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Journal of Geographical Research

Volume 2 | Issue 3 | July 2019 | ISSN 2630-5070 (Online)

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Volume 2 Issue 3 • July 2019 • ISSN 2630-5070 (Online)

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Journal of Geographical Research
https://ojs.bilpublishing.com/index.php/jgr

REVIEW

Decolonizing Geography and Access to Powerful Disciplinary Knowledge

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ARTICLE INFO

Article history
Received: 6 June 2019
Accepted: 8 October 2019
Published Online: 30 November 2019

Keywords:
Decolonize
Disciplinary knowledge
Epistemology
Social realism
Curriculum

ABSTRACT

This article engages with and aims to advance the debate about Decolonizing geography, examining its approach to knowledge and its implications for the discipline. Decolonizers draw heavily upon social constructivist and historically-rooted notions of knowledge which emphasize its embeddedness in power relations. While shedding light on the social and political conditions under which knowledge is produced is valuable, its context-dependent view of knowledge limits its scope to account for disciplinary knowledge. Taking a particularistic epistemology which conflates knowledge with experience is insufficient to explain the historical evolution of theoretical and disciplinary frameworks. Denying the potential for and even the desirability of context-independent (theoretical) knowledge Decolonizing geography can be read as post-disciplinary and post-universal, potentially denying that geography can offer all students, regardless of their background, access to powerful knowledge and insights. Here, social realism is proposed as an alternative approach to knowledge which accounts for both the social context of knowledge production and its distinctive epistemic qualities. An epistemological framework for geography is examined which demonstrates the relationship between propositional (conceptual), contextual and procedural knowledge, and why all three are essential for the student of geography.

1. Introduction

The 2017 RGS/IBG annual conference theme was "Decolonizing Geographical Knowledges – opening the discipline out to the world". In special conference-editions of *Transactions of the Institute of British Geographers* and *Area*, as well as at the conference itself, Decolonizing the discipline was presented by Jazeel as an "imperative" for all geographers to consider [1]. What is meant by Decolonizing disciplinary knowledge?

Making reference to what they call "the shine and shadow of powerful knowledge", Rudolph, Sriprakash and Gerrard propose that "Both the production and use of knowledge (disciplinary and non-disciplinary) have been implicated by these colonial and racial violences", adding that epistemic violence has resulted from "ordering, classification and naming that occurs through the practices of colonialism" [2]. Hence, they call for closer scrutiny of the historical circumstances in which knowledge was produced, which they suggest equates with the global North.

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 DOI: https://doi.org/10.30564/jgr.v2i3.898

Writing in *Transactions*, Jazeel himself finds the very process of abstraction and theory-making within the discipline of geography problematic:

What I want to stress therefore is that we must remain continually vigilant against the authoritative prescription of any "correct theoretical practice" (Spivak 1985, 346) for Decolonizing geographical knowledge, because it is precisely the representational containment of geography's theoretical orthodoxies that battens the hatches against the outside, the minor, the excluded. In other words, postcolonial geography must itself be situated within the political economy of academic knowledge production [3].

For Jazeel, geographical theory has become something that potentially excludes those outside of the discipline rather than something from which they might learn.

Yet, it is worth pausing and reflecting on where this well-intention, "themed intervention" might take our discipline before geographers head too far down this path. At one level, the call to diversify geographical knowledge, to open the discipline to a wider audience and to move away from a Western-centric narrative sounds progressive and common sense. Yet, at the same time, why is it that in 2017-18, decades after colonialism was discredited, that some academics are asserting the need to "Decolonize" disciplinary knowledge? And, why is Decolonizing geography presented as an "imperative" for changing the discipline, and how it is taught, rather than as a topic for analysis and debate about the way knowledge is produced and in which settings?

2. Objectives and Method

This article takes a theoretical and interpretivist approach to examine the debate about Decolonizing geography. I begin by analysing its particularistic approach to epistemology as well as its origins. I will show how the imperative to Decolonize the curriculum grows out of and extrapolates previous assumptions about knowledge, especially its political and socially-rooted nature. Indeed, advocates for Decolonizing geography claim that they are expanding ideas from "postcolonial and subaltern studies, black studies and critical Indigenous theory, queer and feminist theory" [4], although some assumptions are shared across other social sciences. While this field has added new insights, experiences and stories to light which were insufficiently represented in geography, its particularistic approach is unable to distinguish between context-dependent and context-independent knowledge, and hence offer a theory of disciplinary knowledge.

Here, I draw on the sociological theory of social realism to propose an alternative way to conceptualise knowledge, one that seeks to account for both context-dependent and context-independent knowledge. Social realism aims to differentiate between knowledge types, such as personal, everyday knowledge and theoretical, scientific knowledge. And, it seeks to account for how knowledge is produced, the procedures and methods of verification that are specific to a disciplinary community. Next, I apply social realism to the discipline of geography and examine its evolution and traditions. I show that the distinction between the study of phenomena in one *place* versus their *form* originated in the nineteenth century and has persisted to present day geography. Here, I suggest that geography does have its own epistemology and knowledge structure which is danger of being overlooked in Decolonizing narratives. Finally, I show why induction into this disciplinary framework and modes of reasoning is necessary if education is to be a powerful, transcendental experience.

3. Does Geography need Decolonizing?

"The geographical discipline has also been exposed as a handmaiden of empire, providing its experts, maps and institutions," reports Legg [5]. That the evolution of geography and empire in the nineteenth and twentieth century went hand in hand is in little dispute. David Livingston's *The Geographical Tradition* recounts this story in some detail. Yet, Decolonizers go much further than this, asserting that knowledge in the present is "implicated" by its colonial past: "decolonial scholars argue that the modern episteme is always and intrinsically saturated with coloniality although it is insecure in its reach and depth" suggests Radcliffe [6]. Yet, the discipline and the practices of geographers today are very different from the colonial era, an important point that is glossed over in decolonial discourse. While many eighteenth and nineteenth century geographical expeditions were backed by government and/or monarchy, clearly that is not the case today.

Radcliffe also makes reference to "power relations in the colonial present", which she proposes "permeate all forms of knowing about and understanding the world" [7]. Similarly, Collard *et al*. propose that "knowledge production and everyday relations are informed by European colonial modalities of power and propped up by imperial geopolitics and economic arrangements" [8]. It would be naïve of academics not to consider the geopolitical and economic arrangements when conducting any given study. However, it is not clear what or where she is referring to by the "colonial present". Powerful nations like the USA and China may well engage in exploitative practices (economic and political) in many countries around the world, but they are not colonial powers in the sense of a nine-

DOI: https://doi.org/10.30564/jgr.v2i3.898

teenth century Britain or Spain. The difference needs to be made more explicit.

For Decolonizers it is evident that *context is king*. This applies to both the historical context of knowledge production and current social, economic and political context in which knowledge is applied. Rob Moore notes that since the cultural turn of the 1970s the dominant view in the sociology of education, and reflected in social theories of phenomenology, ethnomethodology, postmodernism and post-structuralism, has been that "*knowledge is socially constructed, historically located and intrinsically connected with power*" (author's italics) [9]. Indicatively, such theories have taken us away from the very idea and importance of theoretical knowledge, and therefore away from a common basis for understanding the world. Hence, Noxolo arrives at the notion of a "pluriversality of knowledges" [10], indicating that they have moved away from the notion of a university that generates specialist knowledge, which is potentially accessible to all (i.e. *universal*).

Here, knowledge is embedded in social practice, and hence, Baldwin demands of geography scholars: "an abiding recognition that knowledge, all knowledge, is political"[11]. Yet, we might want to qualify Balwin's proposition. All knowledge is *potentially* political. It depends on the context in which it is used. The knowledge that rivers erode the land and deposit material downstream may have political consequences when applied to a river that crosses a political boundary for instance, but, by itself, is this knowledge political? Once river erosion and deposition have been accepted concepts in a discipline they are used by scholars and students all over the world, giving them a universal quality.

Let us proceed by acknowledging that context matters a lot, especially in a subject like geography. Everything we learn transpires in a particular cultural and social setting. The concepts we use to make sense of and to think about the world around us are learnt through social interaction and by using them in different contexts. When we get them "wrong" – meaning our use of them does not make sense to those around us – we must either modify our understanding of the concept or we are likely to experience a similar type of miscommunication in the future. We learn concepts and they gain meaning for us through social interaction, including when meanings change or new ones are created. This applies to both every day and theoretical concepts. For this reason it is misleading to suggest, as social constructionist sometimes do, that when individuals learn they "construct knowledge". The student may acquire new *meaning* as they study, but very rarely do they generate new knowledge.

Second, ideas are powerful and do have serious implications in society – socially, environmentally, economically and politically. It would be foolish to suggest otherwise. It is well-known that nineteenth century colonialism was fed by ideas of racial superiority linked to theories of Social Darwinism. Over time, society questioned and challenged the application of naturalist theories as ill-suited to human nature and were superseded by more egalitarian ideas about our humanity, reveals Malik [12]. This is one very important reason why we need to be able to distinguish between better and worse ideas (and more/less accurate theories) and to distinguish between different knowledge domains. And, as Jim Butcher [13] cautions, we need to be careful to distinguish between the production of knowledge and its application in a given political settings. The two are not the same thing. And, just because knowledge is used for immoral acts does not mean the knowledge itself is flawed. Social movements may take a progressive idea and apply it in a harmful way.

The social context of knowledge production also matters – our thoughts, questions and interpretation of findings are all influenced by the cultural setting in which one lives and works. Social constructivist theories have helped us to better understand how context influences knowledge production. It has helped us to gain a deeper appreciation of the role of the human subject in knowledge construction, whereas prior theory tended to treat knowledge as a given. As Jennifer Negal observes, "Knowledge demands some kind of access to a fact on the part of a living subject" [14]. The role of the human subject in making and accessing knowledge is an important part of epistemology, something we have learnt from the work of Lev Vygotsky among others (see Derry [15]).

So, context matters for all these reasons. But, this doesn't mean that we are prisoners of circumstance. As Alexander notes:

Theoretical knowledge can never be anything other than the socially rooted efforts of historical agents. But this social character of knowledge does not negate the possibility of developing either generalised categories or increasingly disciplined, impersonal and critical modes of evaluation [16].

There are two ways in which it is possible to transcend context: individual reason and procedural knowledge applied in a scholarly community.

As noted above, individuals learn through social interaction. This is how they acquire concepts and meanings that constitute language – both every day language and specialist knowledge. Once mastered, we use these concepts to think – they are tools for making sense of the world around us. Again, Vygotsky's work provides insight

 DOI: https://doi.org/10.30564/jgr.v2i3.898

into the interplay between thought and language. But, as Robert Brandom shows concepts are not necessarily fixed and they do not exist in isolation from other concepts [17]. As subjective beings we are capable of modifying our understanding of a concept or even rejecting it altogether, if, for example, we were to find a better concept. The same applies to theories. Over time, some theories are superseded by more accurate or sophisticated theories. For instance, convection currents as an explanation for plate movement has recently been challenged by the idea of slab-pull during plate subduction [18]. In order for new ideas or theories to become accepted theoretical knowledge depends upon acceptance by the disciplinary community. This occurs through a process of reasoned scrutiny by individuals (peer review) and through collective dialogue with a commitment to a seeking better explanations or approximations towards truth [19].

Disciplines need ways of distinguishing between better and worse knowledge. This is achieved through *procedural knowledge* (explored further below). Disciplines have created tried and tested methods and procedures of verifying the accuracy of new ideas. New findings or theories (like the Anthropocene) should only become accepted after rigorous scrutiny by a disciplinary community. It is through such procedures that ideas are able to transcend the context in which they were produced – demographic transition and Newton's Laws of Motion being two worthy examples.

This is in no way to dismiss the contribution to knowledge of minorities or "excluded" people Decolonizers seek to highlight. Contextual knowledge has an important role to play in understanding the particular circumstances of people in a given locality, at a given time. However, geography is not an amalgam of millions of unconnected accounts. The point is to learn from them, to identify some common trends, experiences and patterns of interaction. This involves abstracting from context in order to work towards a theory of understanding spatial interactions at the surface of the earth.

Through identification of common experiences and patterns of behaviour, geography explores an aspect of truth about human experiences and planetary interactions. "Knowledge links a subject to truth" finds Nagel [20] and hence is a means for developing our subjectivity. Social constructivists are mistaken in the assertion that "scientific truths are no more than what scientists at the time say is true" suggests Young[21], because they have not sufficiently taken account of the relationship between knowledge and the object under analysis. There is a difference between belief and knowledge, which Nagel calls *factivity*: "We can only know facts or true propositions", whereas, "belief can easily link a subject to a false proposition" [22]. Nagel gives a simple example, "Bill thinks his door is locked, but it isn't" [23]. Each discipline has developed its own procedures by which knowledge is tested and verified, and thus a basis upon which judgements about the reliability of knowledge are made.

It is the deeply-rooted or over-socialised view of knowledge that leads some Decolonizers to question the feasibility of context-independent knowledge. Here, knowledge and the knower become inseparable and there is a risk that knowledge gets reduced to a matter of perspective. Making reference to postmodern approaches to knowledge, Young writes:

[I]n dismissing other theories rather than entering into a dialogue with them, postmodernism precludes the possibility of an alternative theory of knowledge, except one that reduces all knowledge to experiences or statements about knowers [24].

Young draws on the work of Rob Moore and Johan Muller who identify a drift towards relativism in literature on "voice discourses". He surmises, "There is no *knowledge* for the voice discourses, only the power of some groups to assert that their experiences should count as knowledge" (author's italics) [25]. This view is echoed in the article by Rudolph, Sriprakash and Gerrard [26] where they surmise that traditional disciplines are ill-equipped to deal with the experiences of gay people, minorities and women, as if the purpose of a discipline were only to articulate the experiences of a particular group in society. Despite their call to "bring history back in", this is an ahistorical view of what disciplinary knowledge is. Below, I say more about geography's evolution as a discipline, and who contributed to its development.

This relativist turn in academia is part of a wider rejection of the idea that some knowledge is better than other knowledge, or culture for that matter. Because "better knowledge" or "better culture" (or Culture with a capital "C") are associated with and often monopolised by elites they have been recast as simply one standpoint next to others, as Moore observes:

The reason why Culture might be confused with the culture of the ruling class is that part of what being a ruling class entails is having privileged access to Culture and the capacity to partially recontextualize it within its culture [27].

Yet, rather than attempt to change the social and pedagogical access to better knowledge and Culture contemporary social theory has focused on the producers of knowledge, their social context and power relations, while paying insufficient attention to the distinctions between different types of knowledge.

DOI: https://doi.org/10.30564/jgr.v2i3.898

The "imperative" for a Decolonized geography does not offer an epistemological account for disciplinary knowledge. What it lacks is a basis for evaluating what counts as geographical knowledge, how geographical knowledge can be tested and evaluated, and how can it advance. We can begin to see some answers to these questions by drawing upon the sociological theory of social realism. This is introduced below before being applied to geography.

4. Towards a Social Realist Theory of Knowledge

For some time, sociological debates about knowledge have been stuck between two positions: positivism and constructivism. Young and Muller [28] suggest that neither provides an adequate account of knowledge; both being tied to an ideology and ends extrinsic to knowledge. Positivism is associated with an "under-socialised" view of knowledge where its givenness is assumed rather than explained. This position is often associated with cultural elitism and the defence of tradition, with knowledge, largely unchanging, being handed down from generation to generation. As noted above, social constructivism tends towards an "over-socialised" view of knowledge in which knowledge is treated as simply the expressions of the knower. Here, authority is vested in who produced the knowledge rather than the value of the knowledge itself.

However, in recent years social realism has emerged as a theory to explain how knowledge can be both social and "real" at the same time. By real I mean that knowledge has an objective quality, so is more than just a construct of the author's imagination and is therefore able to capture some essence of the object under investigation. Here, social realists draw on critical realism and the work of Roy Bhaskar: "Realism is important because of the way in which the principle of ontological realism provides the basis for a non-positivistic (non-empiricist) rebuttal of constructivist relativism" report Maton and Moore [29]. If the world exists beyond the human imagination then it is through human consciousness that we come to know it. Moore notes the coincidence between critical realism and Marxism in the form of "materialism and the concept of 'emergence' both in relation to the characteristics of scientific thought and in terms of the nature of 'the social' " [30].

Therefore, social realism aims to understand knowledge as produced in a given cultural and social context (emergence), but at the same time aiming to describe something real – be it an aspect of the natural or human world. To better understand knowledge types and the different forms means "taking seriously" the question of the "internal ordering of symbolic forms", suggests Moore[31]. One important aim is to understand the distinctiveness of knowledge types, including academic and vocational knowledge, suggesting that boundaries between disciplines are important and not arbitrary, and also how knowledge changes and advances over time. Social realists are also very interested in how knowledge is "re-contextualised" in curricula, both at university and school levels. Contemporary social realists, including Karl Maton, Rob Moore, Johan Muller, Elizabeth Rata, Michael Young and Leesa Wheelahan, draw on the earlier epistemological work of Émile Durkheim, Lev Vygotsky, Basil Bernstein and Ernst Cassirer.

