

The Rise of Geotechnology: A Paradigm Shift from Geopolitics and Geoeconomics in the Context of Industry 4.0

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Abstract. *As the Fourth Industrial Revolution unfolds, where the physical, digital and biological areas merge, there is a growing demand for technology-centred thinking in world affairs. In the dynamic and complex landscape of international economic relations, the 21st century may witness a transformative shift in strategic thinking from traditional geopolitics and geoeconomics to the new realm of geotechnology, from the analogue and the geographic towards the digital and the abstract amidst the incoming economic disruption that is represented by the Fourth Industrial Revolution. This article explores the emerging paradigms, and how technological advancements have not only altered the traditional power dynamics among states but have also opened the way for a more interconnected and interdependent international system which necessitates new methods of thinking in order to cope with the economics of Industry 4.0. By discussing key aspects of the Fourth Industrial Revolution, this study aims to elucidate how technological innovations have become influential determinants in decision-making processes traditionally dominated by geopolitical or geoeconomic considerations. Through a rigorous review of the speciality literature, the article aims to contribute to a nuanced understanding of the rise of geotechnology and its transformative impact on shaping the future of international relations, by democratising global governance and providing a technologically-centric view in the context of the proliferation of the Fourth Industrial Revolution and its potentially disruptive capabilities.*

Keywords: Fourth Industrial Revolution, Geotechnology, Geopolitics, Geoeconomics, World Economy, Global Governance

Introduction

In the dynamic landscape of the 21st century, the intersection of The Fourth Industrial Revolution and international affairs is offering a transformative paradigm shift, giving rise to the field of geotechnology. This evolution represents a departure from traditional considerations of geopolitics and geoeconomics, as societies around the world navigate a complex web of interconnected challenges and opportunities driven by the constant advance of technology.

Historically, geopolitical and geoeconomic analyses have primarily focused on the interplay of political power and economic interests within traditional geographical boundaries. However, the emergence of geotechnology brings a new era where the boundaries between physical and virtual spaces are blurred, redefining the very fabric of international relations and world economic dynamics. The rise of Artificial Intelligence, the Internet of Things, autonomous vehicles advanced robotics and smart factories have introduced an unprecedented level of complexity, ushering in an era where technological innovation is a critical determinant of global influence.

This scientific paper delves into the multifaceted dimensions of geotechnology, as an alternative or as a complement for geopolitics and geoeconomics. By examining the key components of geotechnology, this article aims to contribute to a deeper understanding of the evolving dynamics that shape our world amidst the proliferation of Industry 4.0. As we stand at the confluence of innovation, international relations and economics, it is essential to unravel the

characteristics of this paradigm shift to anticipate and navigate the challenges and opportunities that lie ahead.

Literature review

To fully understand the nature of the shift in terms of geopolitical and geoeconomic thinking, a comprehensive literature review is in order. Schwab, (2016) states that the Fourth Industrial Revolution's (himself being responsible for the popularisation of the term) impact on international security, overshadowed by discussions on work and business, holds a crucial and overlooked threat, as technological changes risk exacerbating inequalities, fostering social instability, and necessitating a coordinated, cross-disciplinary response to address evolving conflicts and emerging security threats.

Moreover, the increasing need for modern geotechnological thinking is mentioned by Bánkuty-Balogh (2023), as he highlights the need to update geopolitical narratives to reflect a changing world system characterized by global interconnectedness and technological advancements, as geopolitics has evolved from early theories focused on state actors and geographic dynamics to modern theories challenging traditional spatial thinking, with globalization and a unified world economic system having reduced nation states' control over cross-border processes, while technological advancements have transformed global capitalism into a more flexible, decentralised, and interdependent networked system; Dynamic models emphasizing relations and flows are seen as more suitable than static classical conceptions for understanding the contemporary world.

Goodman & Khanna (2013) address the issue of a continuously accelerating technological innovation by discussing the concept of geotechnology; given the geography-centred dogmas of geopolitics which dominated European affairs in the 1800s and the emergence of geoeconomics during the Cold War as an economics-focused school of thought, geotechnology views technological capabilities as having the same importance as diplomacy, the economic or military power of a country, these three concepts complementing each other to offer a clearer picture regarding international affairs, security and power dynamics.

