptionalism in geography*: A Methodological Examination was published. In this work, Schaefer rejected Hartshorne's *exceptionalist interpretations* about the discipline of geography and having the region as its central object of study. Instead, Schaefer envisioned as the discipline's main objective the establishment of *morphological laws through scientific inquiry,* i.e. incorporating laws and methods from other disciplines in the social sciences that place a greater emphasis on processes.

Hartshorne, on the other hand, addressed Schaefer's criticism in a series of publications, Hartshorne (1954, 1955,1958, 1959) where he dismissed Schaefer's (1953) views as subjective and contradictory. He also stressed the importance of describing and classifying places and phenomena, yet admitted that there was room for employing laws of generic relationships in order to maximize scientific understanding. In his view, however, there should be no hierarchy between these two approaches. While debates about methods carried on, the institutionalization of systematic geography was taking place in the U.S. academy. The geography programs at the University of Iowa, Wisconsin, and Washington were pioneering programs in that respect. At the University of Iowa, Harold McCarty led efforts to establish laws of association between geographical patterns. At the University of Wisconsin, Arthur H. Robinson led efforts to develop statistical methods for map comparison. And at the University of Washington, Edward Ullman and William Garrison worked on developing the field of economic and urban geography, and central place theory. These institutions engendered a generation of geographers that established spatial analysis as part of the research agenda at other institutions including University of Chicago, among others (Johnston, 2016; Gregory, 2009).The changes introduced during the 1950s and 1960s under the banner of bringing *'scientific thinking'* to geography led to an increased use of technique-based practices, including an array of mathematical techniques and computerized statistics that improved precision, and theory-based practices to conceptualize location and space in geographical research (Gregory, 2008). Some of the techniques that epitomize the quantitative revolution include, Burton (1963):

- Descriptive statistics;
- Inferential statistics (e.g. correlation and regression);
- Basic mathematical equations and models, such as gravity model of social physics, or the Coulomb equation;
- Stochastic models using concepts of probability, such as spatial diffusion processes;
- Deterministic models, e.g. Von Thünen's and Weber's location models.

The common factor, linking the above techniques, was a preference for numbers over words, plus a belief that numerical work had a superior scientific pedigree (Burton,1963).

2.1. Epistemological Underpinnings

The new method of inquiry led to the development of generalizations about spatial aspects in a wide range of natural and cultural settings. Generalizations may take the form of tested hypotheses, models, or theories, and the research is judged on its scientific validity, turning geography into a nomothetic science. One of the most significant works to provide a legitimate theoretical and philosophical foundation for the reorientation of geography into a spatial science was David Harvey's book, *Explanation in Geography*, published in 1969. In this work, Harvey laid out two possible methodologies to explain geographical phenomena: *an inductive route* where generalizations are made from observation; and *a deductive* one where, through empirical observation, testable models and hypothesis are formulated and later verified to become scientific laws Harvey (1969). He placed preference on the latter method. This positivist approach was countered by critical rationalism, a philosophy advanced by Karl Popper (1963, 1969) who rejected the idea of verification and maintained that hypothesis can only be falsified.

Both epistemological philosophies, however, sought to achieve the same objective: to produce scientific laws and theories (Johnston et al., 2016). The paradigm shift had its strongest repercussions in the sub-field of economic and urban geography, especially as it pertains to location theory. However, some geographers such as Ian Burton (1963) expressed their dissatisfaction with quantification while others debated the feasibility of law-making (Jones 1956; Lewis, 1965; Golledge and Amedeo, 1968) .Others, such as Luckermann (1965), criticized the scientific explanations offered in geography as conjectural and lacking empirical basis. As a result, even models that were tested failed to accurately depict reality. By the mid-1960s the quantitative revolution had successfully displaced regional geography from its dominant position and the paradigm shift was evident by the myriad of publications in geographical academic journals and geography textbooks. The adoption of the new paradigm allowed the discipline to be more serviceable to the public and private sectors (Johnston et al., 2016).