Durkheim's distinction between the *sacred* and the *profane* provides a useful starting point for social realism because he sought to understand that some knowledge was context-independent, while at the same time being a product of social relations. For Durkheim, sacred knowledge existed at a different level and played a different (moral) role in society than profane knowledge. Young [32] applies this distinction to the difference between every day concepts and the theoretical concepts that make up specialist knowledge. He notes that it is the purpose of schools and universities to induct young people into specialist forms of knowledge and ways of thinking.

But, of course, theoretical knowledge came from somewhere. It has a history and cultural context which should be acknowledged and considered, as the Decolonizing movement is keen to remind us. Lloyd traces the evolution of disciplinary thinking back to Ancient Greece, Rome, China, South Asia, Islamic territories, among other cultural hearths[33]. While there is qualitative difference between "emergent disciplinary thought" and more modern systematised knowledge which has undergone "scientification" suggests Burke, the one has emerged from the other. In *Disciplines in the Making* Lloyd [35] details the historical evolution of intellectual thought in different regions of the world, including the diffusion of ideas and texts between regions. For instance, scholarly works from Ancient Greece and Rome were translated into Arabic, where knowledge was advanced in several areas (mathematics, geography, literature and philosophy) during the expansion of the Muslim Empire in the Middle Ages. In mathematical geography, the size and shape of the earth were calculated, as were the solar length of a year and the Precession of the Equinoxes, reported Ziauddin Alavi[36]. Hydrological studies were conducted of the Nile and the canal systems of Mesopotamia, including the search for "hidden water" in mountains. Al-Mas'udi and al-Idrisi were two prominent

 DOI: https://doi.org/10.30564/jgr.v2i3.898

geographers who studied environmental effects on life and the qualities of people in different climate zones. So, when geographers such as Derickson[37] and Pulido[38] posit the "unbearable whiteness of geography" they are not acknowledging the contribution of other cultures to the emergence of disciplinary thought, both in the past and present university setting.

Let us now look more closely at how disciplinary knowledge is made or comes into being. Social realism claims that the objectivity of truth claims depends upon (1) their external validity – they explain objects of study in a convincing way, (2) their internal consistency – that they are coherent and follow logic, and (3) their ability to invoke support from a specialist community of experts and with a wider legitimacy.

Starting with their external validity, the concepts that we have created aim to capture an essence or aspect of the particular object of study, in geography's case - *the surface of the earth*. Social realists such as Wheelahan [39] call this the *aboutness* of knowledge – the relationship between knowledge and the object being accounted for. In geography, we use concepts that are about both the natural world (rivers, atmosphere, rocks, landscape) and concepts about the human world (settlements, economies, political territories, development).

We have Ernst Cassirer [40] to thank for depicting how the process of objectification (concept formation) is different for natural concepts and cultural concepts, resulting in different forms of knowledge in the natural sciences and social sciences or humanities. With natural objects the concept can potentially subsume the object and does this through empirical verification. On the other hand, with human constructs (social sciences and humanities) concepts are mediated by other concepts and so the relationship is less direct and potentially less precise. Nevertheless, in both sciences the aim is the same: "achieving the maximum absorption of the object by the concept" and also "the maximum abstraction or objectification possible under the circumstances consistent with the nature of the objects under study", suggest Young and Muller [41]. However, as observed by Harstshorne [42] it is also important to recognise that no concept can capture the complete essence of an object and that disciplines often have unique concepts because they are asking particular questions about their object of study. That said, geographers "borrow" many concepts from other disciplines like meteorology, biology, geology, economics, demography and political science. Yet, we geographers use them in a unique way because we are interested in location, spatial arrangements and human – environment interactions [43-45].

Of course, concepts do not exist in isolation. Each concept relates to and is inferred from another concept – referred to by Brandon as inferentialism [46]. Disciplines themselves are made up of large networks of inter-related concepts with their own internal logic. Understanding the inferential relations of concept formation has significant pedagogical implications for teaching and also for curriculum planning. Already, we can see that the distinctive approach of a discipline will result in the construction of a framework or system of concepts unique to its way of interpreting its object of study. Learning a discipline means entering into the system and comprehending its particular framework of concepts.

The educational theorist Basil Bernstein [47] differentiated between knowledge that is hierarchical versus knowledge that is horizontal in structure. Hierarchical knowledge progresses through increased levels of abstraction, as with the natural sciences. Greater levels of abstraction facilitate understanding of relationships, powerful explanations and the establishment of generalisations or laws. With knowledge that demonstrates horizontal structure, knowledge progresses through adding new segments of knowledge that are distinctive, but related, to the previous knowledge, as with the arts, humanities and some social sciences. Geography demonstrates aspects of both hierarchical and horizontal structure because the knowledge is segmented (into sub-disciplines of geomorphology, tourism, economic geography), but hierarchical within segments. It is not being suggested that disciplines fit neatly into Bernstein's framework. Rather, his analysis provides us with an analytical tool to comprehend how knowledge can progress in different ways.

Finally, disciplines have historically tested and established *procedural knowledge* – methods of enquiry for conducting and scrutinising research, as well as for critique and the verification of findings. This includes the review and communication of research findings through publication. This involves scholars reading and commenting on the *reliability* of the work produced, and its acceptability for distribution within the disciplinary community. Drawing on Karl Popper's notion of falsification in the sciences, it is the openness to challenge and the processes of *verification* within specialist communities that make knowledge a social product, and gives rise to its reliability [48]. Again, there are important pedagogical implications if we are aiming to teach students to make judgements between better and weaker knowledge claims.

Drawing on Hannah Arendt, Frank Furedi speaks to the centrality of judgement to scholasticism: "The testing of ideas, the questioning of colleagues' views, and the pursuit of intellectual clarity require the freedom to judge" [49]. Importantly, one must remember that what is

DOI: https://doi.org/10.30564/jgr.v2i3.898

being judged, recounts Furedi, is ideas not people. This distinction can get missed in an academic environment that treats people and ideas as one, whereupon the act of judgement can be perceived "*as directed at an individual's identity and assumes that everything is personal*" (author's italics) [50]. Failure to distinguish between ideas and the person not only avoids the disciplinary framework in which ideas are test, but also denies the potential *for* agreement that can arise out of disagreement. In the words of Arendt, "judging is one, if not the most, important activity in which this sharing-of-the-world-with-others comes to pass" [51].

While each discipline has its own unique purpose, object of study, conceptual framework, modes of thought and methods for validating and acquiring new knowledge, these are by no means fixed and within the same discipline there often co-exist different approaches, methods and organising concepts or frameworks. And, as noted by Polyani [52], in each there is an aspiration for *Truth* – they seek to describe and account for some aspect of reality. The pursuit of truth is not as distant from the social constructivist position as some might think, since it contains within it its own claim to truth, as Rob Moore reveals: "all truth is standpoint relative, except the truth that all truth is standpoint relative" [53]. In order to induct young people into disciplinary ways of thinking a robust understanding of the discipline's epistemic relations is necessary. Students don't just need knowledge. They need to learn how the discipline works.

5. Geography as Disciplinary Knowledge

Tim Cresswell suggests that two questions underpin the geographical tradition:

"[W]hat is the connection between the human and physical worlds?"

And, "how can we account for spatial difference?" [58]

Cresswell finds the embryonic form of geographical concepts in the writings of Ptolomy, Eratosthenes, Plato and Aristotle. Plato used the terms *chora* and *topos* in his discussion of the process of becoming. *Chora* refers to the place or setting for becoming and *topos* was the achieved place. However, important to the establishment of the modern discipline was the relationship between the particular and the universal, as Sarah Radcliffe observes: "Geographers have of course engaged, albeit through widely divergent lenses, with the universal and the particular for much of its disciplinary history" [54].

This distinction was articulated through the work of nineteenth century geographers including Immanuel Kant, Alexander Humboldt, Karl Ritter and Alfred Hettner. Yet, if we were to "Decolonize geography" and replace it with a particularistic epistemology with no relationship to theoretical knowledge, then it would cease to be a discipline. What is important to understand, suggest Winch [56] is why and how both the universal (theoretical or propositional knowledge) and the particular (contextual or empirical knowledge) work together to achieve epistemic ascent.

Kant lectured in physical geography for 30 years at Königsberg (now Kaliningrad). Finding the subject disorganised and lacking direction he proposed two ways of classifying empirical data: in accordance with their nature or in relation to their position in time and place. The former being a *logical classification* is a precondition for studying the spatial variation of particular geographical "layers" or phenomena (systematic geography / propositional knowledge). The latter is a *physical classification* and provides the basis for the study of the interaction of phenomena in given places and regions (regional geography / contextual knowledge). For Kant, between them history and geography were able to fill the total span of scientific knowledge – history being the study of time and geography the study of space.

Humboldt (1769-1859) and Ritter (1779-1859) also conceived of geography as the study of the inter-relationship between phenomena in a given locale. However, Hartshorne[57] suggests that only later did they become aware of Kant's work and that they may well have arrived at a similar conception independently. They also developed a scientific method for geography, taking an empirical approach to their studies of Central America (Humboldt) and Central Asia (Ritter). Through extensive fieldwork and data collection Humboldt and Ritter went beyond description in their quest for identifying patterns and relationships through a comparative method. Humboldt called his scientific approach *physikalische* (not to be confused with physical geography) through which he sought to establish relations between the flora, fauna, humankind, and conditions of landscape and climate. The concept of *Landshaft* (a small regional unit) became popular amongst German geographers who were seeking to find unity and purpose in the landscape (a similar tradition evolved in France with pays identified by Vidal de La Blache in his (1908) *Tableau de la Geographie de la France*). For Ritter this unity was god given, while Humboldt leaned towards aesthetic interpretation.

So, while Humboldt and Ritter were very interested in the particularities of small regional units through their nomothetic approach they were also looking for generalisations. What would later be known as systematic geography involved the creation of concepts, models, theories and principles about how things are spatially related (*propositional or conceptual knowledge*). Geographers do this by

 DOI: https://doi.org/10.30564/jgr.v2i3.898

examining one geographical phenomenon (e.g. glaciation or population) at a time – how it varies in space and how it is influenced by other phenomena. Systematic geographical knowledge has evolved as a series of sub-disciplines (geomorphology, climatology, urban geography, political geography, feminist geography) each of which is related to its own branch of science (geology, meteorology, planning/urban studies, political science, feminist social theory). Geographers draw from these individual sciences using the concepts constructed for the study of its specific object (lithosphere, atmosphere, settlements, political ideas/institutions, social categories). However, the geographer utilises these concepts for a different purpose: to comprehend spatial relationships and patterns. Because geographers are interested in how objects are associated with other objects they may modify generic concepts or invent new ones (e.g. sphere of influence).

The value of nomothetic science is that by abstracting from the real world we can begin to see patterns of behaviour and relationship that are not apparent at a more concrete level. With the systematic approach geographers are seeking explanations of the behaviour and patterns of phenomena. Its knowledge structure is often hierarchical – aiming for greater precision, certainty and truth [58].

When constructing *propositional knowledge* the danger is that the theory becomes too removed from the real world and unable to explain the behaviour of the phenomena in question. Sciences often experience a tension between the need for universal laws and the facts and circumstances of particular cases. Therefore, disciplines need *contextual (empirical) knowledge* – the facts, data and observations of human and physical features of the earth's surface. By its very nature contextual knowledge cannot be abstract, although it may be interpreted with the help of generic concepts or theories. In contrast to propositional knowledge, it is horizontal in structure; so that studying new places and regions adds to existing knowledge – but sideways rather than hierarchically.

However, regional geography is more than the compilation of facts about a locale. Rather, Frances Slater suggests the regional geographer asks: "What are the inter-relationships among phenomena that produce this particular set of features?" [59] This task requires *synthesising knowledge* from geography's sub-disciplines, notes Gilbert:

Cultural, political and economic processes together shape and structure the specific regions under investigation and it is only through the study of their interrelationships that the regional specificity can be retraced. Such a study involves a process of synthesis, a process that takes the results of analysis, the detailed studies of particular aspects of society and draws out the web of relationships that generates and binds them to produce spatial differentiation.[60]

This means that places and regions are a product of a complex web of interactions, which presents a challenge of selecting the geographical criteria to study and also the starting point. Hartshorne suggests that no geographical phenomena should be discounted if one is aiming to depict something whole. However, not all geographical phenomena are equally significant in shaping the character of a region. The character of regions can be strongly influenced by topography, proximity to oceans, climate, resources, flora and fauna, culture, population, political and economic history, and more. The selection of features and aspects to study is subjective, but purposeful: exploring the relationships that together give rise to particular characteristics or patterns.

It should now be clear that the discipline of geography depends upon both theoretical and contextual knowledge. As Phil Gersmahl notes, students of geography must study both systematic and regional knowledge because, "The interplay between topical and regional perspectives is what stimulates thought" [61].

If geographical generalisations, models and principles are of value they must necessarily explain aspects of the real world. This can be done by testing or applying them in different contexts. This does not mean that models will perfectly predict patterns and behaviour on the surface of the earth. However, in order to say something meaningful about spatial arrangements we should be able to find evidence of their principles at work. In the course of applying generic models and principles the geographer may well discover imperfections and errors, forcing them to go away and refine their ideas and models. The process of hypothesising, testing, analysis and verification of knowledge comes from *procedural knowledge*. So, while the reliability and value of generic concepts and theories are dependent upon their application in different contexts Hartshorne found that "regional geography in itself is sterile; without the continuous fertilisation of generic concepts and principles from systematic geography it could not advance to higher degrees of accuracy and certainty in interpretation of its findings" [62].

We can surmise that geography is an integrative discipline. While knowledge in its sub-disciplines may be organised hierarchically, what matters to the geographer is the ability to understand the connections across areas of systematic knowledge and apply these to explain spatial patterns and places.

6. Conclusion

In conclusion we can see two very different visions of

DOI: https://doi.org/10.30564/jgr.v2i3.898

education and the individual emerging between a particularistic and a universalist approach to epistemology. Furedi[63] reminds us that historically the role of the university was to enable the individual to transcend the limitations of their personal experience and background. This was possible because of the transformative potential of knowledge or we can say that disciplinary knowledge is "powerful" [64].

There are three ways in which disciplinary knowledge is powerful. First, from knowledge comes understanding. While learning involves posing questions and wondering at the way things are in the world, as we come to understand and gain clarity of insight. Here, our wonder about things has been replaced by a wonder at them, "to amazement at the structure of things and our capacity to grasp this structure", surmises Kronman[65]. The idea of *threshold concepts* has been theorised by Meyer and Land [66] as a way to denote the transformative impact that learning has on the way a student sees the world. Once a student has stepped over a particular educational threshold to a higher or more sophisticated level of comprehension they will forever see things differently.

Here, we can see the transformative potential of knowledge. Not only does it transform understanding, but it also transforms the individual because it develops their critical faculties (a second sense of power). In geography, Lambert[67] notes how the acquisition of deep and explanatory knowledge develops the relational thinking that underpins geographical thought and a propensity to apply the analysis of alternative social, economic and environmental futures to particular places contexts. Similarly, Alaric Maude surmises that disciplinary knowledge in geography provides students with "new ways of thinking about the world", "powerful ways of analysing, explaining and understanding', "power over their own knowledge" and it "enables young people to follow and participate in debates on significant local, national and global issues" [68].

Maude's final point takes us to the third sense in which knowledge is powerful: it transforms their capacity to act in and contribute to society. This point is echoed by Wheelahan who suggests that class divisions are likely to be reinforced because "unless students have access to the generative principles of disciplinary knowledge, they are not able to transcend the particular context" [69]. Similarly, Rata also finds such generative principles and the ability to transcend context as essential to the social contract that underpins liberal democracies, because "one is the condition for the other" [70].

Rata's observation is prescient because it highlights how education (schools and universities) and society work together to foster progressive ideals. However, the reverse is also true. The contemporary movement to Decolonize geography, and the curriculum more broadly, arises out of very different social conditions: a movement away from a common understanding of the human condition towards a form of cultural and biological determinism (a university replaced by a pluriversity). Thus, Furedi worries that "where cultural politics has become so prominent in higher education" there is the potential that "its values directly contradict those of the university"[71]. Hence, the transformative potential of disciplinary knowledge could potentially be undermined if the "fossilisation of identity accomplished through reducing students to the workings of their culture dispossesses people of their individual agency and capacity for moral autonomy" [72].

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 DOI: https://doi.org/10.30564/jgr.v2i3.898

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Journal of Geographical Research
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ARTICLE

Geographic Models of Socioeconomic and Cognitive Development: A Test in Peru

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ARTICLE INFO

Article history
Received: 25 October 2019
Accepted: 6 November 2019
Published Online: 30 November 2019

Keywords:
Absolute latitude
Altitude
Socioeconomic development
Cognitive development
Peru

ABSTRACT

Few explanations of geography's influence on economic and cognitive development have been proposed. This study was purported to test three development models based on absolute latitude (AL) and additionally addressed altitude above sea level and the particular case of the *Amazonía* in Peru. Information on 1468 Peruvian districts was obtained from Peru's Ministry of Education and United Nations Development Program's Human Development Report. The data were best fitted by ad hoc path models which combined AL with altitude and took different forms in the *Amazonía* and remainder of Peru. AL + altitude explained education + health, and income, through cognitive ability in the *Amazonía*. In the remainder of Peru, AL – altitude explained income and cognitive ability through education + health, with an additional, weak but significant, direct AL → cognitive ability path. The findings add to evidence suggesting the mediation of UV radiation in the relationship between latitude and development.