Furthermore, Khanna (2014) explores the significance of technology among the current mega-trends, suggesting a need for a paradigm shift in interpreting global change from traditional geopolitics to geotechnology, as the latter focuses on the impact of technology on world affairs, examining innovation diffusion, actors leveraging technology for power, and its role in global regulations while complementing geopolitics and geoeconomics, the author acknowledging a shift towards a multipolar and post-Westphalian order.

Bhutani (2019, pp. 36–28) traces the shift from geopolitics to geoeconomics and introduces the concept of geotechnology; As geopolitics originally focused on states expanding through military power, but post-world wars, nations turned to economic development, thus geoeconomics emerged. The author introduces the concept of geotechnology and predicts that a nation's strength will depend on how well it manages geotechnological resources, showcasing the competition for resources on Earth and even in outer space.

Criekemans (2021) examines the intricate relationship between technology and geopolitics, projecting a future where the United States and China emerge as dominant technologically powerful blocs, potentially leading to a global restructuring; The author also highlights challenges for European nations and others to stay relevant geopolitically, emphasizing the need for strategic

investments in research and development, as regulatory obstacles, especially in the EU, hinder its role, leaving the U.S. and China in control.

Manning (2020) underlines the importance of a country's technical skills pool, in addition to the value of data, as factors which could influence the power dynamics of a geotechnology-oriented world state of affairs, contrary to Crieckemans (2021), smaller countries like Singapore, Sweden or Israel manage to exercise influence as a consequence of their respective technological innovation.

Methodology

The methodology used in this scientific paper is that of a comprehensive literature review, emphasizing the latest and most relevant findings across the domains of geopolitics, geoeconomics, economics, and geotechnology, with a focus on recent and future technological advancements in the context of the Fourth Industrial Revolution's proliferation.

Furthermore, the main objective of this paper is to systematize these findings, thereby offering a coherent framework for better understanding the shifts occurring in the fields of international economic relations and geopolitics amidst the disruptive changes that Industry 4.0 is set to bring. Moreover, the analysis examines the selected articles, papers, and books to extract key elements defining the theoretical background of geotechnology, geopolitics, and geoeconomics. Through this process, the paper aims to conduct a rigorous theoretical comparison, highlighting their respective similarities and differences within the technologically disruptive and economically transformative international landscape.

Therefore, the methodology adopted for this paper is represented by a thorough examination of contemporary literature. By integrating a qualitative methodology, the paper aims to offer a comprehensive understanding of the complex relationship between technology, geopolitics, and international economic relations in the context of the Fourth Industrial Revolution's proliferation.

Transitions and disruptions, the rising demand for a new paradigm

The Fourth Industrial Revolution (IR 4.0 or Industry 4.0) is set to bring unprecedented waves of connectivity and automation that are prone to radically change the very fabric of our society, through new technological innovations such as Artificial Intelligence, the Internet of Things, advanced robotics and sensors or autonomous vehicles and 3D printing (Schwab, 2019). However, technology is not the only variable which leads to an industrial revolution. Thus, an industrial revolution encompasses disruptive technological innovation and its rapid spread, transforming processes, nature, and human relations in relation to work, and changes regarding commerce, power relations (in the sphere of international relations), as well as fluctuations concerning the way people live their lives (mundane changes), especially in urban environments (Moll, 2021).

The First Industrial Revolution (19th century), the most well-known of them, brought the concept of industry into our economies, represented by the invention of the steam engine and the birth of mass production, with the starting point being the British Isles. The phenomenon that rapidly engulfed the Western hemisphere brought much more influential and disruptive elements in the long term. Thus, based on technological development and innovation, 19th-century societies changed, some even seismic in proportions, both socially and economically. Later, in the same century, human innovation brought the energy sector to the forefront to further improve the way we produce (the Second Industrial Revolution). Here, we witness the proliferation of the internal

combustion engine, as well as electricity and its sources, such as oil and gas. In the second half of the 20th century, the third revolution began, introducing new concepts and innovations, such as nuclear energy, electronics, and information technology that we see today as advancements of their past prototypes. (Institute of Entrepreneurship Development, 2019)