3. POST-REVOLUTION GEOGRAPHY

The quantitative revolution had enormous implications in shaping the discipline of geography into what it looks like today given that its effects led to the spread of positivist (post-positivist) thinking and counter-positivist responses (Johnston and Sideway, 2016).The rising interest in the study of distance as a critical factor in understanding the spatial arrangement of phenomena during the revolution led to formulation of the first law of geography by Tobler (1970). The development of spatial analysis in geography led to more applications in planning process and the further development of theoretical geography offered to geographical research a necessary theoretical background (Gregory et al., 2009). The greater use of computers in geography also led to many new developments in geomatics, such as the creation and application of geography information system (GIS) and remote sensing. These new developments allowed geographers for the first time to assess complex models on a full-scale model and over space and time and the relationship between spatial entities. To some extent, the development of geomatics helped obscure the binary between physical and human geography to some extent, as the complexities of the human and natural environments could be assessed on new computable models (Johnston and Sideway, 2016).

The overwhelming focus on statistical modelling would, eventually, be the undoing of the quantitative revolution. Many geographers became increasingly concerned that these techniques simply put a highly sophisticated technical gloss on an approach to study that was barren of fundamental theory. Other critics argued that it removed the 'human dimension' from a discipline that always prided itself on studying the human and natural world alike. As the 1970s dawned, the quantitative revolution came under direct challenge. The counter-positivist response came as geographers began to expose the inadequacy of quantitative methods to explain and address issues regarding race, gender, class and war (Gregory et al., 2009). On that regard, David Harvey disregarded earlier works where he advocated for the quantitative revolution and adopted a Marxist theoretical framework (Harvey 1972, 1973). Soon new subfields would emerge in human geography to contribute a new vocabulary for addressing these issues, most notably critical geography and feminist geography.

The term ‘scientific method’ denotes the logical structure of the process by which the search for trustworthy knowledge advances. The primary task of scientific method is to explain empirical phenomena. There is no need to argue that geography ought to be a science. Geography simply is a science by virtue of the fact that it is a truth- seeking discipline whose raw materials consist of empirical observations. There is no suggestion that geography should undergo any sort of epistemological restructuring. The scientific method is often characterised by five elements – **theory (and fact), law, logic and reduction**, which necessarily sustain the scientific thinking and/or approach. However, there is one more element, i.e. **‘hypothesis’** that also sustains and provides the required input to scientific practice and process in geography, and also in related sciences.

4. ON GEOGRAPHY LAWS

The second key element in scientific thinking is ‘law’. ‘Any fully developed scientific theory contains, embedded within it, certain statements about unvarying relationships’. These laws may be evident at the level of everyday experience or only at the level of scientific investigation, for example, by controlled experiment or microscopic investigation. As with theories there is a predisposition among scientists to seek laws which cover broad categories of phenomena. There is also a preference within science for deterministic laws - that ‘wherever’ A and B are present C ‘will’ result. But it is recognized that some laws have a probabilistic form even if they represent a transient stage in the development of the discipline and will give way to deterministic laws as the discipline develops’. The credit to put the relevance of ‘law’ in geography goes to Schaefer (1953) who said that geographers should seek to make law-like statements. ‘A science’, according to him, ‘is characterized by its explanations, and explanations require laws’. To explain the phenomena, one has described means always to recognize them as instances of laws. In geography, the major regularities which are described refer to spatial patterns with focus on space. Hence, geography has to be conceived as the science concerned with the formulation of the laws governing the spatial distribution of certain features on the surface of the Earth.

Geographical procedures would then not differ from those employed in the other sciences, both natural and social observation would lead to a hypothesis - about the interrelationship between two spatial patterns, for example, and this would be tested against large number of cases, to provide the material for a law if it were thereby verified. A law should be unrestricted in its application over space and time. It is thus a ‘universal statement’ of unrestricted range. This suggests at least one important criterion for distinguishing a law. A substantial part of Braithwaite’s (1953) analysis of scientific explanation is concerned with establishing how laws are related to a surrounding structure of theory. It is impossible to determine whether a statement is or is not a law simply by referring to the truth or falsity of the generalisation it contains. A major criterion in determining whether a statement is or is not a law is the relationship of that statement to the system of statements that constitutes a theory. If this criterion is accepted, then the ideas are required to be adjusted regarding the verification procedures necessary to transform a scientific hypothesis into a scientific law. A generalisation may be set up or established as true or false simply by direct reference to empirical subject matter. The truth of an empirical law has to be established by this method too, but in addition, it requires support from other empirical laws, theoretical laws (that cannot be given any direct test), and also from other lower level empirical laws that helps it to predict.