1. Introduction

This introduction provides the theoretical context and empirical background of the research presented in the article. A critical summary of geographic, institutional, and genetic explanations for differences observed in nations' wealth is followed by a presentation of evidence on absolute latitude's influence on cognitive ability and wealth and the likely mediating role of UV radiation. Then, study objectives in reference to the specific case of Peru are delineated incorporating altitude as a likely co-determinant and differentiating the *Amazonía* from the remainder of Peru. The terms intelligence, IQ, cognitive ability, and math and reading scores are used interchangeably based on Rindermann's [80] demonstration that IQ scores and scores from standardized student evaluations measure the same construct between nations.

1.1 Geographic, Institutional, and Genetic Explanations of Country Development

The negative consequences of tropical climate for nations' wealth were insightfully addressed by Kamarck [33]. His reasoning suggested that "the adverse effect of tropics arises largely from (a) erratic patterns of tropical rainfall that can play havoc with agriculture; (b) continuous heat and absence of frost that lead to a large variety of weeds, insects, fungi, and other microbes that affect both crops and human life; (c) the consequent abundance of various types of enemies of agriculture; (d) tremendous human health hazards and the associated low productivity, and depressed rates of human and nonhuman capital accumulation; (e) poor quality of tropical soils; and (f) difficulty of finding

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DOI: https://doi.org/10.30564/jgr.v2i3.1329

natural resources" [79]. The relationship between geography and wealth became more precise when economists started using absolute latitude (AL) [36], i.e., distance from the equatorial line, in their research. Ram [78,79] and Sala-i Martin [87] demonstrated between countries and/or within the United States that income increases with distance from the equator and other studies upheld this relationship using diverse economic indicators [7,13,22,23,65,67,70,72,90]. Important empirical confirmations of Kamarck's ideas emerged in the late 1990s and early 2000s and the effects of tropical climate on disease environment and of the latter on economic development appeared to have been well established [5,8,12,24,88,89].

In parallel, however, history had become an alternative source of explanations and finally displaced geography in research on economic development [71]. Hall and Jones [30], utilizing instrumental variables, showed that between-country variation in worker productivity was explained by the dissemination of such institutions as rule of law and economic freedom from Western Europe. More to the point, Acemoglu, Johnson, and Robinson [1] argued that the latitude-wealth relationship was spurious. According to their influential paper, the differences in wealth among developing countries started in colonial times. "Europeans adopted very different colonization policies in different colonies, with different associated institutions. The choice of colonization strategy was, at least in part, determined by whether Europeans could settle in the colony. In places where Europeans faced high mortality rates, they could not settle and they were more likely to set up worst (extractive) institutions. These early institutions persisted to the present" [1]. These researchers reported that African countries did not present lower incomes nor AL predicted wealth if the effects of rule of law and other economic and political institutions were controlled. Jeffrey Sachs judged Acemoglu et al's instrumental-variable estimates to be biased [71] and showed that the prevalence of malaria predicted wealth regardless of institutions [88], but most of the published economic-development research aligned with the historicist view [14,18,71,72,77,85].

León [42] criticized the lack of parsimony of the historicist explanations of nations' wealth using as example the fact that "free-city formation in Northern Italy in the Middle Ages [29] or ancient immigration from Northern Africa [58], regarded as causes of the current latitudinal gradient of wealth observed in Italy, cannot explain the (dependence of wealth on AL) seen in Brazil [76], China [15], the United States [79], or Western Europe as a whole." Research interest in the economic effects of temperature has been revived and has produced evidence that mean temperature and deviations from the biological optimum have economic consequences [10,17,31]. Furthermore, Andersen, Dalgaard, and Selaya [2] showed across 147 countries that absolute latitude and UV radiation explain country wealth. León [47], considering that an overwhelming majority of the 66 ex colonies used as units of analysis in the Acemoglu et al. study were located close to the equator, constructively replicated their research using a more heterogeneous group of countries that included nations closer to the poles which were not colonies at least since 1500 AD. Analyzing data from 96 countries, León [47] demonstrated that rule of law, government effectiveness, and economic freedom behave as net dependent variables of UV radiation, both directly and through country wealth. It is surprising that more than 15 years had to elapse until the erroneous conclusions of Acemoglu et al. [1] were so clearly contradicted by the evidence.

On the other hand, evolutionary psychologists addressed the topic with a singular view of country development. Inherited intelligence, not geography, would be the direct source of nations' wealth [61,62]. According to Lynn [56], the dark-skinned *H. sapiens* who stayed in the tropics (e.g., Sub-Saharan Africans) or returned to the tropics after a stay of some millennia at high latitudes (e.g., Peruvians) did not face the opportunities for cognitive growth that the predictable harsh winters of temperate regions afforded to the cousins who established in Europe and Northeast Asia about 40,000 years ago, remained there, and became light-skinned. Such winters would have exerted cognitive demands for survival that resulted in the millenary evolvement of higher levels of intelligence; in this view, the less intelligent humans, unable to anticipate the need for securing warming clothes, adequate food, and safe refuge for the septentrional winter, died early and did not pass their genes into the future; consequently, the average IQ increased. The cognitive capitalism perspective assumes that, presently, cognitive ability determines wealth through the mediation of technology and institutions and disregards contemporary geography as a possible cause [81-83]. This view was also challenged in León's [49] study; using structural equation modeling (SEM), he showed that, when the effects of AL and education and health are taken into account, IQ becomes unrelated to wealth and wealth determines institutions rather than the other way around.

1.2 The Possible Role of UV Radiation

Cognitive ability declines with proximity to the equator between countries [53,63] and within such countries as Italy [58], Japan [35], Peru [44,51], Russia [28], Spain [59], Sudan [3], the United States [20,45,46,74,86], and Vietnam (Kirkegaard & Pesta, 2018), although not in Turkey [60] nor India [64]. The exceptions may be accounted for by the greater longitudinal than latitudinal extension of Turkey and the fact that Mus-

 DOI: https://doi.org/10.30564/jgr.v2i3.1329

lims, whose IQ is lower than the IQ of followers of other faiths [57,92], are more concentrated in the northern regions of India (Basant & Shariff, 2010). León [48] has explained why the AL-wealth and AL-IQ relationships may not hold above 52° N or S and prior to the 20th century.

Lynn [58] attributed the latitude-IQ correlation observed in Italy to Middle European versus Mediterranean genes, but was refuted [4,49]. Rindermann, Woodley, and Stratford [84] analyzed haplogroups across Europe, but the latitude-IQ *r* transcends genetic distance from South Africa [53]. Even more damaging to the geneticist and cognitive capitalism views is the fact that neither evolutionary nor institutional concepts are able to account for the consistent AL-cognitive ability *r* found in the megathermal *Amazonía* of Peru [51]. On the other hand, UV radiation can explain the specific phenomenon on the basis of its strong negative correlation with AL.

UV radiation emerged as a possible encompassing determinant of human behavior when León [41] appealed to this variable to account for the north-south gradients of married [37] and unmarried women's fertility desire [37] vis-à-vis women's domestic power [40] observed in Peru. Since UV photons increase production of vitamin D [34] and this, in turn, increases production of sexual hormones [32], men would be more masculine and women more feminine closer to the equator; this would explain why women are more comfortable with the dependent roles of wife and mother in northern Peru and exhibit greater domestic power in southern Peru. The greater consumption of tobacco, alcohol, and coca leaf in southern than northern Peru [39] was explained by León [43] taking into account that vitamin D also increases production of dopamine, "the neurotransmitter of happiness". He predicted and confirmed empirically a similar gradient of domestic violence; the more positive emotions of northern Peruvians would limit the emergence of domestic violence closer to the equator. Increased dopamine would also affect cognitive growth by inducing play rather than study [51]. Having established, against conventional economic wisdom, that southern Peruvians have greater household assets and education levels than northern Peruvians, León [42] considered Lynn and Vanhanen's [61,62] notion that wealth is determined by intelligence. He theorized that the discovered AL-wealth relationship in Peru could be explained by negative effects of UV radiation on cognitive ability considering that larger families (promoted by greater sexual activity under intense UV radiation) are associated with children's diminished access to adult minds [94], decreased educational opportunities [9], and consequent lower IQ [6]. In an analysis of 24 Peruvian regions, León [44] showed that birth rate mediated the increasing reading comprehension and math achievements of children in 2nd grade of primary instruction from north to south and then León and Burga León [51], in a more thorough study of standardized student evaluation scores which encompassed 1479 districts, confirmed the trend. The heuristic power of the emerging theory was shown when León [45], considering UV radiation patterns, predicted and confirmed greater math and reading scores in the eastern than western United States.

But there is an alternative hypothesis for the AL-IQ correlation which considers infectious diseases, more frequent closer to the equator. Eppig et al. [21] assumed that the human immunological system needs energy to fight infections and, when these occur in childhood, the system takes energy from the developing brain, thus impairing cognitive growth; these researchers supplied confirmatory data from the United States. However, León [46], in the same country, showed that the effects of AL on math and reading scores transcend the effects of infectious diseases and León and Hassall [55], using direct measurements of UV radiation, demonstrated that the effects of the UV Index on the cognitive ability of White children transcend the effects of both infectious diseases and temperature. Moreover, in the latter study, the AL-cognitive ability *r* was absent among African American and Hispanic children, plausibly because their high levels of skin melanin absorb and dissipate light.

Yet, some recent findings present contradictions. León and Burga-León [49], using SEMs, found satisfactory model adjustment for a UV Index → cognitive ability → income linkage (see American Model in Figure 1) but not for a UV Index→ income → cognitive ability linkage in a study of the 48 contiguous states of the United States. This evidence was understood considering that the generation of wealth requires able individuals capable of developing science and technology, designing and implementing innovations in economic life, and effectively managing production and service units. On the other hand, a study of 21 regions and provinces of Italy which addressed a socioeconomic latent variable defined by per capita GDP, education, and unemployment revealed a solar radiation → socioeconomic factor → cognitive ability SEM (Italian Model of Figure 1) with positive indicators of model adjustment that were absent in the case of a solar radiation → cognitive ability → socioeconomic factor SEM [49]. The results were understood considering that UV radiation causes cell oxidative stress [68], which has been associated with the presence of fatigue in humans [93]; the interpretive hypothesis that explained the findings was that repeated exposure to high UV radiation impairs industriousness, a component of conscientiousness, one of the Big Five personality factors [16]. If southern Italians are less industrious, it is only logical that they are also poorer. As for the second leg of the linkage, psychological

DOI: https://doi.org/10.30564/jgr.v2i3.1329

research has shown a strong influence of parents' socioeconomic status on children's IQ [69] and that poverty itself reduces cognitive capacity because poverty-related concerns consume mental resources, leaving less for other tasks [66]. The difference observed with respect to the American findings suggested that social mobility based on ability prevails in the United States whereas a more rigid social structure prevails in Italy. Finally, a study of 96 countries yielded the World model of Figure 1. In that study, the SEM that best fitted the structure of the data posited education and life expectancy as mediators of the effects of AL on country income, on one hand, and cognitive ability, on the other [47]. Institutional strength emerged as a net dependent variable.

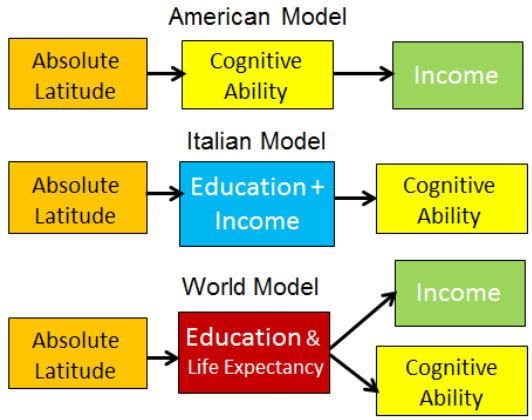

Figure 1. Three geographic models of country development

1.3 Research Questions

Foreign Models. Which of the three geographic models of national development does best describe the situation of Peru? Answers to this question were needed on two grounds. First, there was an interest in generating evidence with the potential to clarify the theoretical issue, that is, determine the circumstances leading to the prevalence of one model vis-à-vis another. Second, the findings could help Peruvians to better understand the processes of national development of their country.

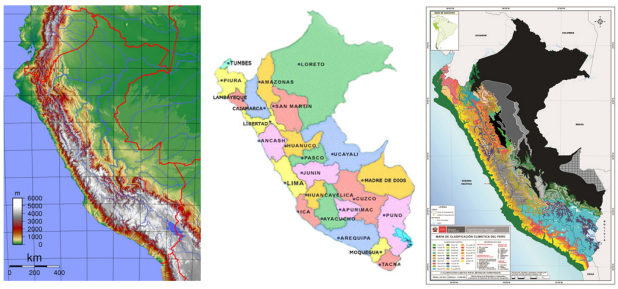

Figure 2. Topographic (left), political (center), and climatological (right) maps of Peru

Role of Altitude. A study with these purposes and set in Peru could not ignore altitude above sea level. Peru, and not only its Amazonian region, would be an entirely tropical country if the Andean mountains and Humboldt marine current did not exist. The latter brings cold into the Peruvian coast and altitude above sea level does in a large part of the national territory (see topographic map in Figure 2). However, UV radiation behaves differently in the two settings. Clouds over the Peruvian coast filter UV photons whereas altitude increases exposure to them [34]. This is why León and Avilés [46] hypothesized that birth rate mediates the negative effects of altitude on intelligence noticed by León and Burga León [51]: the higher the altitude, the greater UV radiation, vitamin D, sexual hormones, and family size and, hence, the lower the opportunities for children's cognitive growth. It is well established that estrogen and testosterone increase with altitude [25-27] and, consequently, total fertility rate is greater in the sierra zones than the coast of Peru [19]. León and Avilés [50] confirmed the mediation of birth rate, discarded lack of oxygen as a cause of lower intelligence at high altitude, and also found evidence suggesting that rugged terrain impairs intelligence by making economic activities more difficult; that is, people at high altitude are less intelligent not only because of their large families but also because they are poorer. The second research question of the present study was whether a combination of AL with altitude would improve the predictive power of the foreign development models.

The Case of the Amazonía. But things are seldom simple in Peru. León and Avilés [50] reported that the relationship between AL and cognitive ability was moderated by habitat: the *r* was negative in most of Peru but positive in the *Amazonía*. This region encompasses Loreto, Ucayali, and Madre de Dios as well as parts of adjoining political regions (see center map in Figure 2). Considering evidence on the high rate of infectious diseases in the lower *Amazonía* [11,73,95] and Eppig et al.'s [21] hypothesis concerning negative effects of infections on children's cognitive growth, León and Avilés [50] attributed the positive effects of altitude on cognitive ability found in this region to the prevalence of infectious diseases in the lower *Amazonía* and its decreasing prevalence with altitude in that region.

The third question that animated the present research was whether AL + altitude yields positive outcomes in the *Amazonía* (that is, the higher the absolute latitude and the higher the altitude, the better the socioeconomic and cognitive outcomes) whereas AL - altitude does in the largest part of Peru (that is, the higher the absolute latitude and the lower the altitude, the better the socioeconomic and cognitive outcomes). León and Avilés [50] did not deal with

 DOI: https://doi.org/10.30564/jgr.v2i3.1329

the American, Italian, and World models of cognitive and socioeconomic development.

2. Method

The study used a data set in the public domain created by León and Burga León [52].

2.1 Subjects

The data set has at its nucleus the 2011 national census of children in 2nd grade of primary instruction of the Ministry of Education of Peru (N = 506,345). The students were part of schools, the schools were in some cases part of towns, and the towns were part of districts. The units of observation and analysis for the present study were the 1468 districts which satisfied the Ministry's sampling standards (at least 90% of schools accessed and 80% of students tested) and had average data on all the study variables.

2.2 Measurements

Cognitive Data. The children responded to questions entailing mathematics and reading comprehension. The reliabilities of the summed scores were α = .89 and α = .87, respectively. Math and reading correlated .89.

AL and Altitude. The AL and altitude of the town with the greatest student population within a district were assigned to the district. The measurements were obtained from the website of the Ministry of Education.

Socioeconomic Variables. Three indicators from the Peru 2009 Human Development Report [75] were used. Per capita family income actually refers to expenses in national currency. Educational achievement is an average of literacy and school attendance by the population between 5 and 18 years of age. Life expectancy was calculated considering infant mortality rates.

2.3 Analytic Strategy

Data were analyzed separately in the *Amazonía* and the remainder of Peru. The *Amazonía* ranges from 1 up to 600 meters above sea level and comprises four humid-megathermal climates represented by the rightmost areas of the climatological map in Figure 2. Owing to difficulties for agriculture, this region is under-populated, over-urbanized, and poorly connected with the rest of the country. AL and altitude standardized scores were combined as follows:

$$(zAL + zAltitude) / 2 \quad (1)$$

$$zAL – zAltitude \quad (2)$$

Equation 1 was designed for use with *Amazonía* data and Equation 2 for use with the remainder of Peru. Path analyses with bootstrapping were used in testing the models. The adjustment criteria for the models were the conventional $\chi 2/df < 2$ or 3, SRMR < .08, CFI > .95, and RMSEA < .08 [91].