In addition to this, the Fourth Industrial Revolution does not only refer to machines and intelligent and (over)connected systems; its domain is much broader, and the subject is much more complex. Simultaneously, waves of advancements are taking place in fields ranging from gene sequencing to nanotechnology, from renewable energy sources to quantum computers. Industry 4.0 represents the fusion of these technologies and their interaction in the physical, digital, and biological domains, which makes the Fourth Industrial Revolution fundamentally different from previous revolutions (both in terms of innovation and propagation). In this revolution, emerging technologies and innovation spread much faster than in previous ones, which have yet to fully develop in some parts of the world. For example, the second industrial revolution has still not been fully experienced by 17% of the world, with nearly 1.3 billion people still lacking access to electricity. This holds true for the Third Industrial Revolution as well, where more than half of the world's population lack access to the internet. (Schwab, 2019)

However, it should be noted that the relevance of Industry 4.0 is heavily debated. Another point of view is provided using arguments based on a rigorous review of the literature, that the Fourth Industrial Revolution does not fully deserve the connotation of revolution. Instead, it is viewed predominantly as a materialization, or even an apotheosis, of the Third Industrial Revolution, with many of the technologies we now consider inevitable in the global economic landscape being deeply rooted in the technological innovations of the last century. The author believes that future technological changes will considerably alter the way we perceive society as a whole, with changes of a socio-economic nature and significant ramifications. However, the label of myth is placed upon the Fourth Industrial Revolution in the author's view, as it could be considered the apex of the preceding one. (Moll, 2021)

Geopolitics, Geoeconomics and Geotechnology

With all this in mind, we can safely presume that Industry 4.0 will bring technologically disruptive elements into the world economy, keeping in mind that the socio-economical aspects are up to debate (as previously shown). Whether we talk about a radical socio-political-economical shift following the unravelling of the Fourth Industrial Revolution (similar to what humanity witnessed during the First Industrial Revolution), or an apotheosis of IR 3.0 which bring an unprecedented level of connectivity and automation (which can also lead to changes in the global economical sphere, but without disruptively changing the fabric of society), there has been a growing need to rethink the way we perceive geopolitics and geoeconomics, by adding a new dimension to the spectrum, that of geotechnology. Analysts have historically relied on both geopolitics and geoeconomics to grasp and contextualize the constantly evolving dynamics of world economics and international relations.

Geopolitics focuses on territorial variables and offers a holistic view of global issues, while International Relations encompasses diplomatic history, economic theory, and international law (as it branches into power (Realism), interdependence (Liberalism), international norms (Constructivism) and even inequality (Marxism); both fields possess diverse theoretical perspectives, including variables such as power, interdependence, inequality, and identity, however, the multitude of theoretical branches makes it challenging for outsiders to see how

geopolitics and international relations can mutually enhance each other's perspectives. (Crikemans, 2022)

Geopolitics traces its origins back to nineteenth-century European scholars and diplomats, who were primarily focused on geographic, and spatial dominance and the ability to exert influence abroad, while throughout much of the twentieth century, the predominant method of evaluating one's power dynamics involved examining key components of geopolitical advantage, such as demographics, natural resources, military forces and conventional and nuclear weaponry (Goodman & Khanna, 2013). On top of that, as the political, economic and military connections between global actors increased, demand for a new paradigm arose, one which could better explain and interpret the intricate webs of increasing economic and commercial activities.

The term *geo-economics* surfaced after the Cold War through the work of Edward Luttwak (1990). During the 1990s, *geo-economics* emerged as a balance or complement to *geopolitics*, as *geo-economics* applied conflict principles to commerce dynamics where key components such as GDP, trade balances, investments and economic leverage shape global power dynamics. Therefore, *geopolitics* and *geo-economics* work symbiotically, yet manage to offer an incomplete view by themselves. (Goodman & Khanna, 2013)

It is here, in *geo-economics*, that we see the rise of postmodern and critical *geopolitics* as an alternative to the ideas popularised by Henry Kissinger (Bánkuty-Balogh, 2023).