A key concept in this respect is that laws must be proven through objective procedures and not accepted simply because they seem plausible. As Bunge (1962) puts it, ‘The plausibility or intuitive reality of a theory is not a valid basis for judging a theory. A valid law must predict certain patterns in the world, so that having developed an idea about those patterns; the researcher must formulate them into a testable hypothesis - a proposition whose truth or falsity is capable of being asserted”. An experiment is then designed to test the hypothesis, data are collected, and the validity of the prediction evaluated. One successful test will not turn it into a law replication on other data sets will be needed since a ‘law is supposed to be universal’. However, Jones (1956) pointed out the impossibility of discovering universal laws about human behaviour and indicated the existence of two types of law in physics -the ‘determinate’ laws of classic physics, which apply microscopically; and the ‘probabilistic quantum laws’ which refer to the behaviour of individual particles. Golledge and Amedeo (1968) attempted to indicate that science recognises several types of law, and also that the veracity of a law-like statement can never be finally proven, since it cannot be tested against all instances, at all times and in all places. They indicated four types of laws which have relevance for human geographer:

- Cross-sectional laws, which describe functional relationships, but show no causal connection, although they may suggest one;
- Equilibrium laws which state what will be observed if certain criteria are met;
- Dynamic laws, which incorporate notions of change, with the alteration in one variable being followed by (perhaps causing) an alteration in another. Dynamic laws may be historical, showing that B preceded by A and followed by C, or developmental, in which B would be followed by C, D, E, etc.; and
- 'Statistical laws' which are probability statements of B happening given that A exists. All laws of the other three categories may be either deterministic or statistical with the latter almost certainly the case with phenomena studied by geographers.

However, according to Sack (1972), space, time and matter cannot be separated analytically in an empirical science which is concerned to provide explanation. He attempted to show that geometry is not an acceptable language for such a science, i.e. geography. Nevertheless, geography is closely allied with geometry in its emphasis on the spatial aspects of events (the instances of law), but geometry alone is insufficient as a basis for explanation and prediction since no processes are involved in the derivation of geometries. Bunge (1973), however, responded to this statement, claiming that spatial prediction was quite possible with reference to the geometry alone, as instanced by central place theory and Thunian analysis. Sack (1973) responded by saying that, 'the static laws espoused by Bunge are only special cases of dynamic laws having antecedent and consequent conditions and that although the laws of geometry are unequivocally static, purely spatial, non-deducible from dynamic laws, and explain and predict physical geometric properties of events, they do not answer the questions about the geometric properties of events that geographers raise and they do not make statements about process'. Geography, according to Sack, is concerned to explain events and it requires substantive laws – such laws may contain geometric terms, such as 'the frictions of crossing a certain substance', but these terms of themselves are insufficient to provide explanations. He identified two types of laws relevant to geographical work, Sack (1973):

- Congruent substance laws which are independent of location - statements of 'if A then B' are universals which require no spatial referent;
- Overlapping substance laws which involve spatial terms 'if A then B' in such cases contains some specific reference to location.

Both types are relevant and necessary in providing the answers to the geographical questions, so case may be made for a necessary 'spatialness' to the substance laws of human geography. Thus, positivist-led geography has wider application of laws for successful and fruitful analysis of geographical phenomena together with spatial patterns. The concept of law has a much wider significance in such geography which is being conceived of as a science with law-seeking episteme because it postulates a three-fold hierarchy of scientific statements from factual statements or systematised descriptions through a middle-tier of 'empirical generalisations or laws', to general or theoretical laws. There are two alternative routes to explanation, or which are followed in establishing a scientific law, according to Harvey (1969). The first by '*induction'*-proceeding from numerous particular instances to universal statements and the second that of *'deduction'* proceeding from some a *priori* universal premise to statements about particular sets of events.