3. Results

Table 1 presents descriptive statistics for the *Amazonía* and Remainder of Peru. Compared to the latter, the *Amazonía* is closer to the equator; lower in altitude, cognitive ability, and life expectancy; higher in income and education; and more homogeneous in all the variables. Table 2 shows the inter-correlations between the study variables within each

Table 1. Characteristics of the *Amazonía* and Remainder of Peru

Variable	*Amazonía*		Remainder of Peru	
	Mean	SD	Mean	SD
Absolute latitude	7.39	2.56	11.29	3.43
Altitude	271	143	2386	1410
Reading score	471.92	41.07	507.20	45.24
Math score	457.97	46.24	503.34	52.36
Log Income	5.40	0.32	5.34	0.44
Education rate	86.51	5.55	86.00	6.83
Life expectancy	71.35	1.90	71.71	2.51
(N)	(119)		(1349)	

Table 2. Inter-correlations between study variables, per setting. *Amazonía* above the diagonal; Remainder of Peru below the diagonal

Variables	1	2	3	4	5	6	7
1. Absolute latitude	-	.41***	.39***	.40***	.28**	.04	.15
2. Altitude	.36***	-	.42***	.48***	.10	-.20*	.28**
3. Reading score	.03	-.46***	-	.93***	.57***	.34***	.60***
4. Math score	-.02	-.36***	.89***	-	.48***	.25**	.54***
5. Log Income	-.03	-.61***	.68***	.49***	-	.60***	.37***
6. Education rate	.12***	-.40***	.61***	.44***	.71***	-	.25**
7. Life expectancy	-.12***	-.62***	.48***	.36***	.64***	.47***	-

Note: * p < .05, ** p < .01, *** p < .001.

Setting: The variables are significantly inter-correlated in the *Amazonía*, with the exception of AL with education and life expectancy and altitude with income. They are also highly inter-correlated in Remainder of Peru, excepting AL with income and cognitive abilities.

DOI: https://doi.org/10.30564/jgr.v2i3.1329

3.1 Foreign Models

The first study question had to do with the validity of the American, Italian, and world development models in Peru. It can be seen in Figure 3 that only the American

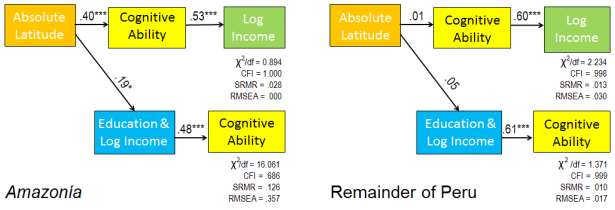

Figure 3. Path coefficients connecting absolute latitude with per capita income through complex cognitive ability (American Model) and with cognitive ability through education + per capita income (Italian Model) in Peru, per setting

Note: Each panel presents two sets of model adjustment indicators, one for model. Significance levels like in Table 2.

Model replicated well in the *Amazonía*; cognitive ability is an average of math and reading standardized scores. The Italian Model presented satisfactory adjustment criteria in remainder of Peru, but the effects of AL on education and income were not significant. Results for the World Model are shown in Figure 4; this model did not work well in either setting. Evidently, a developmental model oblivious to altitude is destined to failure in Peru, except in a region with low altitudes such as the *Amazonía*.

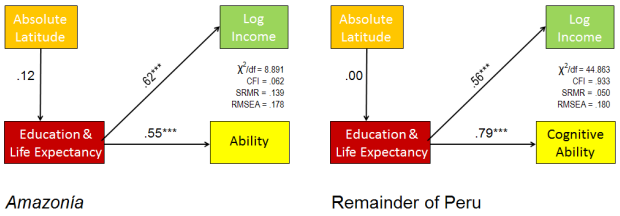

Figure 4. Path coefficients connecting absolute latitude with cognitive ability and per capita income through education + life expectancy (World Model) in Peru, per setting

Note: Significance levels like in Table 2.

3.2 Combinations of Absolute Latitude and Altitude

Figure 5A depicts the regression of cognitive ability scores on AL having administrative regions as units of analysis. The regression is clearly positive in the case of Peru as a whole, the coastal administrative regions (circles), and the *Amazonía* (rhombuses), but not in the heterogeneous remainder of the country (rectangles). In the case of the regression of cognitive ability on altitude (Figure 5B), the sign is negative for Peru as a whole, the coastal administrative regions, and the remainder of the country, but is positive for the *Amazonía*. The regression of cognitive ability on Equation 2 (Figure 6A) was steeper than that on absolute latitude alone; among other changes, Metropolitan Lima and Callao moved closer to the regression line. An even steeper regression line was obtained when altitude was weighted double than absolute latitude and the *Amazonía* was treated with Equation 3 and the remainder of Peru with Equation 4 (Figure 6B).

$$(0.5\ zAL + zAltitude) / 2 \quad (3)$$

$$0.5\ zAL - zAltitude \quad (4)$$

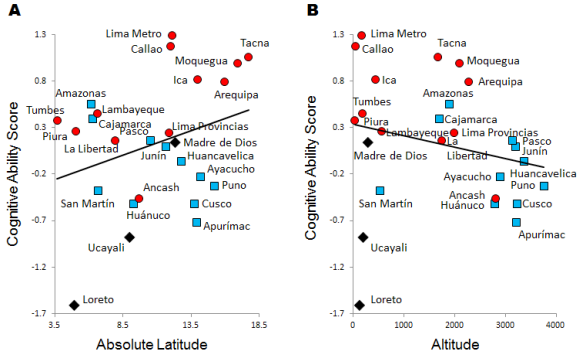

Figure 5. Regression of averaged math and reading standardized scores of 26 administrative regions of Peru on absolute latitude (Panel A) and altitude (Panel B)

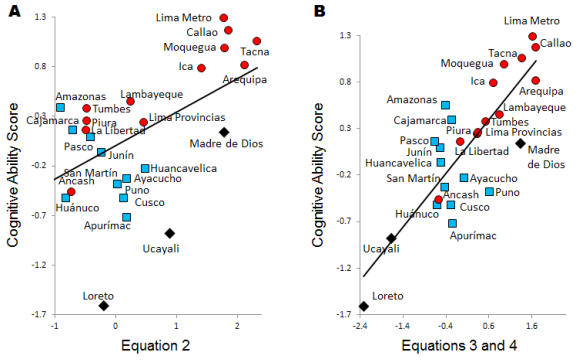

Figure 6. Regression of averaged math and reading standardized scores of 26 administrative regions of Peru on Equation 2 (Panel A) and on Equation 3 for Loreto, Madre de Dios and Ucayali and Equation 4 for the other 22 regions (Panel B)

3.3 Peruvian Models of Development

Several ad hoc models were tried using equations 3 (*Amazonía*) and 4 (Remainder of Peru). The upper panels of Figure 7 depict the most successful models. Since the

DOI: https://doi.org/10.30564/jgr.v2i3.1329

model for Remainder of Peru did not meet the model adjustment standards, equations 1 (*Amazonía*) and 2 (Remainder of Peru) were tried (see lower panels of Figure 7). Whereas the results for the *Amazonía* changed little, those for Remainder of Peru achieved more satisfactory levels of adjustment. Entering separately education and life expectancy in the equations deteriorated adjustment of the statistical model (not shown).

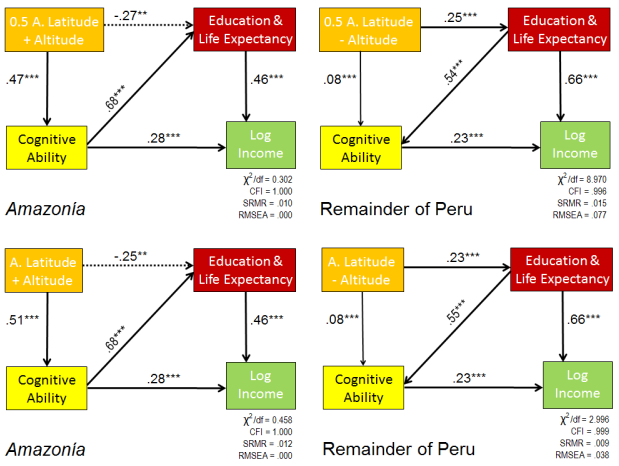

Figure 7. *Path coefficients connecting absolute latitude and altitude with complex cognitive ability, per capita income, and education + life expectancy (Ad Hoc Models) in Peru, per setting*

Note: In the upper panels, absolute latitude is weighted 0.5; in the panels below, it is not. Significance levels like in Table 2.

4. Discussion

Different models explain development in the Peruvian habitats addressed. The American Model explained the case of the *Amazonía*: reading and math abilities were affected by AL in this habitat and, in turn, affected wealth. León and Burga León [51] noted that:

"(In the Amazonía), birth rate's effects on (cognitive ability) were greater than those seen in the other Peruvian regions…, which suggests that the negative cognitive effects of family size are intensified under strong UV_B radiation. The Amazonía is the Peruvian region closest to the equator and, given its high temperature, its residents wear slight clothing and expose large parts of the body to sunlight all year round. Regional stereotyping of Amazonians in Peru, pointing to sexual hyperactivity and promiscuity, suggests deficits of parenting, which could help explain an incongruous finding of the study: whereas the Amazonía occupied an intermediate position between the rich coast and poor remainder of the country in social development, it fell behind the latter in (cognitive ability)… Consistent with the emerging explanatory hypothesis on parenting, the effects of birth rate on (cognitive ability) decayed from northern to central to southern latitudinal segments when we divided the Amazonía into three equal parts."

The American Model specifies positive effects of AL on cognitive ability and implies high social mobility based on personal ability. Sociological studies comparing the social mobility of the *Amazonía* with the remainder of Peru are needed to confirm this interpretive hypothesis.

A comparison of Figure 3 with Figure 7 shows that the path coefficients and indicators of model adjustment in the *Amazonía* improved when the American model was combined with altitude and incorporated education and health. Since infectious diseases decrease with altitude in the *Amazonía*, the improvement of the statistical model can be interpreted along Eppig et al.'s (2009) conception that child infections interfere with cognitive development. That is, the negative cognitive effects of infectious diseases in childhood would add to the impairment of cognitive ability caused by the larger families and deterioration of parenting under greater exposure to UV radiation. On the other hand, the Peruvian development models designed for the *Amazonía* (upper and lower leftmost panels of Figure 7) presented a negative relationship between AL + altitude and education + life expectancy. This may reflect the concentration of more and better educational and health services in the larger cities of the northern than southern *Amazonía* (Iquitos/Loreto, pop. 437376; Pucallpa/Ucayali, pop. 211651; Puerto Maldonado/Madre de Dios, pop. 74494). More generally, the Amazonian findings help to understand the poor GDPs of Sub-Saharan African countries, exposed to strong UV radiation and high rates of infectious diseases and, consequently, characterized by very low IQs [63]. They also suggest straightforward remedies both for the *Amazonía* and Sub-Saharan Africa: reduced exposure to UV radiation, more effective use of contraceptive methods, and control of infectious diseases. This should immediately improve the cognitive growth of children. It can be expected that, as adults, they will become richer and, as authorities, contribute to the improvement of education and health.

The American Model failed to explain the situation of Remainder of Peru and both the Italian and World models failed in both habitats (*Amazonía* and Remainder of Peru). However, inclusion of altitude with inverted sign and equal weight as AL in the World Model yielded a statistically satisfactory model in Remainder of Peru (Figure 7). León & Burga-León [54] interpreted the World Model considering that the effects of absolute latitude on education/health can be understood considering the possible mediation of the oxidative stress caused by UV radiation:

"The free radicals associated with cell oxidative stress

DOI: https://doi.org/10.30564/jgr.v2i3.1329

have been implicated in the pathology of several human diseases, including cancer, atherosclerosis, malaria, rheumatoid arthritis, and neurodegenerative diseases (Aruoma, 1998). Rate of disease has been shown to impair CCA (Daniele & Ostumi, 2013)… Disease is also likely to cause desertion from school (and) impoverish educational achievements…"

It seems only logical that people close to the equator are less healthy and less educated. The creation of wealth demands healthy and educated economic agents, and the growth of cognitive ability is impaired by deficits in education [69]. Moreover, energetically costly infectious diseases of the child impair cognitive growth.

5. Conclusions

An AL – altitude → education + life expectancy → wealth and cognitive ability chain of effects explains development among an overwhelming majority of the population of Peru. It should be noted, however, that the impact of AL – altitude on education + life expectancy in Remainder of Peru was weaker than that of AL + altitude on cognitive ability in the *Amazonía*. The interpretation proposed here is that the latter entails contemporary effects of AL + altitude whereas the former involve historical, cumulative effects of AL – altitude. In other words, the effects of geography in the *Amazonía* would be visible in one generation whereas those in Remainder of Peru would require several generations. Changes in the life expectancy of a population and in the rates of educational achievements take a time to materialize and are probably related to culturally determined ways of life with impacts on health as well as to the educational aspirations of society. The results of the present study highlight the importance of health and education in the causation of wealth and cognitive ability in Peru. On the other hand, AL simultaneously affected cognitive ability directly, though somewhat weakly. This may reflect a contemporary effect.

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DOI: https://doi.org/10.30564/jgr.v2i3.1329

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ARTICLE

Retail Outlets and City Centrality: Perspectives from a Sub-Saharan African City

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ARTICLE INFO

Article history
Received: 1 November 2019
Accepted: 12 November 2019
Published Online: 30 November 2019

Keywords:
Retail outlets
Sub-Saharan africa
Central business district
Uyo urban

ABSTRACT

Sub-Saharan African cities are uniquely characterized by retail competition influencing outlet location. This work focused on revealing retail outlet location in Uyo and its relationship with distances from the Central Business Districts. Distance was measured along the six major arterial roads that link the city to the central business districts by the use of Google Map[5] Distance Calculator and itouch maps [7] technology. Six arteries were divided into four distinct spaces in kilometers namely 0-1km, 1-2km, 2-3km, 3-4km. Retail Outlets were grouped into ten classes. Data was analysed using distance in kilometers from the Central Business District as variable Y1. The independent variables X1, X2, X3, X4, X5 and X6 were the six major arteries represented by the location of each specific retail outlet group. Utilising SPSS version 20 software the results reflected centre a 47.9 percent variation in retail outlets location with correlation coefficient (R) of 69.2 % revealing a strong relationship between the distances from the Central Business Districts and the location of retail outlets located across the six major arteries. H1 was accepted which states a significant relationship in the location of retail outlets as distance increase from the city centre across the linkages. This confirms a strong intensity of location of retail outlets in the city centre with a gradual decline as distance increase from the centre. Although there was an increase in intensity of retail outlets in junctions away from the Central Business Districts according to multiple nuclei concept. It is recommended that urban expansion through growth poles.

Aim: To access the relationship between retail outlets location and distance from central business district in a Uyo. **Research Questions:** This work provided answers to the following questions: 1. Where are these retail outlets located in the city space? 2. What is the relationship between Retail outlets and the distance from the City Centre? **Objectives:** 1. To explain the distribution of location of retail outlets in city space. 2. To reveal the relationship between Retail Outlets and distance from the City Centre. **Hypothesis:** There is no significant relationship between the distance from the central business district and the location of retail outlets.

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 DOI: https://doi.org/10.30564/jgr.v2i3.1371

1. Introduction

Every geographic problem may contain three elements. It must specify what and where and must ask why [9]. Geographers are concerned with diverse phenomena on the surface of the earth. To understand these features and its consequences on man, questions like; what is it? where is it located? why is it there? and what is the significance of the location? Posing these questions, seek responses that will help to organize spatial understanding by revealing the pattern of location of retail outlets in urban centres and the consequences of its location and associations. Most Nigerian cities are scarcely planned and thus are ill prepared for the surge in urban explosion that results from the rural urban migration and the growth that made most Nigerian cities what they are today, a decadence of humanity [2].

Furthermore, most modern research on the location of retail outlets were built on studies that focused on the description of the location and causes of these locations of retail outlets in cities in the developed countries. Thus, there exist gaps in knowledge on how retail outlets are distributed in a city in the developing countries taking Uyo a major city in the Niger-delta region of Sub-Saharan Africa as an example. While other research take location of retail outlets in isolation, this work will add something new to existing knowledge by revealing its relationship with. Currently, there is limited information on the way retail outlets are located and the effect of these location on the quality of the urban environment of a developing country.

1.1 Socio-Economic Activities

Uyo urban experienced socio economic explosion when it emerged as the state capital city of Akwa Ibom State in Nigeria in 23rd September, 1987. Its major city market was popularly called Urua Etuk and a satellite market Urua Itam. Currently, Uyo has several major traditional markets which include but is not limited to Urua Akpan Andem, Itam, Ifa, Ekpiri Nsukara, Nwaniba. Uyo had functioning companies like Champion Breweries, Plastocrown, and Quality Ceramics in its City space. Other conspicuous institutions in Uyo include; the University of Uyo, Uyo City Polytechnic, Ibom Tropicana, Five Star Hotel, Akwa Ibom e-library, Akwa Ibom Water Company, Nigerian Post Office, different branches of Banks, Telecommunication Service Providers, public and private primary Schools, different Churches to mention but a few.