The emergence of a dominant economic world system and the rise of globalisation are factors which contribute to the need for a paradigm shift in the thinking of international affairs. Concepts such as a network-based system or information-based network society present new ways of rethinking *geopolitics* and *geo-economics* in the modern interconnected world (Castells, 1996). In reference to the network society, Bánkuty-Balogh, (2023) adds that the interconnected nature of our society evolves organically, facilitated by the connections among individuals, organizations, and transnational networks, as the contemporary information society, this intricate web of relationships is more accurately described using the network society model.

Moreover, the concept of a knowledge-based economy complements these new trends in showing the socio-economical changes that are prone to influence the way we perceive international actors in the globalised world economy (Figure 1) (Sami Moisisio, 2019). Furthermore, the growing impact of supra-national and sub-national bodies on global affairs, coupled with the interconnectivity of the contemporary world, particularly in financial realms, is fostering a rising interest in *geo-economics*. This trend signifies a transition from a focus on politics to a more economic-centric perspective (Bánkuty-Balogh, 2023).

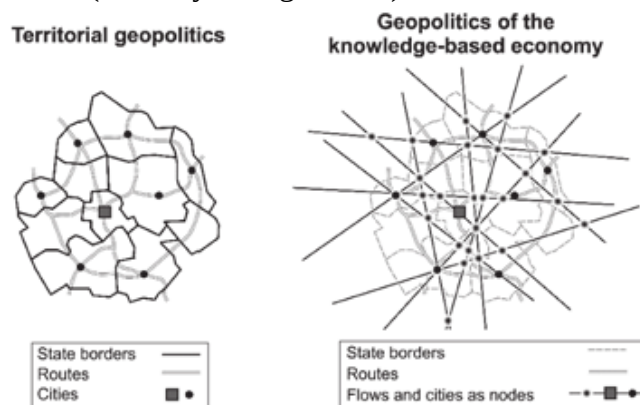


Figure 1. Simplified visualisations of the parallel worlds of the contemporary geopolitical condition

Source: Sami Moisisio (2019).

Therefore, we have witnessed a transition from geographic-centred geopolitics (an example being that of Mackinder's Heartland Theory), to economic relations-centred geoeconomics, which emerged in a time of past-conflicting economic ideologies, that of Western-based free market liberal capitalism and Soviet-sponsored communist planned economy and offers a critical view upon traditional geopolitics. However, new paradigms arose in order to offer a clearer picture of an ever-technologically progressive and economically and socio-culturally interconnected world that emerged in the latter half of the previous century. Moreover, geographic spatial dynamics seem to hold less significance as newer technologies unfold. As the information era is constantly disrupting the socio-economical landscape, the Westphalian international system which focuses solely on state actors and geographic boundaries is eroding, physical distances having a considerably smaller role in shaping international politics, with innovative technologies of the present world shaping a new world order where international actors are no longer exclusively nation states (Bánkuty-Balogh, 2023). This process can be interpreted as a democratisation of world governance, similar to how the internet democratised many aspects of our society, the information era and subsequently, the Fourth Industrial Revolution, may erode the monopoly on governance, as international organisations, Non-Governmental Organisations or other institutions start asserting their sovereignty in this network shaped world. More now than ever, it seems that technology will play a larger role in world affairs and economics, possibly paving the way for even greater disruptive changes. One of the proposed paradigms is that of geotechnology as a third element in the international geopolitical trilogy, in addition to classical geopolitics and geoeconomics.

Therefore, Geotechnology, the proposed third dimension which may hold greater influence in the years to come thanks to the proliferation of Industry 4.0, sees technology as a greater factor in power dynamics. (Goodman & Khanna, 2013)

As mentioned above, nation-states are no longer the sole governing bodies of the interconnected world which functions more like a network. In addition to the traditional state and multi-state actors, private and public organisations are likely to play a larger role. Moreover, companies are more dominant than ever, starting to resemble digital empires as their networks encompass the whole world (Khanna, 2017, pp. 216–218), furthermore, in this technologically innovative environment, start-ups can rapidly gain momentum, especially when nowadays, even small companies have access to world markets and to the newest technologies, the accessibility and performance of modern technologies (like the smartphone) have even helped less developed nations to leapfrog entire generations of technological innovation (Manning, 2020).