5. DEFINITION OF LAW AND TOBLER'S FIRST LAW OF GEOGRAPHY

Definition of a law comes from a scientist, namely Richard Feynman (1967). In his book on 'The Character of Physical Law', he describes how to invent a new law. He points out that the first, and most difficult, step is to guess (Feynman 1967, 156). Then, the criterion becomes to ''compute the consequences of the guess to see what would be implied …Then we compare the result…with experiment or experience …[or] observation to see if it works. If it disagrees with experiment it is wrong.'' So guess again. He also points out that, 'laws can only be discovered by doing something radically different'. The procedure used by previous discoverers of laws, therefore, cannot succeed. Feynman suggests that there is no fixed method that can lead to the discovery of laws. ''Laws'' in the social sciences for example, Zipf's several laws (1949) based on his principle of least effort - one on spatial interaction and another on word frequencies are often cited, as is 'Pareto's law in economics relating to the distribution of incomes'. The Auerbach-Pareto-Zipf law of city sizes is analysed by Mandelbrot (1965). Lotka (1929) proposed alaw concerning the frequency distribution of scientific productivity; Bradford's law (Garfield 1980) is similar. Also in economics there is Say's (1803) ''law of markets: supply creates its own demand'' (Patinkin 1948, cited in Weintraub 2002, 159). In sociology Merton (1973, 16) mentions Scheler's ''law of three phases,'' and Thorndike's ''law of effect'' comes from psychology (cited in Lewin 1951, 27, 66).

The Stanford nonmetric scaling pioneer psychologist Roger Shephard has a law attributed to him in relation to multi-dimensional scaling: ''if a solution exists, probably it exists in two dimensions'' (Coxon 1982, 87). The French engineer Lalanne in 1875 proposed *''la loi de l''equilat'eralie''* and *''la loi des* distances multiples,'' having to do with the distribution of towns and route connections, anticipating Christaller by half a century (Palsky 1996, 103). There is also a ''first law of cognitive geography'' by (Fabrikant et al., 2002).The First Law of Geography, according to Waldo Tobler (1970), is 'everything is related to everything else, but near things are more related than distant things'. This first law is the foundation of the fundamental concepts of spatial dependence and spatial autocorrelation and is utilized specifically for the inverse distance weighting method for spatial interpolation and to support the regionalized variable theory for krigingKaren (2008). Tobler first presented his seminal idea during a meeting of the International Geographical Union's Commission on Qualitative Methods held in 1969 and later published by him in 1970. Though simple in its presentation, this idea is profound. Without it, 'the full range of conditions anywhere on the Earth's surface could in principle be found packed within any small area'. There would be no 'regions of approximately homogeneous conditions to be described by giving attributes to area objects'. Topographic surfaces would vary chaotically, with slopes that were everywhere infinite, and the contours of such surfaces would be infinitely dense and contorted. Spatial analysis, and indeed life itself, would be impossible (Smith, 2007). Less well known is his second law, which complements the first: "The phenomenon external to an area of interest affects what goes on inside" by Martin (1999).

6. TOBLER'S LAW APPLICATIONS

'Everything is related to everything else, but near things are more related than distant things'."TBL: Tobler argued for simple, if it works. He argued for a way to reduce complexity based upon geographical proximity. Others have offered up their versions of this law examples include: "Ecology" "Cognitive geography" "Political behaviour" and "Financial". Tobler's law does make sense for spatial optimization (Spatial optimization involves identifying how land use and other activities should be arranged spatially in order to optimize efficiency or some other measure of goodness). Examples include:

- The capacitated facility location problem (Baumol and Wolfe, 1958).
- The general warehouse location Problem (GWLP) (Geoffrion, 1977).
- Districting, zonation, and region delineation.
- Land use protection for species preservation.

Roots of Spatial Optimization

- Economics: Weber 1909; Hotelling (1929); Kantorovich (1939); Koopmans and Reiter (1951);
- Regional Science: Beckmann (1952); Isard (1956); Stevens (1961);
- Geography: von Thunen (1826); Christaller (1933); Garrison (1959);
- Agriculture:O'Heady and Candler (1958);
- Operations Research: Dantzig, Fulkerson, & Johnson (1954); Baumol and Wolf (1958); Balinski(1964)Ford and Fulkerson, (1962).

Spatial Analysis Types / Techniques Applications

- Measurements(Distance and length, Shape, Slope and aspect);
- Transformations and Interpolation Methods (Buffering, number of points in polygon, Overlay, Interpolation - Thiessen polygons, Inverse Distance Weighting (IDW), Kriging, Density estimation);

- Descriptive Analysis (Gravity centres, Dispersion, Nearest- neighbour, Spatial Autocorrelation, Fragmentation);
- Location Optimisation (Optimum location, routing, location and allocation);
- Hypothesis Testing (predictive analysis) by drawing inferences from sample to population, spatial regression.