Uyo is a commercial and administrative city as the State is governed from Government House, Wellington Bassey Way. There exist both public and private sectors of the economy where majority of the middle income class are Civil Servants with other occupation like traders and artisans (tailors, carpenters, barbers, brick layers, e.t.c) having its fair share of space. It is also worthy to note the large amount of tricycle popularly call Keke napep (named after the Nigerian MDG's National Poverty Eradication Programme (NAPEP)) riders claiming dominance in the cities transport and economic space. Uyo has an averagely good road network with limited.

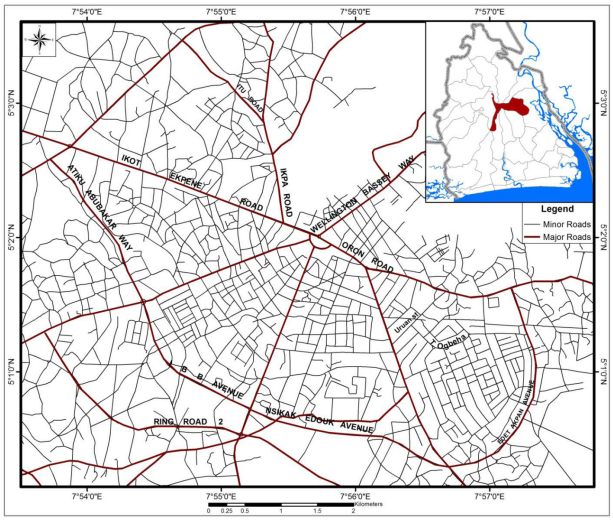

Figure 1. Streets on the Map of Uyo Urban

Traffic jams which mostly occur during the transportation peak periods from 7.30-9.30am and 3.00–7.00pm. This traffic jams occur in mostly populated retail areas. During this traffic peak, street hawkers make brisk sales to motorist and passengers.

The most popular form of transportation around Uyo urban is via Keke where each drop is from NGN50 (USD0.14) and above depending on the distance involved. Though, the popularity of Keke mode of road transportation is being challenged by the growing patronage of Taxi. This is because of the restrictions of the Ministry of Transport where no Keke policy is enforced around the Central Business District in order to reduce traffic jam in the city space. There is a growing commercial night life where various types of goods are displayed for sale by street hawkers who keep their wares on the road and do brisk business by attracting potential customers returning home from work. This commercial night life peaks from 5pm-10pm daily and concentrates at the Central Business District (Ibom Plaza), sprawling along Keke napep terminals on Ikot ekpene road, Aka Road and Oron Road.

1.2 Conceptual Classification

Concentric Zone Model: Ernest Burgess quest to explain the distribution of urban social structures within urban areas in 1923 proposed a model which explains the different

DOI: https://doi.org/10.30564/jgr.v2i3.1371

land uses in an urban centre. Burgess model disclose that land uses are arranged based on concentric rings starting from the central business district located at the centre of the model. He elaborated that these rings expands with different land uses. The first Zone being the CBD comprises of civic, social and commercial land uses, the second Zone contains industrial, residential (modern, obsolete and slum) land uses, the third Zone classed as belt of working class housing which he insisted were occupied by families migrating outwards from the second Zone and still had the need to live close to where there are working. Second-generation immigrants into the city are an important element of this third Zone .He emphasized that Zone four had single – family abode populated by the middle-class groups interspaced with exclusive residences and high class apartment buildings. While Zone five is at the fringe of the urban area which he named commuters Zone characterized as former rural areas gradually evolving into areas with dormitory like settlements where commuters travel every day to work. This Zone and the urban area are separated by continuously built-up area of green belt. This model as proposed applies to certain aspects of Uyo urban space though limited in its explanation of the role roads play in land use determination.

Relating this concept to the Uyo urban reveals an identifiable central business district also known as the city centre which is popularly referred to as Ibom plaza see Fig 1. This Zone consists mostly of civic, social and commercial land uses. The second Zone though limited in the industrial land uses, has most modern and few obsolete residential land uses. Our concern within this model is in its layout of commercial land uses. It states that Central Business District (CBD) is the centre of the concentric zone followed by the transition zone of mixed commercial and residential uses he called zone of transition. While there are series of clusters of retail outlets along Burgess proposed transition zone, retail outlets are not limited to this location. Thus, we need to logically explain its location along linkages and other locations outside of the transition zone but still within the urban space.

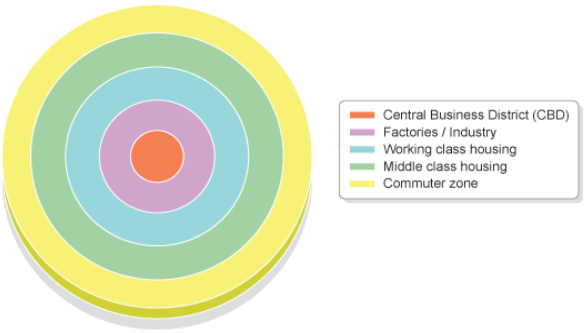

Figure 2. Concentric Zones

Source: GCSE Bitesize, 2016 [3].

2. Methodology

2.1 Research Design

In order to achieve the objectives of the study, this research design used quantitative methodological paradigm techniques in data collection to enhance validity and reliability. Data was analyzed using Multiple Correlation statistical techniques.

2.2 Methods and Sources of Data Acquisition

Data was collected from the field through the actual counting of the different classes of retail outlets as points in space in the sampled areas. The distance from the Central Business Districts was measured along the six major arterial roads that link the city to the central business districts by the use of Google Map Distance Calculator and itouch maps technology. The six arteries were divided into four distinct spaces in kilometers namely 0-1km, 1-2km, 2-3km, 3-4km. A collection of the ten classes of retail in a zone according to their location across the four distinct spaces with the linkages were carried out. Secondary data was sourced from journals, articles as referenced.

2.3 Population of the Study

This study was focused on Uyo urban area and the entire retail outlets in the sample area. The 2015 population of the study area was projected from the 2006 National Population Commission, (NPC) 305,961 persons using the formula;

$$Po = Pt(1 + \frac{r}{100})^n$$

where: Po = Projected Population
Pt = Population of the base year
r = rate of growth (2.3)
n = 9 years

Applying the formula $Po = 305,961(1 + \frac{2.3}{100})^9$

gave a projected population of 375,445 persons for the study area.

2.4 Determination of the Sample Size

The determination of the sample size was based on Cochran [1] formula:

$$No = \frac{(t)^2 * (p)(q)}{(d)^2}$$

Where t = value for selected alpha level of .025 in each tail = 1.96

 DOI: https://doi.org/10.30564/jgr.v2i3.1371

(p)(q) = estimate of variance = .25

d = acceptable margin of error for proportion being estimated = .05

No = determination of sample size

$$No = \frac{(1.96)^2(.5)(.5)}{(.05)^2} = 384 \text{ respondents}$$

This gave a sample size of 384 respondents for the study. The respondents were retailers who frequently shop in retail outlets in Uyo urban. The questionnaire was designed to collect primary data aimed at revealing the effects of location of retail outlets from consumers, retailers and respondents found around retail outlets in Uyo urban.

2.5 Sampling Techniques

A reconnaissance survey of Uyo urban was carried out, and for the convenience of data collection, the area of study was delineated into six zones according to the six major arterial ways. The area in between Ikot Ekpene and Abak Roads made up zone A, Abak and Aka Roads zone B, Ikot Ekpene Road and Wellington Bassey Way zone C, Wellington Bassey way and Nwaniba Road zone D, Nwaniba and Oron Roads zone E, while Oron and Aka Roads made up zone F as adopted from research of diverse retail outlets by Sarwar, Chowdhury & Muhibbullah [10], Tom [11]. Furthermore, zonal delineation aided in revealing the spatiality of retail outlets in Uyo urban as compared to the popular Sector model by Hoyt [6]. Each zone as delineated had two sampled Collectors linkages, two sampled Local linkages and two sampled Arterial linkage where 10 questionnaire was administered in each with an exception of the Major Arterial road where 14 questionnaire was administered. Thus, 64 copies of the questionnaires were administered in each zone. A systematic sampling method was adopted in selecting the sampled streets. Two roads were systematically chosen based on the classes of linkages which are Arterials, Collectors and Locals. The basis for this spatial structuring was for the convenience of unique data collection due to differences in the density of retail outlets and human population in the study area. The zones and classes of roads are as follows;

Table 1. List of Zones and Classes of Roads

S/N	ZONE	CLASS OF ROADS	ROADS
1	Zone A	Arterials	Ikot Ekpene Road
2		Arterials	Atiku Abubakar Way
3		Collectors	Nkemba Road
4		Collectors	Akpan Essien Street
5		Locals	Akpan Udosen[13]
6		Locals	Umoh Itong
7	Zone B	Arterials	Abak Road
8		Arterials	IBB road
9		Collectors	Udo Eduok Street
10		Collectors	Nepa Line
11		Locals	Okon Essien
12		Locals	Mkpong
13	Zone C	Arterials	Willington Bassey way
14		Arterials	Ikpa road
15		Collectors	Nelson Mandela Road
16		Collectors	Urua Ekpa
17		Locals	Idaka Okpo
18		Locals	Ikot Udoro
19	Zone D	Arterials	Nwaniba Road
20		Arterials	Dominic Utuk Avenue
21		Collectors	Ekpenyong Street
22		Collectors	Utang Steet
23		Locals	Asuquo Akpan
24		Locals	Utang Lane
25	Zone E	Arterials	Oron Road
26		Arterials	Gen Edet Akpan Ave
27		Collectors	Akpan Etuk
28		Collectors	Uruan Street
29		Locals	Hospital Street
30		Locals	Ifa Atai Street
31	Zone F	Arterials	Aka Road
32		Arterials	Sir Udoudoma Avenue
33		Collectors	Obio Imo Street
34		Collectors	Udo Umana Street
35		Locals	Affia Etoi lane
36		Locals	Ibiono Street

Source: Researcher, 2016.

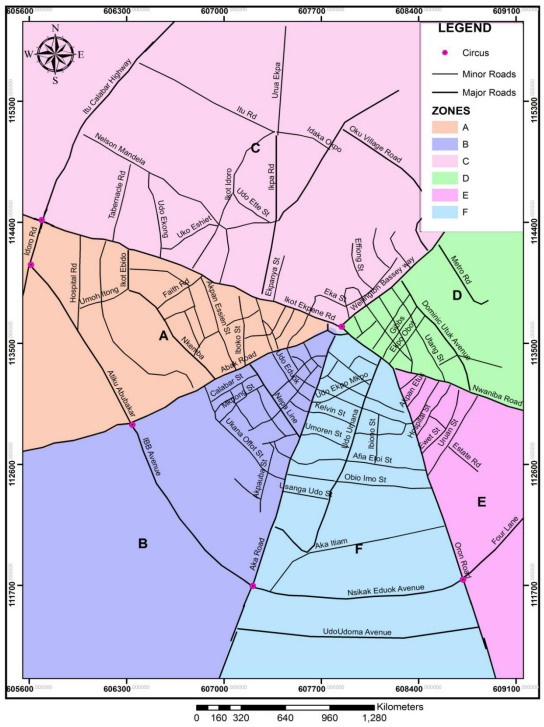

Figure 3. The Study Area and Sampled Zones on the Map of Uyo Urban

Source: Researcher, 2015

DOI: https://doi.org/10.30564/jgr.v2i3.1371

The simple random sampling technique was adopted in selecting locations in the zones for choosing the respondents and administering questionnaire in each location. These responses were limited to respondents from both genders that are 18 years and above who have lived for at least a year in the zone.

2.6 Data Sets

Due to the numerous retail outlets, and in order to make meaningful sense, retail outlets were classed into ten different groups namely; Electronic/Electrical & Computer Appliances, Motor vehicles and spares, Food Products and Restaurants, Clothing and wearing apparels, Building materials and Furniture items, Musical Equipment, Drug and Pharmaceutical Stores, Arts and Stationeries Agro allied products and General Merchandise.

2.7 Sampling Techniques

A reconnaissance survey of Uyo urban was carried out, and for the convenience of data collection, the area of study was delineated into six zones according to the six major arterial ways. The area in between Ikot Ekpene and Abak Roads made up zone A, Abak and Aka Roads zone B, Ikot Ekpene Road and Wellington Bassey Way zone C, Wellington Bassey way and Nwaniba Road zone D, Nwaniba and Oron Roads zone E, while Oron and Aka Roads made up zone F as adopted from research of diverse retail outlets by Sarwar, Chowdhury & Muhibbullah [10], Tom [11]. Furthermore, zonal delineation aided in revealing the spatiality of retail outlets in Uyo urban as compared to the popular Sector model by Hoyt [6]. Each zone as delineated had two sampled Collectors linkages, two sampled Local linkages and two sampled Arterial linkage where 10 questionnaire was administered in each with an exception of the Major Arterial road where 14 questionnaire was administered. Thus, 64 copies of the questionnaires were administered in each zone. A systematic sampling method was adopted in selecting the sampled streets. Two roads were systematically chosen based on the classes of linkages which are Arterials, Collectors and Locals. The basis for this spatial structuring was for the convenience of unique data collection due to differences in the density of retail outlets and human population in the study area.

3. Results and Discussion

In this study of the Location of retail outlets with distances from the city centre, we realized that apart from exceptions in Ikot Ekpene and Nwaniba road, retail outlets peaked in their first kilometer from the Central Business District. The location of retail outlets increased in Ikot Ekpene road in 1-2 km because of the sizes of these outlets. It was observed that the sizes of retail outlets in the 1-2km group were smaller and numerous.

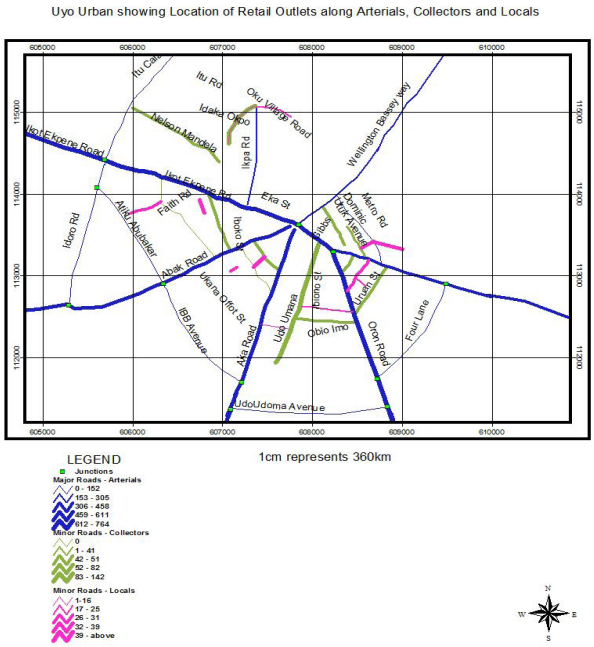

Figure 4. Location of Retail outlets along sampled Arterials, Collectors and Locals on the Map of Uyo Urban

Source: Researcher, 2016

Nwaniba Road had a higher location of retail outlets around 2-3 km from the Central Business District. It was observed that retail activities were intense here based on the location of smaller groups of traditional markets along this artery. Three individual clusters of retail outlets were identified namely; Urua Nwaniba, Urua Ekpiri Nsukara, and Urua Use.

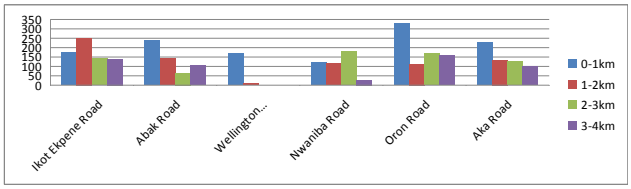

Figure 5. Distribution of Retail Outlets with distance from Central Business District

The Figure 4 above shows a ratio of the total retail outlets as located across the first, second, third and fourth kilometers from the Central Business District to be 39:24:21:16 percent of the retail outlets.

Test of Hypothesis: The hypothesis "there is no significant relationship between the distance from the central business district and the location of retail outlets" sought to understand the relationship that exists on how retail outlets were located as distance increase from the central business

district. The distance from the Central Business Districts was measured along the six major arterial roads that link the city to the central business districts by the use of the Google Map Distance Calculator and itouch maps technology. The six arteries were divided into four distinct spaces in kilometers namely 0-1km, 1-2km, 2-3km, 3-4km. A collection of the ten classes of retail in a zone according to their location across the four distinct spaces with the six zones participating was carried out. This summed up the total number of variables for each zone to be 40. The distances in kilometers as measured from the Central Business District was used as the dependent variable Y1. The independent variables X1, X2, X3, X4, X5 and X6 were the six major arteries represented by the location of each specific retail type of outlet. Each distinct retail outlet on the artery made up 40 X variables with an exception of Wellington Bassey Way whose length ended around the 2km mark which also had 20 distinct variables. This was tested to show how the patterns of retail outlets perform with the various grouped distances from the city centre. This analysis was produced as assisted by the SPSS version 20 software.

The first table populated revealed an R-square of 47.9 percent. This was the degree of variation in the location of retail outlets as the distance increase away from the Central Business District as explained by the location of these retail outlets along the six major arteries. This means that along the six major arteries, as distance increased from the city centre there is 47.9 percent variation in retail outlets location. The correlation coefficient (R) of 69.2% reveals a strong relationship between the distances from the Central Business Districts and the location of retail outlets located across the six major arteries. This confirms what was already obvious in the data collection stage where there was a strong intensity of location of retail outlets in the city centre with a gradual decline as distance increase from the centre. Although there was an increase in intensity of retail outlets in junctions away from the Central Business Districts according to multiple nuclei concept our results still revealed a very strong correlation coefficient.

