



Original Article

# Geotechnology and the Decline of Geographical Determinism: Revisiting Heartland–Rimland Theories

Rakesh Kumar

Asst. Professor, Dept. of Geography, Murarka College, Sultanganj, TMBU, Bhagalpur

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Correspondence Address:

Rakesh Kumar  
Asst. Professor, Dept. of Geography,  
Murarka College, Sultanganj, TMBU,  
Bhagalpur  
Email: [rkrakrak05@gmail.com](mailto:rkrakrak05@gmail.com)



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**Abstract**

*Geopolitical models that are based on traditional theories of geopolitics, for example Halford Mackinder's theory of the heartland or Nicholas Spykman's theory of the rimland (classical geopolitical models), traditionally have focused on the importance of control of both land and sea in determining political and economic power. These reviews examine if and to what extent geotechnology is capable of eroding or reducing the applicability of these models; specifically, because geotechnology can transcend territorial boundaries of a nation-state. Literature from various disciplines will be used to evaluate how the emergence of the cyber domain, satellite constellations, and algorithmic warfare are reshaping geopolitics and thus may reduce the significance of traditional Heartland interiors and Rimland coasts. While there is some evidence of an erosion of determinism, the analysis also finds that many of these classical frameworks remain relevant today but now in new hybrid forms of geopolitical thinking. Some of the critiques of this research include: 1) a tendency to overly rely on technological determinism when analyzing the influence of geotechnology on geopolitical issues; 2) incorporating elements of geotechnology into evolving geopolitical models; and 3) a general finding that this represents a transition toward "networked geopolitics" — a hybrid model that combines aspects of both traditional territorial and virtual/ networked dimensions of competition in a multipolar world.*

**Keywords:** Geotechnology, Geographical Determinism, Heartland Theory, Rimland Theory, Halford Mackinder, Nicholas Spykman, Artificial Intelligence, Cyber Domains

**Introduction**

Geopolitical geographical determinism is the theory that geographic features such as mountains, rivers, oceans etc, determine how powerful states are and how they relate to one another (Fettweis, 2000). Mackinder's Heartland Theory (1904), and Spykman's Rimland Theory (1944) demonstrate this in regards to the relationship between Eurasian territory interiors and coastlines to control the world. The growth of Geotechnology, which includes digital infrastructure, space-based systems and artificial intelligence (AI), undermines territorial paradigms by allowing countries to exert influence regardless of physical geography constraints (Colther et al., 2025).

Cyber-attacks, satellite surveillance and logistical optimization through AI have raised questions about whether these technologies weaken traditional paradigms or strengthen them in new ways.

The purpose of this literature review is to synthesize current and past research and examine geotechnology's role in determining geopolitical relationships, concluding with the argument that there has been a gradual shift in determinism from a strictly deterministic model to a more nuanced form of determination. Through revisiting the classic Heartland-Rimland paradigm, the authors will provide insight into the concept of hybrid geopolitics within a digitally-based world.

**Overview of Heartland and Rimland Theories**

The Heartland Theory by Mackinder focuses on the large Eurasian "pivot area" as the geographic hub of power, which is inaccessible to sea powers and has the potential to be expanded using railroads. Mackinder stated that whoever controls the heartland will also control the World Island, while focusing on a defensive geography and internal mobility (Astarita & Marconi, 2024; Fettweis, 2000; Gerace, 1991).

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Spykman responded to Mackinder with the Rimland Theory, in which he emphasizes the encircling coastal arc in which sea and land based military forces would form an alliance to limit Heartland control (Fettweis, 2000; Gerace, 1991).

In classical terms, both theories are examples of deterministic theory, and are used to show how geography can determine the outcome of power struggles, but they differ in their emphasis on land vs. sea. These two theories were influential in developing various types of strategies such as imperial rivalries and Cold War type containment strategies. Contemporary critiques of these theories have argued that they do not account for the evolving nature of warfare and therefore set the stage for the emergence of geotechnology and its significant disruption of traditional strategic concepts (Putnam & Cohen, 1963; Mahan, 2010).

### **Historical Applications and Reinterpretations**

Heartland Theory has historically directed Soviet strategy in Central Asia, treating it as a defensive bulwark, whereas Rimland principles have provided a framework for United States alliances including NATO, to create a ring of anti-communist nations around communist threats (Knutsen, 2014). The post-World War II reinterpretation of these theories for the new strategic realities of the Cold War introduced both nuclear power and air power, with Saul Cohen introducing the concept of "shatter belts," to represent the fractured geography of many regions (Putnam & Cohen, 1963).

The modern interpretation of these theories includes geotechnology; for example, cyber operations against Estonia (2007), and Ukraine (2015), demonstrate non-territorial incursions into Rimland countries. The use of space-based assets (GPS) during the Gulf War, allowed for the extension of Rimland influence over sea and land borders (Branch, 2024). These examples are early indications that determinism is beginning to decline, because technology has increasingly separated power from territory.