6.1. The Value of TFL in Geographical Information Science (GIScience)

TFL has grown rapidly in the past decade, largely in tandem with growth in GIScience. As geography information system (GIS) has become more popular and widely adopted, more and more attention has been paid to its fundamentals, and there has been a resurgence of interest in such topics as cartography (and its generalization in GIS visualization), quantitative geography, and spatial statistics. The construction of digital representations often requires us to recognize and make explicit, and often to formalize tendencies and truths that are so obvious and so ubiquitous that they are rarely noted in everyday life. Consider spatial interpolation, the process by which systems make estimates of the values of variables at places where they have not been measured, based on measurements at other places. Every weather map relies on this process, taking point observations of such variables as temperature or pressure from weather stations, and interpolating between them to obtain complete surfaces, commonly expressed in the form of *isolines*. No one would deny the logic of estimating the temperature at a point from the nearest available measurements, yet it is in effect an implementation of TFL, and relies implicitly on the law's validity and generality; if TFL were not true, the process would create evident nonsense.

A similar process allows estimates to be made of the total ore to be extracted from mines, or the total water resources in a groundwater basin. When necessary, it is possible to express the principle formally, as a measure of spatial autocorrelation or covariance, or as a variogram or covariogram function. Indeed, TFL forms the conceptual foundation for the entire field of geostatistics (Burrough and MacDonnell, 1998; Cressie, 1991; Goovaerts, 1997), and its cousins in other disciplines. Recent contributions to the tools of spatial analysis, such as Geographically Weighted Regression (Fotheringham, Brunsdon, and Charlton, 2002), now provide the techniques to implement this interesting methodological position. These arguments provide the context to a discussion of the validity and value of TFL in GIScience. It can be read as a statement either about form (interpreting related in the sense of similar), or about process (interpreting related mechanistically).

7. DISCUSSION

If one accepts the First Law of Geography as valid and useful, then are there prospects of additional laws? A possible candidate for the Second Law is the principle of spatial heterogeneity discussed by Harvey (1969). Spatial heterogeneity, or non-stationary in the statistical meaning of that term, implies that geographic variables exhibit uncontrolled variance. There is no concept of an average place on the Earth's surface, comparable for example to the concept of an average human. A corollary of uncontrolled variance in space is that the results of any analysis depend explicitly on the bounds of the analysis: move the study area, and the results will change. Since spatial heterogeneity is a first-order effect, concerning places taken one at a time, and spatial dependence, the basis of TFL, is a second-order effect of places compared two at a time it might make more sense if TFL were the second, rather than the first law. It is easy to advance other candidates for the status of laws of geography. There is the fractal principle: that 'geographic phenomena reveal more detail the more closely one looks; and that this process reveals additional detail at an orderly and predictable rate' (Goodchild and Mark, 1987; Mandelbrot, 1982). There is the principle that two distinct conceptualizations of geographic information are possible, as collections of countable, discrete objects littering an otherwise empty space, and as a finite set of continuous fields, or functions of location (Goodchild, 1992b; Worboys, 1995). There is the uncertainty principle that,'the geographic world is infinitely complex, and that any representation must therefore contain elements of uncertainty; that many definitions used in acquiring geographic data contain elements of vagueness; and that it is impossible to measure location on the Earth's surface exactly' (Zhang and Goodchild, 2002). All of these and many more constitute the foundation principles of GIScience, and merit consideration as potential laws of geography.

TFL is stated in a charmingly informal way, and one wonders if it would be taken more seriously if it were formalized, and made a little less accessible. It might state, for example, that for every geographic variable (a function of location $z = f(x)$) there exists some distance (d) below which covariance is monotonically increasing – or that there exists at least one scale for which spatial autocorrelation is positive. Formalization might address some of the reluctance to give TFL greater stature; but at the same time it would reduce both its accessibility and its charm. Clearly, it is the 'act of discovery of a scientific law that is important in the history of science, together with the context in which the discovery was made and the increment to knowledge that the discovery provided, rather than the law itself'. TFL is also close to everyday human experience, a characteristic that it shares in common with geography and the disciplines of social science, and that denies it the kind of exotic attraction that astronomers and polar scientists can assume for their work. But while arguments like these might explain the lack of attention to TFL, relative to other laws in science, they cannot detract from the law's value and importance in practice.