The result showing the descriptive and correlation table is shown in Appendix. This analysis reveals that the calculated value F= 1.99 and the Significant value = 0.14 at 0.05 significant level. Since the calculated value is higher than the significant value, we reject Ho and accept H1 which states that there is a relationship a significant relationship in the location of retail outlets as distance increase from the city centre across the linkages.

4. Conclusion

Due to the popularity of retailing in city space, more attention should be focused on studies concerning retail location as it relates with or affects the individuals' livability. Each retail outlets should be studied and its effects (positive and negative) revealed. This form of study will aid planners in predicting the various needs available in city space. Retail Outlets cluster around the nodes connected by linkages. As retail outlets populate and congest the central business districts and nodes close to it, there is need to create new nodes away from the populated centre to aid increase growth in suburbs and as well reduce congestion in the Central Business Districts. This confirms the practicality of multiple nuclear theory which should be adopted in city planning to ensure an even growth and expansion even in developing urban centres in Sub-Saharan Africa.

This studies also reveal that while there is an increase in digital retail innovation across city space, the importance of retail outlets accessing location has not changed. It reveals that retail outlets still cluster on highly accessible road network and closer to the central business district irrespective of the high cost of rent.

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DOI: https://doi.org/10.30564/jgr.v2i3.1371

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 DOI: https://doi.org/10.30564/jgr.v2i3.1371

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ARTICLE

Modeling Interstate Banking in the United States: the Spatial 3-Stage Least Squares Approach

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ARTICLE INFO

Article history
Received: 1 November 2019
Accepted: 12 November 2019
Published Online: 30 November 2019

Keywords:
Interstate banking
Banking legislation
Spatial dependence
Contemporaneous correlation
3-stage least squares

ABSTRACT

This study uses a spatial 3-stage least squares approach to model interstate banking of the United States in 1994 and 2014. The method simultaneously takes into account spatial dependence, outward and inward interstate banking and their interaction, and the temporal effects in interstate banking. The study shows that a healthy economic structure, an expanding market, and permissive banking legislation encourage inward interstate banking. A healthy economic structure is a basis for strong banking firms to rise and to expand in other states. Large banking institutions were dominate in outward interstate banking while smaller firm sizes tend to be associated with inward interstate banking. By 2014, large and well-capitalized banking firms from states with a healthy economic structure had expanded into states with lower income levels, and lower capital-to-labor ratios, higher labor resource use, and lower profitability in their banking industry. Evidence shows some banking geographical fragmentation remains.

1. Introduction

This study models interstate banking in the United States to ascertain significant contributing factors. Interstate banking in the U.S. refers to banking firms operating across state lines. It constitutes an important component of banking deregulation since the 1970s when major banking firms demanded more flexibility in choosing geographical locations for their businesses. Interstate banking is highly geographical since it involves banking networks spreading across space connecting various home states with host states. Modeling such networks allows an understanding of factors that contribute to and shape the spatial organization of banking. However, the accuracy in modeling interstate banking depends upon the approach adopted. In addition to data accuracy and model specification, other factors also contribute to the estimation accuracy. First, there is possible spatial dependence where certain geographical structures exist in interstate banking. There is also an issue of modeling "outward" vs. "inward" interstate banking. Outward interstate banking refers to banking firms going out of their own home states to operate in host states while inward interstate banking means host states receiving banking branches from out-of-state banking firms. These are different banking behaviors and both need to be accounted for. In addition, outward and inward interstate banking of the same states may interact with each other. For example, a strong out-

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DOI: https://doi.org/10.30564/jgr.v2i3.1375

ward interstate banking state with major banking firms may deter banking firms from other states to make acquisitions. Finally, there is the temporal factor where the earlier spatial pattern may affect the later pattern. An ideal modeling approach should take all these factors (spatial dependence, outward and inward, interaction between outward and inward, and temporal effects) into account. The purpose of this paper is to estimate interstate banking taking all four factors into consideration, using a spatial 3-stage least squares model (spatial 3SLS). In this approach, outward and inward interstate banking regression equations are included for different temporal points. All regression equations contain a spatial autoregressive term of the dependent variable as an endogenous explanatory variable (also known as the spatial lag) and a spatially autoregressive error term (also known as the spatial error) [2]. The regression equations in the system are estimated simultaneously to account for spatial dependence, and the contemporaneous correlation between outward and inward interstate banking, and between interstate banking of different temporal points.

2. Interstate Banking in the United States

During the 19th century, the U.S. banking industry developed geographical fragmentation due to divergent political and economic interests that existed between cities and rural areas, and between large money center banks headquartered in New York, Chicago, etc. and small community banks [9]. The geographical fragmentation was manifested in the limitations on branch banking, and later on in multi-bank holding companies which hold multiple banks in different locations. The multi-bank holding companies were developed as a way to get around branching limitations before they were prohibited [17]. Although industrialization and urbanization prompted some states to loosen such limitations to various extent (e.g. California and New York), the regulatory restrictions remained in many states until in the late 20th century, especially in agricultural states.

Geographical deregulation in banking came as a result of searching for solutions to the disintermediation in the 1970s and banking crisis during the 1980s [32]. Intra-state branching and interstate bank holding were the two main venues. Many states which previously prohibited or limited in-state branching now loosened or ended the limitation. Many states also passed laws allowing out-of-state banking firms to enter their states, some on the reciprocal basis. Banking geographical deregulation culminated in 1994 with the passage of the federal Interstate Banking and Branching Efficiency Act (IBBEA) which authorizes nationwide banking and branching opening a new era in the U.S. banking history.

Twenty years on, the IBBEA facilitated tremendous interstate banking consolidation. Figure 1 shows the number of interstate banking mergers and acquisitions based on the Federal Reserve Bank Merger data (bars in the figure). The numbers of interstate consolidations in Figure 1 exclude the mergers of institutions that were already operating under the same bank holding companies. During the 1980s, interstate banking mergers and acquisitions were numbered only 16 on average every year, including interstate rescues of failed institutions permitted by federal laws. During the 1990s, the annual average of interstate mergers and acquisitions rose to 96. In 1998, there was a record 183 deals of interstate banking consolidation. Although the number of interstate consolidations declined since then, there were still 100 deals per year on average between 1999 and 2005. These numbers are largely consistent with estimates from Jones and Critchfield [16] and DeYoung et al [10] whose research shows a peak in consolidation values around 1998. Adams [1] estimates that between 2000 and 2010, of the largest 30 bank merger and acquisition deals in the United States, 19 were interstate consolidations. The 2007/8 financial crisis triggered another wave of interstate banking mergers and consolidations as many weakened banking institutions entered the voluntary mergers [21].

Interstate banking consolidations have significantly altered the geography of banking in the United States. For example, in 1994, out of 10,328 independent domestic banking institutions (bank holding companies, independent commercial banks and saving institutions), 353 or 3.4% were engaged in interstate banking. Twenty percent of the total deposits and offices in the country was held across state lines (deposits and offices located in host states were owned by out-of-state banking firms). In 2014, banking consolidation had led to a reduction of the number of domestic banking institutions to 6147. There were 692 banking institutions or 11.2% of the total in 2014 which participated in interstate banking, holding 46% of deposits and 41% of bank offices across state lines. Using state centroids to measure interstate distance, the average distance between home and host states in interstate banking was 623 miles in 1994. When using deposits and offices as weights, the weighted interstate banking distance was 676 miles (deposits as weights) or 596 miles (offices as weights). In 2014, the average interstate banking distance rose to 773 miles with the weighted distance at 1100 miles (deposits as weights) or 895 miles (offices as weights). Figure 2 shows the percentage of deposits and offices held across state lines by distance range. In 1994, over half of the deposits and offices involved in interstate banking

 DOI: https://doi.org/10.30564/jgr.v2i3.1375

were held within 500 miles. In 2014, both percentages dropped below 50%. At the same time, percentages of deposits and offices held in longer distances consistently increased in 2014 than in 1994 with the exception of offices held at the 1500 to 2000 miles range.

Maps in Figure 3 confirm significant changes in the geography of interstate banking between 1994 and 2014. Figures 3a and 3b show deposits held in other states as a percent of total deposits of a state in 1994 and 2014, respectively, a measure of a state's outward interstate banking (i.e. owning banking facilities in other states). In contrast, Figures 3c and 3d display deposits held by other states as a percent of total deposits of a state in 1994 and 2014, respectively, a measure of a state's inward interstate banking (that is, deposits owned by other states). Clearly, during the 20 year span from 1994 to 2014, more states had become involved in outward and inward interstate banking, and in general at increasing magnitudes (rising percentages of deposits held in or by other states). A careful examination of the maps shows that inward interstate banking is much more common than outward interstate banking. While most states saw their shares of deposits held by other states increased, only a selective number of states emerged owning significantly higher shares of deposits in other states. These differential patterns motivate this study which aims to ascertain contributing factors of the outward interstate banking and inward interstate banking, respectively.

3. Method

The traditional banking modeling mostly uses the single equation method [4,15,24,27]. Using a single equation model, outward interstate banking and inward interstate banking would have to be estimated in separate regression models. The above maps suggest shortcomings of the single equation approach. For example, Figures 3b and 3d show that in 2014, major outward interstate banking states, such as California, North Caroline, New York, Ohio, Pennsylvania, Georgia, and Alabama had higher percentages of deposits held in other states but lower percentages of deposit held by other states. In contrast, many states with higher percentages deposits held by other states have lower percentages of deposits held in other states. This suggests that outward and inward interstate banking equations are not independent of each other and there may be possible inter-equation correlation. Taking the inter-equation correlation into account may help improve the efficiency of estimation.

In addition, some early patterns in interstate banking persisted to later time. For example, some Western states and states in the Southeast were major inward interstate banking states in 1994 (Figure 3c). In 2014, these states were still among those with higher percentages of inward interstate banking (Figure 3d). The persistence in outward interstate banking is less prominent than in inward interstate banking. Still, one can recognize states such as North Carolina, Ohio, and Minnesota which continued to be major outward interstate banking states from 1994 to 2014. Such temporal persistence suggests possible inter-equation correlation in models where different equations contain models of different years.

In addition to temporal persistence, the prominent position in inward interstate banking of Western states also suggests possible spatial dependence. Indeed, there are reasons to believe certain spatial structure in interstate banking. Historically, Western states tended to have more liberal banking laws compared with the Midwestern states, contributing to higher inward interstate banking in the West than in the Midwest. During the 1980s, there were regional interstate banking compacts where neighboring states agreed to allow each other's banks to enter respective markets [25,33]. In general space seems to act in a powerful way to shape interstate banking. Figures 2a and 2b show significant distance decay, though weakened somewhat from 1994 to 2014, suggesting spatially close states are more likely to enter interstate banking relationships. The distance decay may catch other various spatial factors which influence banking but are not easy to capture explicitly in regressions. These factors include costs, information, and preferences associated with distance in banking. The above discussion highlights the significance of a method which simultaneously account for spatial dependence, outward and inward interstate banking and their interaction, and the temporal effects. This motivates the adoption of the spatial 3SLS as a modeling approach.

Zellner [38] proposes the seemingly unrelated regression or SUR in a multi-equation system to account for contemporaneous covariance in the errors between different equations. Suppose a single cross-section regression in an M equation system as follows

$$y_i = X_i\beta_i + u_i \qquad i = 1,2,...M \tag{1}$$

where $y_i = (y_{i1}, y_{i2}...y_{in})'$ is a n×1 vector containing observations of a dependent variable in equation i; X_i an n×k matrix containing n observations for k independent variables in equation i; $\beta_i=(\beta_{i1},\beta_{i2},...\beta_{ik})'$ a k×1 vector of k regression coefficients in equation i; and $u_i=(u_{i1},u_{i2},...u_{ik})'$ a vector of n errors in equation i. In Zellner's original work, the simultaneous system is estimated by using the (feasible) Generalized Least Square estimator

DOI: https://doi.org/10.30564/jgr.v2i3.1375

$$\hat{\beta}_{GLS}=\left(X'\Omega^{-1}X\right)^{-1}\left(X'\Omega^{-1}y\right)=\left(X'\left(\sum^{-1}\otimes I\right)X\right)^{-1}\left(X'\left(\sum^{-1}\otimes I\right)y\right) \quad (2)$$

in which $\Omega=\Sigma \otimes I$ where Σ is an M×M matrix of variance-covariance of the M equations in the system. I is an N×N identity matrix. The Kronecker product operator $\otimes$ multiplies every element in Σ by I, leading to a $(M\cdot N)\times(M\cdot N)$ variance-covariance matrix Ω for the entire M equation system. The GLS estimator incorporates the inter-equation covariance and thus increases the estimation efficiency, with the efficiency gains rising with increasing inter-equation covariance [12].

In standard SUR, each equation by itself is a classical regression. Thus each equation's variance-covariance matrix is $\sigma_{ii}I$ with 0 in the off principal diagonal. When spatial effects exist, the following relationships replace equation (1) in an M equation system

$$y_i=\rho_i W y_i+X_i\beta_i+u_i$$

$$u_i=\lambda_i W u_i+\varepsilon_i \quad (3)$$

where W is a weight matrix that defines the spatial autocorrelation structure; $\square_i$ the spatial autoregressive parameter for the spatial lag variable in equation I; λ_i the autoregressive parameter for spatial error; and ε_i a spherical error term. Other terms are defined as before. Lee [22] shows that the variance-covariance of any single equation *i* is $\sum_i=\sigma_{ii}(I-\lambda_i W)^{-1}(I-\lambda_i W')^{-1}$ The off principal diagonal elements are not necessarily zero and errors are spatially correlated. In addition, the endogenous explanatory variable Wy_i and error terms are correlated [20]. All these make Zellner's OLS-based estimator biased and inconsistent [2].

Kelejian et al. [20] and Anselin et al. [3] show a spatial Cochrane-Orcutt transformation, which uses filtered variables to remove the spatial dependence from the error term in (3). That is,

$$(I-\lambda_i W)y_i=(I-\lambda_i W)Z_i\delta_i+(I-\lambda_i W)u_i \quad (4)$$

where $Z_i=[X_i, Wy_i]$ and $\delta_i=[\beta_i',\rho_i]'$

Define filtered variables $y_{si}=(I-\lambda_i W)y_i$ and $Z_{si}=(I-\lambda_i W)Z_i\delta_i$ (5)

Thus (4) becomes $y_{si}=Z_{si}\delta_i+\varepsilon_i$ (6)

In both (4) and (6), the endogenous variable Wy_i is correlated with the error term [22]. As a result, 2-stage least squares (2SLS) is needed in estimation in which instrumental variables are used to generate residuals uncorrelated with the endogenous variable [36].

In the spatial regression system, parameters to be estimated include λ_i, ρ_i and β_i. Operationally, this can be done in three steps [3,20]. In the first step, a 2SLS is applied to estimate (3). Instrumental variables H=[X, WX] are used to instrument Wy_i (first stage) and then use the resultant $H(H'H)^{-1}H'Z$ to instrument y_i (second stage) to obtain initial estimates of ρ_i and β_i [22]. In the second step, residuals from the first step are used to estimate λ_i and the variance of the errors, by solving a three moment-equation system from the moment conditions, or the General Method of Moments (GMM) suggested by Kelejian and Prucha [19]. Anselin [3] gives a detailed description of implementation of the GMM. In the third step, λ_i from the second step is used to create filtered variables as in (5) and the Feasible Generalized Least Squares estimator is applied to (6) in a spatial SUR to obtain revised ρ_i and β_i. The Feasible Generalized Least Squares estimator is

$$\hat{\beta}_{FGLS}=(Z_s'\hat{\Omega^{-1}}Z_s)^{-1}(Z_s'\hat{\Omega^{-1}}y_s)=(Z_s'(\hat{\Sigma^{-1}}\otimes I)Z_s)^{-1}(Z_s'(\hat{\Sigma^{-1}}\otimes I)y_s) \quad (7)$$

where Z_s and y_s are filtered variables, $\hat{\Omega}=\hat{\Sigma}\otimes I$, and $\hat{\Sigma}$ is the estimate of Σ from the sample. The last step is essentially a 3-Stage Least Squares (3SLS) [2,14] in which a 2SLS is first performed on each single equation as in (6) of the equation system. The instrumental variables can still be those used in the first step as discussed above. However, Lee [22] suggests the use of the filtered instrumental variables, which is adopted in this study. Residuals from the 2SLS are then used to estimate between-equation correlations to obtain $\hat{\Sigma}$. Finally, estimator (7) is used to estimate the system of equations.