Geotechnology broadens our understanding of global dynamics in two key ways, firstly, it recognizes technology as a historical driver in addition to economic and military power, shaping events like Europe's seventeenth-century power shift. Secondly, it acknowledges nonstate actors' rising influence (WikiLeaks and Google being examples) in challenging traditional nation-state dominance. Moreover, Moore's Law, which initially predicted transistors doubling annually, now extends to all circuit-based technologies, which may further impact geopolitics and geoeconomics. These technologies, growing exponentially, reshape our world, exemplified by smartphones surpassing even Apollo-era computing, and while the Internet's military origins are often overlooked, its impact on society and global affairs is undeniable. (Goodman & Khanna, 2013)

Sometimes, geotechnology is even considered a dominant idea in the future of geopolitical thinking, as it can be viewed as a new era, where technology will be the dominant tool for achieving a state's geopolitical objectives (Bhutani, 2019). Yet, these changes represent only the beginning of 21st-century, as geotechnology will likely take its place alongside geopolitics and geoeconomics

as tools that can help explain the complex dynamics of economic and power structures, now more than ever as the disruptive, technologically innovative and socio-economical possible destabilizer, the Fourth Industrial Revolution unfolds. Even if the disruptive capabilities of Industry 4.0 are still up for debate, geotechnology manages to meet the demand for a new way of unravelling the power dynamics of the contemporary world. Whether we refer to a change in the very fabric of society or just an apotheosis of the previous industrial revolution, the geotechnological paradigm is a byproduct of the digital age, similar to how geopolitics is closely related to the balance of power policies of the 19th century and to how geoeconomics is linked to the economics of a complex, yet ideologically divided world of the past century (Figure 2).

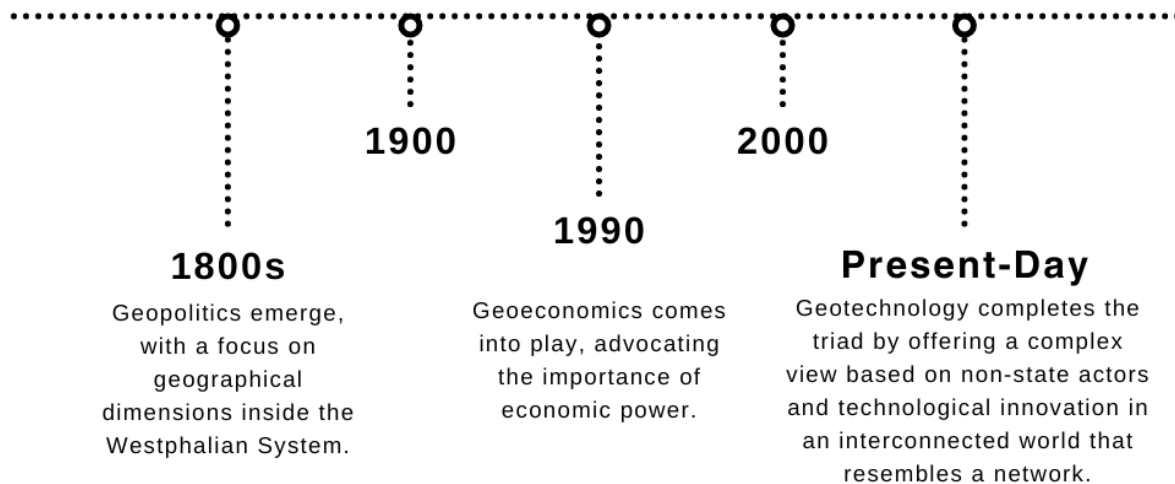


Figure 2. Timeline of Geopolitics, Geoeconomics and Geotechnology

Source: Autor's work based on information from Goodman & Khanna (2013).