8. CONCLUSION

Tobler originally stated the First Law (TFL) in the form "All things are related, but nearby things are more related than distant things". The important message is in the second part, and because "related" carries unnecessary connotations of causality TFL is better stated as "**nearby things are more similar than distant things**". TFL thus forms the basis of the process known as spatial interpolation, or the formal process by which the gaps produced by spatial sampling can be filled. Seen from half a decade later, the discipline of geography of the 1950s appears to have been remarkably homogeneous. The debates of that period led to the divisive quantitative revolution, which was followed by an equally divisive retreat. Today, however, the discipline is thriving, at least in the U.S., as a polyglot of vastly different perspectives and methodologies. The reaction to TFL, as reflected in the *Annals* Forum of 2004, is only one indicator of the degree to which the discipline has agreed to tolerate, or at least agreed to differ. Within the GIS community TFL is regarded as a cornerstone of representation and a key to analytic insights, while large sectors elsewhere in the discipline may raise fundamental objections to the very idea of laws in geography.

It is easy to advance other candidates for the status of laws of geography. There is the fractal principle: that, 'geographic phenomena reveal more detail the more closely one looks; and that this process reveals additional detail at an orderly and predictable rate' (Goodchild and Mark, 1987; Mandelbrot, 1982). There is the principle that two distinct conceptualizations of geographic information are possible, as collections of countable, discrete objects littering an otherwise empty space, and as a finite set of continuous fields, or functions of location (Goodchild, 1992b; Worboys, 1995). There is the uncertainty principle, that,'the geographic world is infinitely complex, and that any representation must therefore contain elements of uncertainty; that many definitions used in acquiring geographic data contain elements of vagueness; and that it is impossible to measure location on the Earth's surface exactly' (Zhang and Goodchild, 2002). All of these and many more constitute the foundation principles of GIScience, and merit consideration as potential laws of geography.

REFERENCES

[1] Ackerman, E.A. (1945). "Geographic training, wartime research, and immediate professional objectives". *Annals of the Association of American Geographers.* **35**: 121-43.--as cited in Balinski, M.L. and Gomory, (1964). A primal method for transportation problems, *Management Science***10**, 578-593,

[2] Baumol, W. & Wolfe, P. (1958), 'A warehouse location problem', *Operations Research* 6(2)**, 252–263**

[3] Braithwaite, R.B. (1953). Scientific Explanation. Cambridge: Cambridge University Press

[4] Beckmann M.J (1952). A Continuous model of transportation. *Econometrica***20**:643–660

[5] Bunge, M. (1973). Method, Model and Matter, Reidel, Dordrecht.

[6] Bunge, W. (1962). Theoretical Geography, 2nd ed. Lund, Sweden: Gleerup.

[7] Burton, I. (1963). "The quantitative revolution and theoretical geography". *Canadian Geographer.* **7**: 151-62.

[8] Burrough, P.A., andR.A. MacDonnell, (1998). Principles of Geographical Information Systems. New York: Oxford University Press.

[9] Coxon, A. (1982). The user's guide tomultidimensional scaling. Exeter, U.K.: Heinemann.

[10] Cressie, N.A.C. (1991). Statistics for Spatial Data. New York: Wiley.

[11] Christaller. W. (1933). In translation (1966), Central Places in Southern Germany, translated by C. W. Baskin. Prentice-Hall, Englewood Cliffs, New Jersey.

[12] Dantzig, G, Fulkerson, R, Johnson, S (1954). Solution of a Large Scale Traveling Salesman Problem, Paper P-510, The RAND Corporation, Santa Monica, California, [12 April] 1954 [published in *Journal of the Operations Research Society of America***2** 393–410].

[13] Fabrikant, S., M. Ruocco, R. Middleton, and D. Montello. 2002.The first law of cognitive geography: Distance and similarity in semantic space. Proceedings of *GIScience* . Boulder, CO: 31–33.

[14] Feynman, R. (1967). The character of Physical law. Cambridge, MA: MIT Press

[15] Ford, L.R. Jr, D.R. Fulkerson, (1962). Flows in Networks, Princeton University Press, Princeton, New Jersey,

[16] Fotheringham, A.S., C. Brunsdon, and M. Charlton, (2002). Geographically Weighted Regression: The Analysis of Spatially Varying Relationships. Chichester, UK: Wiley

[17] Garfield, E. (1980). Bradford's law and related statistical patterns. Essays of an information scientist IV, 476–83. Philadelphia: ISI Press

[18] Geoffrion, A.M. (1977) A Priori Error Bounds for Procurement Commodity Aggregation in Logistics Planning Models, *Naval Research Logistics Quarterly*, **24** (2), 201-212.