4. The Estimating Model, Variables and Data

In actual estimation, the method discussed above is applied to a panel data set. Equation (3) is adopted for all 50 states in the United States plus the District of Columbia. These are home and host states in the interstate banking networks. In addition, these are regulatory units regulating branch banking and multi-location bank holding historically, and to a certain degree, regulating interstate banking today (see below). For each state plus DC, outward and inward interstate banking equations are specified for both 1994 and 2014. Thus the following four estimating equations are included in the spatial 3SLS system.

$$y_{out1994}=\rho_{out\ 1994}Wy_{out\ 1994}+X_{out\ 1994}\beta_{out\ 1994}+(I-\lambda_{out\ 1994}W)^{-1}\varepsilon_{out\ 1994}$$

$$y_{out\ 2014}=\rho_{out\ 2014}Wy_{out\ 2014}+X_{out\ 2014}\beta_{out\ 2014}+(I-\lambda_{out\ 2014}W)^{-1}\varepsilon_{out\ 2014}$$

$$y_{in\ 1994}=\rho_{in\ 1994}W_{yin\ 1994}+X_{in\ 1994}\beta_{in\ 1994}+(I-\lambda_{in\ 1994}W)^{-1}\varepsilon_{in\ 1994}$$

$$y_{in\ 2014}=\rho_{in\ 2014}Wy_{in\ 2014}+X_{in\ 2014}\beta_{in\ 2014}+(I-\lambda_{in\ 2014}W)^{-1}\varepsilon_{in\ 2014} \quad (8)$$

y_{out} is a 51×1 matrix of dependent variable, outward interstate banking, defined separately for 1994 and 2014.

DOI: https://doi.org/10.30564/jgr.v2i3.1375

Similarly y_{in} is a 51×1 matrix of dependent variable, inward interstate banking, defined separately for 1994 and 2014. X is a 51×k matrix of independent variables. In operation, for each year, the same k independent variable are entered for both y_{out} and y_{in} regressions. However, each equation may end up having a different or overlapping combination of statistically significant variables from the k independent variables entered. I is a 51×51 identity matrix. W is the weights matrix that defines the pattern of spatial dependence. The Queen contiguity specification is adopted for the weights in this study. ε are errors of each equation. Parameters to be estimated are ρ, λ, and βs for each equations. It should be noted that due to the use of the Queen contiguity weights, Alaska and Hawaii are actually dropped out of the simultaneous system since these two states are not physically adjacent to any other states. They would be retained within the system with the use of alternative weights matrixes (such as distance-based or socioeconomic relationship-based matrices).

4.1 Dependent Variables

Table 1 contains brief definitions of dependent variables, democratic and socioeconomic intendent variables, banking intendent variables and banking legislative independent variables. Outbanking, or outward interstate banking, is defined as the deposits owned by a state (home state) but located in other states (host states) divided by the total deposits of the home state and measured as a percentage. Inbanking or inward interstate banking is the deposits located within a state (host state) but owned by other states (home states) divided by the total deposits of the host state, measured as a percentage. Outbanking and Inbanking measure the extent to which a state engages in outward and inward interstate banking, respectively.

4.2 Demographic/Socioeconomic Independent Variables

Demographic and socioeconomic variables are included to capture possible impacts from income, market size, and economic structure which essentially translate to demands for banking [6,13,28]. The percent of urban population (UrbanPop) and per capita income (PCI) measure states' general economic wellbeing and development. The total state employment or Employees is a proxy of the market size of a state, avoiding using the same aggregates (population, total deposits, total income, etc.) that are used in creating other variables. Location quotients are calculated using employment data to characterize states' economic structures. The location quotient is the ratio of a state's percent of employment in an industry to the percent of the U.S. employment in that industry. A high location quotient above 1 means a strong specialization in that industry, and a small value below 1 means a lack of specialization. The location quotients used in the study include primary (LQPrimay), service (LQService), manufacturing (LQMFG), FIRE (LQFIRE), and government (LQGov) sectors. Due to changes in industrial classification in 1997, location quotients for 1998 were calculated as a proxy of the economic structure of 1994. PopChange, or the average annual population change rate in a 10 year interval, is designed to reflect the changing market size (More in Subsection 4.3 on how the 10 year interval is determined).

4.3 Banking Independent Variables

FirmSize is the average size of a state's banking firms involved in interstate banking, calculated as the total deposits of these firms divided by the number of these firms. PCO or the average number of bank offices per 1000 people in a state measures the banking service availability, though online banking may have made such a measure less relevant. It turns out that PCO is not statistically significant in any of the four equations in the system. The Herfindahl-Hirschman Index or HHI measures the level of concentration of a state's banking industry. The HHI is the sum of the squared deposit market shares of banking firms in a state and ranges between close to 0 and 10000. Higher HHI values indicate higher levels of concentration which is associated with less competitive markets. ROEChange is used to capture the profitability of a state's banking industry. It is the average rate of return on equity for a state's banking industry in a 10 year interval. KalaChange is the average capital-to-labor ratio for a 10 year interval for a state's banking industry. The capital-to-labor ratio is the ratio of bank expenses on premises/physical capital to expenses on labor. LaborChange is the average percent of expenses on labor in the total non-interest expenses for a state's banking industry, calculated for a 10 year interval. Together, KalaChange and LaborChange may help capture the use of technology in banking as reflected in capital expenses. Since the two anchor years of the study are 1994 and 2014, the 10 year interval is taken as the 10 years prior to the two anchor years. That is, from 1984 to 1994, and 2004 to 2014 respectively.

4.4 Banking Legislative Independent Variables

Bklaw is a composite index adding up scores assigned to state banking laws concerning geographical restrictions on banking. Two sets of banking laws are used, intra-state branch banking and interstate banking. Within each law category, the 1985 statute and the 1992 statute are used to

DOI: https://doi.org/10.30564/jgr.v2i3.1375

reflect the changing state banking laws from the 1980s up to the eve of the IBBEA in 1994. In terms of intra-state branching, various state laws permit statewide (3 points assigned), limited (2 points), or no branching (1 point). In terms of interstate banking, various state laws allow nationwide (4 points assigned), nationwide reciprocal (3 points), regionwide reciprocal (3 points), regionwide reciprocal when the state law takes effect (2 points), or no interstate banking (1 point). A few states had no interstate banking law in 1985 and/or 1992. They are assigned 1.5 points since they did not explicitly permit or prohibit it. The assigned value rises with increasing permissibility in the respective law. Each state's score in Bklaw is the sum of assigned values in both intra-state branch banking and interstate banking laws/regulations.

While Bklaw reflects the state banking laws prior to the nationwide interstate banking, Stbklaw is a composite measure designed by Johnson and Rice [15] to index limitations to interstate banking by states since the nationwide interstate banking in 1994. The IBBEA expressly allows states to restrict the manner by which the out-of-state banking firms enter a host state market in four ways. Host states can set the minimum age of the target institution in acquisition by out-of-state banking firms up to five years; host states can decide whether establishment of de novo branches is permitted by out-of-state banking firms; host states can decide whether out-of-state banking firms can acquire an existing office of a bank, instead of acquiring the entire bank; and host states can establish a deposit cap to restrict the size of an out-of-state banking firm under a certain percentage of the total deposits in a state, such as no more than 30% [15]. For each limitation, Johnson and Rice give one point if a certain limitation is applied or 0 otherwise. That is, one point is assigned for each of the following limitations: a minimum of 3 years or more is required for the interstate acquisition target institution; a de novo branching is not permitted; acquisition of a branch is not permitted; and a deposit cap less than 30% is imposed [15,31]. Stbklaw ranges from 0 to 4 with higher values indicating more restrictions on interstate banking.

Following Zhou and Kockelman [39], all explanatory variables are entered four equations individually. A stepwise regression procedure is applied to retain statistically significant variables. These variables are used in the three steps in the estimation process, as discussed in Section 3.

Income, population, and employment data are obtained from the U.S. Department of Commerce Bureau of Economic Analysis Internet sites. Urban population is from the Bureau of Census. All banking data are from the Federal Deposits Insurance Corporation Internet sites. The banking institutions include bank holding companies and independent banking institutions including commercial banks, state banks, saving banks, and saving and loans institutions which receive the depositary insurance from the FDIC. Thus it has the widest possible coverage of banking institutions in the United States.

5. Results

In estimating the four equation system, linear restrictions are applied to ρ and λ to restrict their values to be 0. The result is compared with the unrestricted model in order to test the statistical significance of spatial effects. The following F test is used following Greene [12] and Henningsen and Hamann [14].

$$F = \frac{\left(ESS^{*} - ESS\right)/j}{ESS/\left(M \times N - k\right)} \tag{9}$$

where ESS* and ESS are sums of squares of residuals for restricted and unrestricted models respectively; j is the number of linear restrictions, k the number of explanatory variables, N the number of observations in each equation, and M the number of equations. The F test has j and M×N-k degrees of freedom respectively. The resultant F value is 3.6 and the null hypothesis is rejected at the 0.01 level. Thus the spatial effects are present in the interstate banking system as a whole.

Table 2 provides between-question contemporaneous correlations. They show that in 2014, there was only slight contemporaneous correlation in residuals (-0.07) between Outbanking and Inbanking. However, this was not the case in 1994 when the contemporaneous correlation in residuals between Outbanking and Inbanking was much stronger at 0.22. In terms of temporal correlation, residuals in Outbanking during the earlier period informed later period (0.19) more than in Inbanking (-0.11). Incorporating these correlations in estimation has moderately significant impacts on the results. Of the 46 parameter estimates, twelve or 25% experience a change in the magnitude at or above 10% after incorporating the between-equation contemporaneous correlations.

Table 3 provides the final estimation result of the four-equation system. Since the expected signs for all parameters are either positive or negative for the alternative hypothesis, the table gives one-tailed p-values. The discussion below will focus on the roles of spatial variables, demographic/socioeconomic variables, banking variables, and banking legislative variables.

5.1 Spatial Lags and Spatial Errors

The spatial lag is statistically significant with a positive sign

 DOI: https://doi.org/10.30564/jgr.v2i3.1375

in the Inbanking equations of both years. This indicates a positive spatial autocorrelation in inward interstate banking where a state's position in inward interstate banking is positively associated with their neighboring states. In other words, states with similar levels of Inbanking tended to cluster, as seen in Figures 3c and 3d where the West in 1994 and the West and Southwest in 2014 had many higher inward interstate states, and the central portion of the country had many moderate inward interstate banking states in both years. The positive spatial autocorrelation is closely related to the distance decay as shown in Figures 2a and 2b. In banking, the need to obtain information, control costs, and understand markets still generally favor closer locations [8]. Another contributing factor may be the lingering effects of the regional patterns of geographical restrictions on banking (e.g. the restrictive Midwest vs. the permissive West) and the regional banking compacts. Indeed, analyzing the destinations of interstate banking acquisitions between 1988 and 1993, McLaughlin [23] finds that most expansions occurred in neighboring states, rather than non-contiguous states. On the other hand, the spatial lag is not statistically significant for the Outbanking equations of both years. In Figures 3a and 3b, states with higher Outbanking did not demonstrate clear concentration. This indicates that whether states rose as significant outward interstate banking players is not necessarily associated with their neighboring states' outward interstate banking status. It is likely that the actions and business strategies of banking firms (especially the large banking firms as discussed in Sub-section 5.3) within the states play significant roles. The spatial effects in the error term reflect factors which are not explicitly incorporated as explanatory variables in the model. Though magnitude varies, all equations show a negative impacts between neighboring states.

5.2 Demographic/Socioeconomic Variables

UrbanPop is significant for the 2014 Outbanking equation with a negative sign, indicating active outward interstate banking states are not confined to those with the highest percent of urban population. Indeed, in 2014, of the states with the highest Outbanking scores, only New York and California were among the top 10 states with the highest UrbanPop. Regional interstate banking center powerhouses such as Pennsylvania, Ohio, Alabama, Minnesota, Georgia, and Virginia ranked 14, 18, 26, 27, 28, and 30 in terms of UrbanPop. North Carolina, one of the three national outward interstate banking states, along with New York and California, ranked 29 in UrbanPop. While the last 20 years have seen significant banking consolidation, the U.S. banking industry as whole is still less concentrated than many other advanced economies. As stated early, by 2014 there were still over 6,000 independent banking institutions with nearly 700 of them engaged in interstate banking. Interstate banking activities from a vast number of banking institutions allowed strong outward interstate banking states to emerge in their respective regional contexts even though these states did not reach the highest level of urbanization at the national level. For example, as strong regional outward interstate banking states, Alabama and Minnesota ranked 26 and 27 respectively in UrbanPop nationwide but ranked 1 in their respective East South Central Region and North West Central Region. The correlation coefficient between Outbanking and the percentage of deposits held by top 20 outward interstate banking states as host states' deposit total is -0.24% (p-value = 0.04). At the same time, the correlation coefficient between Outbanking and the percentage of deposits held by home state banks as the state deposit total is 0.35% (p-value = 0.006). These relationships seem to suggest that while major outward interstate banking states tended to hold more of deposits in their own states, they tended to hold less deposits in other major interstate banking states. In other words, major interstate banking firms appear to be avoiding competition against each other on their own home turf. This finding is consistent with studies which suggest that due to the common ultimate ownership by fund managers and cross-ownerships (banks hold each other's stocks), there is little competition among some of the largest banks [5,34]. In the context of interstate banking, the net effect is that major regional outward banking states are shielded from an out-right onslaught by the largest banking centers in the country.

Employees, as a measure of market size, was significant in 1994 Outbanking with a negative sign suggesting that smaller states may actually be active centers of outward interstate banking. This may be due to the fact that in 1994, there had not been states with nationwide interstate banking connections (California banking firms operated in 25 other states, compared with 43 in 2014, the highest of all states in both years). Active outward interstate banking states include large states (e.g. California, Ohio, and North Carolina) as well as many smaller states (e.g. Rhode Island, North Dakota, Idaho, Connecticut, Oregon, Utah and Nebraska). The uneven state banking legislation by the early 1990s had allowed some small states to rise to prominence in outward regional interstate banking. However, by 2014, the prominence of the smaller states in Outbanking all but disappeared. Employees has a positive sign for the sample 2014 Outbanking equation, though it is not statistically significant at the 0.05 level.

While Employees measures the market size per se, PopChange, or the average population growth rate in a 10

DOI: https://doi.org/10.30564/jgr.v2i3.1375

year interval, measures the change in the market size. The variable is significant for Inbanking equations with a positive sign in both 1994 and 2014, indicating that the rapidly growing markets were more likely to be the target of inward interstate activities. This result is in line with Gunther [13] who finds rising population leads to banking expansion.

Location quotients for manufacturing, FIRE, and government sectors are significant for Outbanking 2014 with a positive sign, indicating states with healthy economic structures tended to be actively engaged in outward interstate banking. In the 2014 Inbanking equation, location quotients for primary, manufacturing and FIRE sectors are significant with a positive sign, and location quotient for service is significant with a negative sign. The significant Primary sector may reflect the role of booming commodities sectors, especially in energy, in recent years. In addition, PCI is significant with a negative sign. Taken together, this seems to suggest that states with lower income but strong primary, manufacturing, and FIRE, and weak traditional service sector, tended to received much inward interstate banking. These results point to the role of broader economy in interstate banking: a strong state economy may bolster banking firms with an expansion ambition across state lines while states with healthy economic structures but lower income levels may attract inward interstate banking. Interestingly, location quotients for service and government sectors are significant for 1994 Inbanking with a positive sign. This still supports the notion that a strong economy may make a state an attractive interstate banking target. However, while the service sector may be part of what constituted a healthy economy in 1994, by 2014, its role is reversed.

The above findings are in general consistent with Morgan et al [26] regarding the state economy and the banking industry. While a healthy state economy supports a strong banking industry, a collapsing state economy tends to cause widespread bank failures [26]. Morgan et al find that under interstate banking, the collateral shocks are stronger than capital shocks. That is, while an interstate banking firm can supply bank capital for profitable lending from its home state to a host state, poor quality collaterals in the host state will cause the withdraw of bank capital [26]. This should necessarily impel the out-of-state banking firms to enter states with healthy economic structure since this help find quality lending customers with solid collateral assets.

5.3 Banking Variables

FirmSize is significant in all equations with a positive sign for Outbanking and negatives sign for Inbanking. Clearly, larger firm sizes contribute to dominant position in outward interstate banking while smaller firm sizes is a significant factor in states' role in inward interstate banking. This result is in line with Phillis and Pavel [28]. Here lies a paradox in the early days of interstate banking. As discussed in 5.2, many of the active outward interstate banking states in 1994 were small states. However, quite a few large and active interstate banking institution actually originated from these small states such as Riggs National Corporation in Washington D.C., First National of Nebraska Inc. in Nebraska, Shawmut National Corporation in Connecticut, U.S. Bancorp in Oregon, Zions Bancorporation in Utah, West One Bancorp in Idaho, Community First Bankshares Inc. in North Dakota, First Interstate BancSystem of Montana Inc. in Montana, Fleet Financial Group Inc. in Rhode Island, etc. Uneven banking legislation in early days allowed large banking firms to emerge and expand at the regional level, both from large and small states.

HHI is significant for 2014 Inbanking equation with a positive sign, suggesting a more concentrated banking industry as a factor in active inward interstate banking. This is generally consistent with the view that the active banking consolidation leads to higher concentration at the state level [29,37]. This evidence by itself does not suggest rising local market concentration. Early study of the local market concentration shows mixed results as a consequence of interstate banking [30,35]. However, more studies are sorely needed to assess the competitiveness effect using more recent data.