### **Geotechnology in Contemporary Geopolitics**

The new geotechnologies of today are transforming the geopolitics of tomorrow by expanding the ability of nations to project power beyond their physical geography using digital means, space-based systems, and AI-driven tools (Branch, 2024; Colther et al., 2025). The ability to conduct cyberattacks such as Stuxnet against the nuclear facilities of Iran has enabled an attack on a nation without crossing its physical or geographic borders (Branch, 2024; Fettweis, 2000). Similarly, the use of space-based surveillance assets, such as the satellite constellation Starlink, provide a real time flow of information that is outside of the limits of littoral vulnerability and the geographic choke points that exist at the edges of a nation's territory (Branch, 2024). Additionally, the use of AI based predictive analytics and autonomous systems will provide a significant advantage to those who can optimize their logistics and decision-making processes, thus reducing the value of having control over specific pieces of land (Fettweis, 2000).

This redefines what we consider a closed system in terms of the struggle for power and supremacy in the world of states. The traditional geographic boundaries that once defined the competition between states are no longer the sole determining factor for the struggle for power and supremacy in the world, much like Mackinder did when he reevaluated the relevance of geography in the post Columbian epoch (Pejić, 2019; Mousinho et al., 2018). However, it is evident that the current competition for power in the world of states is no longer solely based on control of territory but also increasingly includes the ability to dominate digitally and strategically through technological partnerships (Liu & Miao, 2024).

In addition to this, the increasing competition between the United States and China over the production of semiconductors (Liu & Miao, 2024; Colther et al., 2025) provides evidence that AI is being used to optimize supply chains and warfare tactics. Algorithmic models that allow for the creation of predictive simulations of conflict, and strategic foresight independent of the need to take control of territory, provide an additional tool in the toolbox for nations competing for power in the world. These technologies also provide a means of empowerment to non-state actors, such as hackers, to carry out digital incursions into critical infrastructure, such as pipelines, further eroding the role of geography in shaping the behavior of states (Branch, 2024). These technologies have created a "Virtual Heartland" in cyberspace, where the ability to exercise dominion over data flows can be equal to and may even surpass the ability to exercise dominion over physical resources, thus challenging the physical core of Mackinder's pivot (Fettweis, 2000).

### **Assessment: Weakening of Classical Territorial Models**

The use of geotechnology has been able to weaken many traditional, territorial models of state power, allowing for a level of power projection largely disconnected from physical geography, and thus undermining the core principle of classical theories of statecraft, such as those presented by Halford John Mackinder (Branch, 2024; Colther et al., 2025), which placed an emphasis on a state's ability to project its influence into the heartlands of other states due to their inability to be physically penetrated by foreign armies. The advent of digital networks, has allowed for the penetration of previously secure interior spaces within the heartlands of other states through cyber attacks and/or other types of digital intrusions, such as the United States' Stuxnet attack against Iran's nuclear capabilities (Branch, 2024; Fettweis, 2000). This has also diminished the importance of the physical aspects of the heartland model in terms of a state's ability to defend itself against foreign aggression (Branch, 2024). In addition to this, the increasing number of space-based platforms and constellations of satellites, such as the United States' Starlink system (Branch, 2024) have created the opportunity for states to utilize what are commonly referred to as "rimland" or littoral strategies in far-flung regions around the world that were previously difficult to access due to their location at the periphery of continental landmasses. As such, it is now possible for states to project their power into distant regions of the world using these types of systems, without having to establish a permanent presence in the region (Branch, 2024).

Finally, the increasing amount of artificial intelligence (AI) being used in geopolitical decision making processes has introduced the potential for predictive determinism (Branch, 2024), where algorithms can predict future outcomes based upon data collected from previous events, rather than on a state's physical geography, as is the case in the current rivalry between the United

States and China in the area of semiconductors, where both countries are vying for technological superiority, but not necessarily for the purpose of expanding their respective territorial holdings (Colther et al., 2025; Liu & Miao, 2024).

However, there are also arguments made against the idea that geotechnology will eventually completely eliminate the impact of geography on international relations, and that while digital tools may provide new ways to project a country's power onto the world stage, they do not provide new opportunities for projecting power, and instead, simply amplify existing geographical factors in hybrid forms of warfare, and expose the vulnerabilities of a country's infrastructure, such as the vulnerability of undersea communications cables, particularly in rimland choke points (Branch, 2024; Putnam & Cohen, 1963).

For example, in the case of Russia's ongoing hybrid war in Ukraine, Russia has combined its conventional military efforts with a large-scale campaign of cyber disinformation, however, even though Russia has been successful in using these types of tools to disrupt the Ukrainian government's operations, and undermine public confidence in the Ukrainian government, the Russian military has still had to physically take control of key locations in Ukraine in order to achieve its objectives (Branch, 2024; Liu & Miao, 2024).