[19] Golledge, R.G.; Amedeo, D. (1968). "On laws in geography". *Annals of the Association of American Geographers.***58:** 760-74

[20] Gregory, Derek; Johnston, Ron; Pratt, Geraldine; Watts, Michael J.; Whatmore, Sarah (2009). The Dictionary of Human Geography (5th ed.). US & UK: Wiley-Blackwell. p. 611-12.

[21] Goovaerts, P., (1997). Geostatistics for Natural Resources Evaluation. New York: Oxford University Press.

[22] Goodchild, M.F., (1992b). Geographic Data Modelling. *Computers and Geosciences***18(4)**:401-408..

[23] Goodchild, M.F and D.M. Mark, (1982). The fractal nature of geographic phenomena. *Annals of the Association of American Geographers*77: 265-278

[24] Hartshorne, Richard (1954). "Comment on 'Exceptionalism in geography'". *Annals of the Association of American Geographers*. **38**: 108-9.

[25] Hartshorne, Richard (1955). "'Exceptionalism in Geography' re-examined". *Annals of the Association of American Geographers.* **45**: 205-44.

[26] Hartshorne, Richard (1958). "The concept of geography as a science of space from Kant and Humboldt to Hettner". *Annals of the Association of American Geographers*. **48**: 97-108

[27] Hartshorne, Richard (1959). Perspective on the Nature of Geography. Chicago: Rand McNally.

[28] Harvey, D. (1969). Explanation in Geography. New York, St Martin's. [A systematic investigation quantitative revolution in geography, and of its philosophical and methodological implications.]

[29] Harvey, David (1972). "Revolutionary and counter revolutionary theory in geography and the problem of ghetto formation".

[30] Harvey, David (1973). Social Justice and the City. London: Edward Arnold.

[31] Heady, E.O., Candler W.C.(1958). Linear Programming Methods, Ames, IA: Iowa State Press. [A comprehensive coverage of the use of linear programming in agricultural economics by the leading authority in the field.]

[32] Hotelling, H. (1929). Stability in competition. Economic Journal 39, 41–57.

[33] Isard, W. (1956). Location and Space-Economy, A General Theory Relating to Industrial Location, Market Areas, Land Use, Trade, and Urban Structure, New York: The Technology Press of M. I. T. and John Wiley and Sons, Inc.

[34] Johnston, Ron; Sidaway, James (2016). Geography & Geographers: Anglo-American Human Geography since 1945 (7th ed.). New York: Routledge. p. 64-76.

[35] Jones, Emrys (1956). "Cause and effect in human geography". *Annals of the Association of American Geographers*. **46:** 369-77

[36] Kantorovich, L. V., (1939). Mathematical methods in the organization and planning of production. Leningrad Univ., 1939. [English translation: *Management Science*, **6**, 4 (1960), 363–422.]

[37] Karen (2008). "Encyclopedia of Geographic Information Science", SAGE, 2008, p146-147

[38] KoopmansT.C. (1951). (ed). Actively Analysis of Production and Allocation, John Wiley & Sons, Inc., New York, 1951, 404 pages.

[39] Koopmans Tj.C., Reiter, S. (1951). A model of transportation, in: Activity Analysis of Production and Allocation Proceedings of a Conference (Tj.C. Koopmans, ed.), Wiley, New York, 1951, pp. 222–259.

[40] Kuhn, T. S. (1970), The Structure of scientific revolutions. Chicago, University of Chicago Press.

[41] Lewin, K. (1951/1999). Field theory in social science. In Resolving social conflicts and Field theory in social science. Washington, DC: American Psychological Association.

[42] Lewis, Peter (1965). "Three related problems in the formulation of laws in geography". *Professional Geographer*. **17**(5): 24-7

[43] Lotka, A. (1929). The frequency distribution of scientific productivity. *Journal of the Washington Academy of Sciences***16**:317 – 23

[44] Lotka, A. J. (1920). Analytical note on certain rhythmic relations in organic systems, *Proc. Nat. Acad.***6** 410-415

[45] Luckermann, F. (1965). "Geography: De facto or de jure". *Journal of the Minnesota Academy of Science*. **32**: 189-96.