ROEChange or the average of rates of return on equity of the banking industry in a 10 year interval is significant with a negative sign in the 2014 Inbanking equation, suggesting that a lower profitability is a reason for a state becoming an interstate banking destination. This is consistent with Kowalik et al [21] who identify lower profitability as a characteristic of targets in banking merger and acquisition. Lower profitability normally leads to depressed asset values which necessarily attract out-of-state banking firms to enter a bank market [11].

Another telling sign is KalaChange or the average capital-to-labor ratio of the state's banking industry in a 10 year interval. KalaChange is significant in the 2014 banking equations but with a positive sign for Outbanking and negative sign in Inbanking. This suggests that the banking industry in outward interstate banking states tended to have a higher capital-to-labor ratio, while it was the opposite in inward interstate banking states. This may be the result of the larger banking firms in outward interstate banking and smaller firms in inward interstate banking. Since more capital use may embody better technologies, this means that outward interstate banking firms tended to use more new technologies while the inward interstate

 DOI: https://doi.org/10.30564/jgr.v2i3.1375

banking states use less. This is in line with Jones and Critchfield [16] and Berger et al [7] that banking consolidation is in part a response to the use of new technologies in banking and larger banking institutions tend to use new banking technologies. This pattern is in part confirmed by LaborChange, the average of the percent labor expenses in total non-interest expenses in a 10 year interval, which is significant in the 2014 Inbanking equation with a positive sign. For the 1994 Inbanking equation, LaborChange has a negative sign but is only marginally significant.

5.4 Banking Legislative Variables

Stbklaw, the composite index measuring the states' restrictions on interstate banking since 1994, is significant in the 2014 Outbanking equation with a negative sign, meaning that states with less restrictive interstate banking regulations/laws since 1994 tended to actively establish interstate banking connections in other states. This finding is consistent with Johnson and Rice [15]. Although Stbklaw also has a negative sign in the 2014 Inbanking equation, it is not statistically significant.

Interestingly, the effects of banking legislation during the 1980s seem to linger in the past 20 years. Bklaw is significant in three of the four equations. In the Inbanking equations, it is significant with a positive sign for both 1994 and 2014, indicating, unsurprisingly, the positive impacts of states' permissive banking legislation on inward interstate banking in 1994, and, surprisingly, their lingering positive impacts on inward interstate banking 20 years later. Both the regional banking compacts and the regional banking legislation, along with distance decay effect, aided the significant and positive spatial lag in the Inbanking equations.

For the Outbanking in 2014, Bklaw is significant with a negative sign, indicating many states with restrictive banking legislation during the 1980s emerged as the players in outward interstate banking in 2014. This result is also in line with Johnson and Rice [15] who find banking firms from states with restrictive intra-state banking laws tended to expand in other states. Indeed, of the 15 states with the highest Outbanking roles, only 2, California and New York, have a Bklaw score in the top 10. The major regional Outbanking states in 2014 such as Ohio, Virginia, Pennsylvania, Georgia, Alabama, and Minnesota, ranked 24, 29, 30, 36, 40, and 45 respectively in Bklaw scores. These states tended to have similar Bklaw scores as their neighboring states but managed to emerge as major Outbanking states. This provides support to an early argument in Subsection 5.1 that business strategies of banking firms within the states, rather than the banking legislation, played a significant role in states emerging as major outward interstate activity. However, this effect was not clear in 1994 since Bklaw is not statistically significant for 1994 Outbanking equation. This may happen due to the fact that there were not many states which had a strong positions in Outbanking in 1994.

5.5 Interstate Banking and Macroeconomic Conditions

While the discussion so far is focused on particular variables or factors, the role of some of these factors in interstate banking cannot be detached from general macroeconomic conditions. The 1990s witnessed the highest growth period in the U.S. economy since the 1970s. The decade saw an average annual real GDP growth rate 3.4%, compared with 3.2% in the 1980s and 1.8% in the first decade of 2000s (lines in Figure 1). The economy was basked in rising information and globalizing economy [16]. There was much optimism in the U.S. economy. The 1990s also saw the first wave of interstate banking (Figure 1). The desire for interstate banking had been building in many major banking firms and the pent-up demands were released as the IBBEA became law [23]. Under the circumstance, ambitious banking firms took interstate banking as a new venue to discover new markets and opportunities. Thus interstate banking acquisitions normally were accomplished by paying premiums to the acquisition targets [16] As a result, interstate banking targets are not solely guided by profitability, which may explain the statistical insignificance of profitability in the 1994 equation.

The economy around 2014 was much different. The GDP growth rates were down. The U.S. economy grew 4.4% in 1994 but only 3% in 2014. The average annual real GDP growth from 1984 to 1994 was 3.5% while that from 2004 to 2014 was 1.9%. Many state banking industries suffered losses during the 2007/2008 financial crisis, which contributed to lower banking profitability. Under such circumstances, it is understandable that in 2014 outward interstate banking states are those with higher profitability while inward interstate banking states are those with lower income levels and lower banking profitability. This assessment is in general agreement with Kowalik et al [21] who, while analyzing bank mergers between 2011 and 2014, characterize merger targets as those small firms with lower profitability and lower efficiency. In addition, banking technologies in the 1990s were likely to be more uniform between larger and smaller banks they are today. This may explain why profitability and capital-to-labor ratio were not out statistically significant in the 1994 equations, but significant in the 2014 equations.

6. Summary and Conclusions

DOI: https://doi.org/10.30564/jgr.v2i3.1375

This study uses a spatial 3-stage least squares model to estimate the interstate banking in 1994 and 2014. The method takes into account simultaneously spatial dependence, outward and inward interstate banking and their interaction, and the temporal effects in interstate banking. The estimation system contains four equations with outward and inward interstate banking for 1994 and 2014 for the 50 states plus the District of Columbia. The results indicate a more efficient estimation than without taking these effects into account. These reflect in a statistically significant F test on the spatial effects, moderate inter-equation contemporaneous correlations, which results in a quarter of the parameters estimates to change values by more than 10%.

The study shows that interstate banking is driven by multiple factors. A healthy economic structure, an expanding market, and permissive banking legislation seem to encourage inward interstate banking. At the same time, a healthy economic structure is also a basis for strong banking firms to rise and to expand in other states. Large banking institutions were clearly dominate in outward interstate banking while smaller firm sizes tend to be associated with inward interstate banking. By 2014, states with active inward interstate banking had not only smaller interstate banking institutions, but also lower capital-to-labor ratios and higher labor resource use in the entire state banking industry. In addition, possibly for macroeconomic reasons, these states also tended to have lower income levels and possibly resultant lower banking profitability. At the same time, large and well-capitalized banking firms from states with a healthy economic structure had expanded into these states to operate bank branches and hold deposits. While these findings somewhat confirm the public impression of banking restructuring which favors the large and strong and disadvantages the small and weak, they do reveal making profits and improving efficiency through better technology as part of the underlying forces of spatial banking consolidation.

The study also shows evidence of continuous banking fragmentation. In 1994, interstate banking was clearly scattered in that a number of smaller states with large interstate banking firms began to emerge as important players in outward interstate banking. By 2014, while the nation had experienced significant banking consolidation, some active outward interstate banking states were from regions with lower levels of urbanization. Powerful banking firms from states with the highest urban development had not completely dominated over the nation's banking landscape. The study also demonstrates that the spatial effects of past banking legislation can linger for many years. This indicates the significant role of public policy on consumer welfare and points to the need for future banking regulation to carefully weigh conforming to the needs of business against the public interest. In this context, the research finds evidence of rising market concentration in inward interstate banking states and that major interstate banking firms are competing less against each other in their own home states. These findings necessarily raise the issue of competitiveness in banking markets as a result of interstate banking. Clearly, further study should be done at the local market level and necessary policy should be designed to insure that the bank service quality and prices do not come at the expense of consumers.

Appendixes

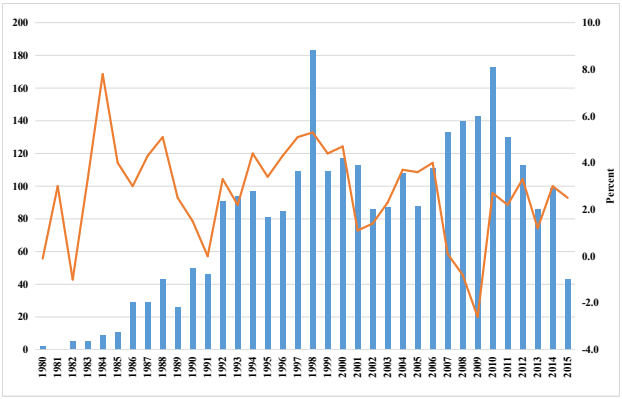

Figure 1. Annual numbers of interstate mergers and acquisitions (bars) and real GDP growth rates (curve)

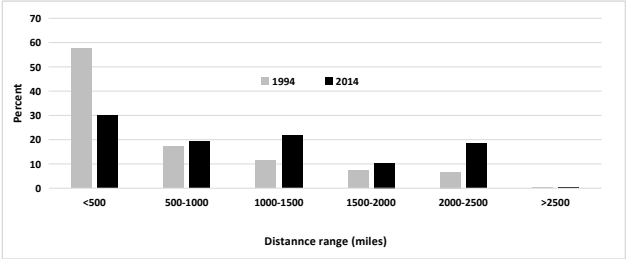

Figure 2a. Percentages of deposits held across state lines by distance range

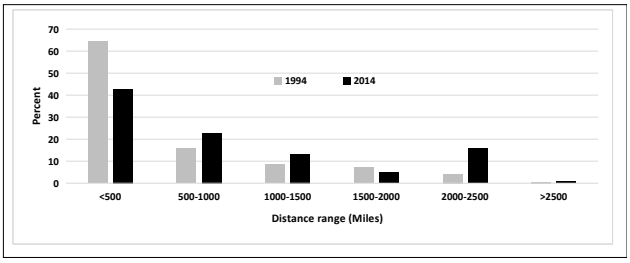

Figure 2b. Percentages of bank offices held across state lines by distance range

Figure 2. Percentages of deposits and offices held across state lines by distance range

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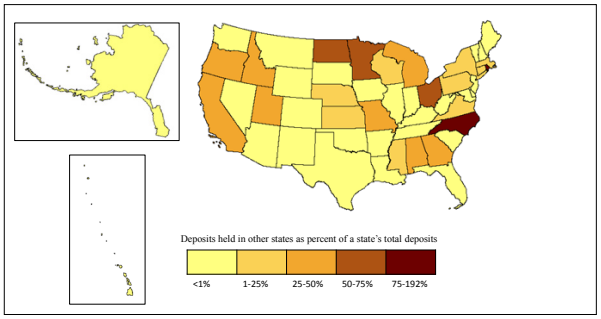

Figure 3a. Deposits held in other states as percent of a state's total deposits, 1994

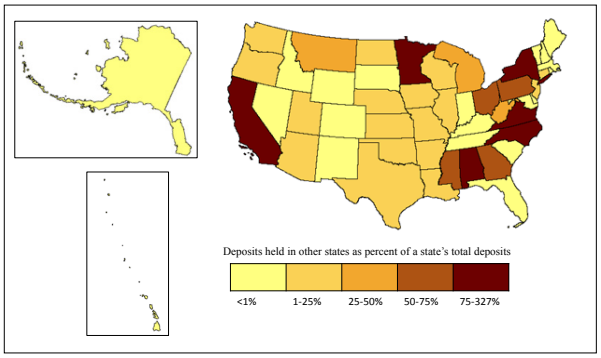

Figure 3b. Deposits held in other states as percent of a state's total deposits, 2014

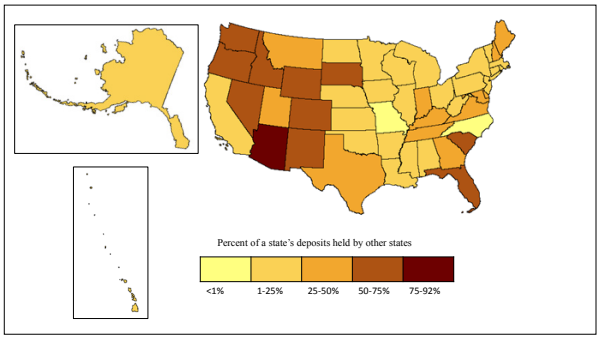

Figure 3c. Percent of a state's deposits held by other states, 1994

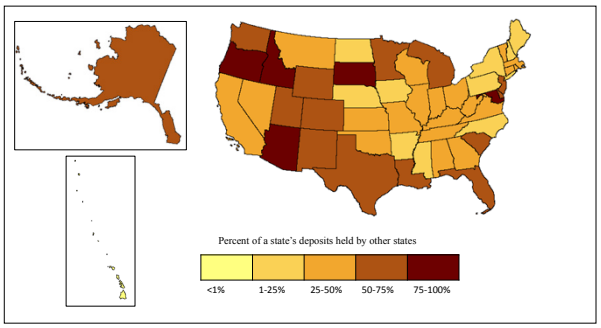

Figure 3d. Percent of a state's deposits held by other states, 2014

Figure 3. Percent of deposits in interstate banking

Table 1. Definitions and Descriptions of Variables used in Estimation

Variable	Definition and description
Dependent	
Outbanking	Outgoing interstate banking; deposits owned by a home state but located in host states as percent of the home state's total deposits
Inbanking	Incoming interstate banking; deposits owned by home states but located in a host state as percent of the host state's total deposits
Demographic and socioeconomic independent	
UrbanPop	Urban population as percent of a state's total population; both years
Employees	Total employments in a state; both years
PCI	Per capita income; both years
LQPrimary	Location quotient for primary sector; both years but use 1998 data for 1994
LQService	Location quotient for service sector; both years but use 1998 data for 1994
LQMFG	Location quotient for manufacturing; both years but use 1998 data for 1994
LQFIRE	Location quotient for FIRE sector; both years but use 1998 data for 1994
LQGov	Location quotient for government sector; both years but use 1998 data for 1994
PopChange	Average annual population change rate during a 10 year interval; 1984 to 1994 for 1994, 2004 to 2014 for 2014
Banking independent	
FirmSize	Average size of a state's banking firms with interstate activities; both years
PCO	Number of bank offices per 1000 population in a state; both years
HHI	The Herfindahl-Hirschman Index; sum of squared deposit shares from all banking firms in a state; both years
ROEChange	Average rate of return to equity of a state's banking industry during a 10 year interval; 1984 to 1994 for 1994, 2004 to 2014 for 2014
KalaChange	Average capital to labor rate of a state's banking industry during a 10 year interval; 1984 to 1994 for 1994, 2004 to 2014 for 2014
LaborChange	Average percent of labor expenses in total non-interest expenses of a state's banking industry during a 10 year interval; 1984 to 1994 for 1994, 2004 to 2014 for 2014
Banking legislative intendent	
Bklaw	A composite index for state banking laws incorporating both intra-state branching and interstate banking laws; same for both years
Stbklaw	A composite index for state interstate banking laws since 1994 reflecting specific restrictions on interstate banking

Table 2. Between-equation contemporaneous correlations

	Outbanking2014	Inbanking2014	Outbanking1994	Inbanking1994
Outbanking2014	1.0000	-0.0742	0.1901	0.0816
Inbanking2014			-0.0719	-0.1065
Outbanking1994				-0.2231

DOI: https://doi.org/10.30564/jgr.v2i3.1375

Table 3. Estimates of parameters and one-tailed p-values (in parentheses)

	Models			
	Outbanking14	**Inbanking14**	**Outbanking94**	**Inbanking94**
Intercept	-11.0755 (0.3815)	44.0140 (0.2127)	73.5375 (0.0089)	-141.159 (0.0016)
UrbanPop	-0.63 (0.0028)		0.42 (0.055)	0.1709 (0.0817)
Employees	0.0002 (0.0577)		-0.001 (0.0001)	
PCI	-0.0003 (0.2518)	-0.0014 (0.0051)	-0.0024 (0.0534)	
LQPrimary		6.1440 (0.0026)		2.1586 (0.1024)
LQService		-96.1698 (0.006)		56.5662 (0.021)
LQMFG	14.0457 (0.0135)	12.0323 (0.0317		6.5600 (0.1267)
LQFIRE	51.8126 (0.0091)	92.1394 (0.0007)		
LQGov	31.4387 (0.0052)			33.9293 (0.0002)
PopChange	-6.8038 (0.0703)	8.0493 (0.035)		6.496 (0.0006)
FirmSize	0.0001 (0.0000)	-0.0001 (0.0001)	0.0001 (0.0000)	-0.0001 (0.0217)
PCO				
HHI		0.0109 (0.00015)		
ROEChange		-239.4 (0.0104)		
KalaChange	77.1646 (0.0005)	-91.3939 (0.0031)		
LaborChange		81.8808 (0.012)		-45.0713 (0.0458)
Bklaw	-4.1412 (0.0017)	3.221 (0.011)	-3.1541 (0.0569)	2.7596 (0.0083)
Stbklaw	-3.397 (0.0369)	-2.4369 (0.0932)		
ρ	0.1237 (0.0505)	0.3525 (0.0174)	-0.0352 (0.4442)	0.3520 (0.0121)
λ	-0.1847	-0.1553	-0.0583	-0.2991
Weighted R^2	0.82			

Note: Parameters used in estimation are selected through a stepwise process. Only selected variables are presented in the table.

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