Quantitative analysis of cyber incidents has shown that the increased use of cyber technology has led to a reduction in the amount of time and effort required to cross national boundaries, and therefore, has eroded some of the traditional territorial barriers to international cooperation, however, the results of this research have also shown that there is no evidence to suggest that the increase in the use of cyber technology has eliminated the traditional territorial determinism that has long been a part of international relations, and instead, has shown that geography continues to constrain the ability of countries to use digital technologies to project their power (Branch, 2024).

Furthermore, geography has continued to play an important role in shaping the course of international relations in areas where the supply of natural resources is critical to the success of a country's economy and/or national security. For example, the recent competition between various countries for access to the newly opening Arctic sea lanes and the hydrocarbon reserves found beneath the Arctic Ocean, demonstrate the continuing importance of geography in determining a country's ability to successfully compete in international relations (Mousinho et al., 2018). Finally, the increasing competition between the United States and China for technological superiority, specifically in the area of semiconductors, highlights the fact that while technology has changed the nature of conflict, it has not eliminated the need for countries to have control over strategic geographic locations, and therefore, geography continues to remain relevant in international relations, albeit in modified and hybrid forms (Branch, 2024; Colther et al., 2025; Liu & Miao, 2024).

### **Critiques and Modern Adaptations**

The authors also point out that critics see geotechnology itself as introducing determinism, and that it is too optimistic about digital space and too pessimistic about the long-standing geographical limitations of terrestrial space — such as the vulnerability of underwater cables in the Rimland seas (Vysotskyi et al., 2022). Critics also say that classical theories have been Eurocentric and therefore do not take account of Global South dynamics, which include the use of artificial intelligence to increase social inequality. Furthermore, an over-reliance on technology may lead to "cyber-utopianism", i.e., the neglect of human and environmental factors (Khan, 2024). However, advocates of geotechnology argue that geotechnology can be used to complement classical models of geopolitical analysis by understanding geography as both opportunity and constraint, and that digital technologies amplify existing territorial factors amidst ongoing physical vulnerabilities such as choke points (Branch, 2024; Putnam & Cohen, 1963). Advocates of geotechnology also argue that "hybrid" approaches to adaptation can help to address the critique that geotechnology is Eurocentric, and the risk of cyber-utopianism, by including Global South dynamics and strategic partnerships into evolving frameworks (Colther et al., 2025; Liu & Miao, 2024).

Proposed modern adaptations to geotechnology suggest "geotech hybrids", which combine classical Heartland-Rimland paradigms with network theory; for example, emerging frameworks conceptualize "cyber-Rimlands" by defining cyberspace as a contested periphery that extends beyond physical littoral zones — e.g., the geopolitics of cyber power (Mousinho et al., 2018; Branch, 2024). Authors such as P.W. Singer suggest using artificial intelligence to develop models that apply Mackinder's thesis to contemporary geopolitical realities — positioning space as a new strategic "high ground" as a result of the increasing technological mobility of forces (Fettweis, 2000). Policy frameworks — e.g., the United States National Security Strategy — integrate the defense of territory with digital resilience and strategic technological partnerships, thereby ensuring that classical theories evolve within the context of U.S.-China rivalry over AI (Liu & Miao, 2024; Colther et al., 2025). As a result, these adaptations mitigate criticisms — such as Eurocentrism and cyber-utopianism — by understanding geography as opportunity and constraint, and by developing resilient forms of geopolitics that incorporate hybrid warfare and Global South dynamics (Putnam & Cohen, 1963; Khan, 2024). Therefore, the application of artificial intelligence in geopolitics represents a paradigmatic shift from traditional theoretical frameworks — offering a modern alternative to bridge normative principles with empirical data (Hassanali, 2025). Therefore, a re-evaluation of this subject requires a multidisciplinary approach to fully understand the complex interaction between geographic factors and emerging technological capabilities (Topalidis et al., 2024).

### **Conclusion**

Although geotechnology undermines the traditional views of geographical determinism by allowing for non-territorial forms of power, the concepts of the "Heartland" and "rimland," based on territory, have been preserved because of new hybridized interpretations of them. The ability to create digital, virtual and artificial intelligence (AI) related innovations will eventually undermine the classical geographical models; however, these classical models are being replaced with the emphasis of non-territorial or networked spaces. However, there is still an ongoing persistence of territorial elements, particularly in regards to resources and conflict. Although critiques and adaptations of these approaches continue to emphasize the importance of developing new, integrated frameworks for understanding the complexities of multipolar geopolitics, they also raise important questions

about the future of such geopolitical models. It will be necessary to examine the ethical implications of future technological advancements and develop new, balanced models that bridge both geography and innovation.

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