[46] Mandelbrot, B. (1965). A class of long-tailed probability distributions and the empirical distribution of citysizes. In Mathematical explorations in behavioral science, ed. F. Massarik and P. Ratrosh, 322–32. Homewood, IL: R.D. Irwin.

[47] Mandelbrot, B.B., (1982). The Fractal Geometry of Nature. San Francisco: Freeman.

[48] Martin D.,(1999). Linear pycnophylactic reallocation- Comment on a paper by I*nternational Journal of Geographical Information Science*,**13(1)**, 85-90, 1999

[49] Martin, Geoffrey J. (2005). All Possible Worlds: A History of Geographical Ideas. 4th ed. New York: Oxford University Press,

[50] Merton, R. (1973). The Sociology of science. Chicago: University of Chicago Press

[51] Murphy, A. B. (2006). Enhancing geography's role in public debate, *Annals of the Association of American Geographers*, **96**(1), pp. 1-13

[52] Palsky, G. (1996). Des chiffres et des cartes. Minist`ere de l'enseign- ment Sup`erieur et de la Recherche, Paris.

[53] Patinkin, D. (1948). Relative prices, Say's law, and the demand for money. *Econometrica***16:**135–54

[54] Popper, Karl .R (1963). Conjectures and Refutations: The Growth of Scientific Knowledge. London: Routledge & Kegan Paul

[55] Popper, Karl ,R. (1959). The Logic of Scientific Discovery. New York: Basic Books.

[56] Richard Hartshorne (1959). The Concept of Geography as a Science of Space, from Kant and Humboldt to Hettner, *48 ANNALS Ass'N AM. Geographers***97**

[57] Sacks, H. (1972). "Notes on Police Assessment of Moral Character," in D.N. Sudnow (ed.) Studies in Social Interaction, Free Press, New York, NY, pp. 280–293.

[58] Sacks, H. (1973/1987). On the preferences for agreement and contiguity in sequences in conversation. In G. Button & J. R. Lee (Eds.), Talk and social organisation (pp. 54 – 69). Clevedon, UK: Multilingual Matters.

[59] Say Jean-Baptiste (1767–1832). The Concise Encyclopedia of Economics. Library of Economics and Liberty (2nd ed.). Liberty Fund. 2008.

[60] Schaefer, Fred K. (1953). "Exceptionalism in Geography: A Methodological Examination," *Annals, Association of American Geographers*, Vol. **43** , pp. 226–49.

[61] Semple, E.C. 1911. Influences of Geographic Environment on the Basis of Ratzel's System of Anthropogeography, Henry Holt, New York, 683 pp

[62] Smith,De; Michael John; Goodchild, Michael F.; Longley, Paul. (2007)." Geospatial Analysis: AComprehensive Guide to Principles, Techniques and Software Tools", Troubador Publishing Ltd, ,

[63] Smith, N. (1987) . Academic war over the field of geography. The elimination of geography at Harvard, 1947-1951. *Annals of the Association of American Geographers*, **77(**1), pp. 155-172.

[64] Stevens, S. S. (1961). To honour Fechner and repeal his law. *Science*,**133**, 80 – 86

[65] Tobler W , (1970). "A computer movie simulating urban growth in the Detroit region". *Economic Geography*, **46** (Supplement): 234-240.

[66] Von Thu¨nen JH (1826). Der Isolirte Staat. Perthes, Hamburg.

[67] Weber, A., (1909) ."Uber den Standort der Industrien"; translated as "Alfred Weber'sTheory of the Location of Industries", University of Chicago, 1929

[68] Weintraub, E. (2002). How economics became a mathematical science. Durham, NC: Duke University Press.

[69] Worboys, M.F., (1995). GIS: A Computing Perspective. New York: Taylor and Francis.

[70] Zhang, J.X., and M.F. Goodchild, (2002). Uncertainty in Geographical Information. New York: Taylor and Francis.

[71] Zipf, G. (1949). Human behaviour and the principle of least effort. Cambridge, MA: Addison-Wesley.

Citation: *Ayodele A. Otaiku. "The Evaluation of Laws of Geography". International Journal of Research in Geography. Vol 4, No. 4, 2018, pp. 12-21. doi: http://dx.doi.org/10.20431/ 2454-8685.0404002.*