The Democratisation of Governance

Geotechnology, as a ramification of geopolitics, aims at offering a 21st century contextualized view of how power dynamics are established in the current world affairs. As it differentiates itself from traditional geopolitics by relying less upon geographic constraints, and while geopolitics ignores nonstate actors and geoeconomics sees them as minor players, geotechnology fully acknowledges current systemic changes leading us into a post-Westphalian globalised world, it recognizes that global actors leveraging new technologies, even with limited resources, can amass significant influence and challenge the traditional nation-states (Goodman & Khanna, 2013), thus managing to offer a paradigm shift which is to become a better tool in deciphering the dilemmas of a world where the disruptive Fourth Industrial Revolution unfolds.

The field of geotechnology also manages to show certain risks, as technology evolves and becomes a major driving force in how humanity interprets security (be it in economic or military terms).

Therefore, the emphasis now lies on addressing issues related to geotechnology, where Industry 4.0 and a global interconnected network of political and economic actors meet. Transparency concerns and establishing new ways and systems to control and manage emerging technologies affecting global stability, developing new norms, laws, regulations, and codes of conduct represent a challenging path toward global governance, while preventing technology from overpowering governance in the current climate of distrust is a significant challenge, with history indicating that it may even require a crisis or conflict to bring a new level of seriousness to the

debate (Manning, 2020). All these processes are linked to the way geotechnology perceives global actors and their respective roles, as not only Westphalian System nation-states exert influence and hold a monopoly on governance, but also international organisations (private, public, multi-state, sub-state, regional or even sub-regional) and, especially in the context of private technological innovation which characterises the future of Industry 4.0, companies, these tech giants taking the form of digital empires (Khanna, 2017, pp. 216–218), which are a leading force in the development of new, potentially disruptive technologies (such as Artificial Intelligence, the Internet of Things, advanced robotics, BioTech, etc.) are increasingly important. Furthermore, in addition to the palpable geographic space, technology companies are actively pursuing the development of a new, virtual space, such as Facebook's Metaverse, which, combined with the future of the space economy (Jora et al., 2022b), will possibly lead to new dimensions of the geotechnological conundrum, further eroding our understanding of spatial dimensions. Therefore, the place of companies in world governance represents a key topic in the future of geotechnological thought as their influence transcends traditional spatial norms.

On the other hand, the role of the nation-state in a pure Westphalian sense and in a power-oriented international environment is not to be neglected. As mentioned by Goodman and Khanna (2013), competition between states from a geotechnological view is set to rely more upon areas such as technological innovation, with the United States as the primary innovator as of now, with its corporate giants (Google, Facebook, Apple, Cisco or IBM) dominating the scene. Furthermore, the rivalry between Washington and Beijing can be interpreted as geotechnological in nature, as it has been marked by China's persistent acquisition of American intellectual property, with China's substantial governmental investment and support for its national research and development initiatives suggesting a shift from mere imitation towards genuine innovation, potentially leading to the emergence of Chinese equivalents to Silicon Valley (Goodman & Khanna, 2013). Therefore, geotechnology, even if it is based upon the diminishing role of geographic constraints in the contemporary interconnected world and views the global environment as a network with a plethora of actors (Jora, 2018), it does not exclude traditional state actors and their respective intricate relationships (such as the rivalry between China and the United States).

Moreover, embracing geotechnological innovation alongside traditional paradigms is imperative. Emerging technologies like Artificial Intelligence and advanced robotics are rapidly reshaping global dynamics while challenging established power structures, the competition for technological dominance has far-reaching implications for global security and foreign policy (Goodman & Khanna, 2013), and even for the global management of environmental/ecological (dis)equilibria (Jora et al., 2022a), as geotechnology joins geopolitics and geoeconomics in a trinity of instruments useful at explaining the international political and economic state of affairs in a world which could be heavily disrupted in the near future by the unravelling of the Fourth Industrial Revolution and its ample socio-economical ramifications.

Conclusions

In conclusion, geotechnology represents a crucial departure from traditional geopolitics of the past two centuries, recognizing the influence of technology and non-state actors in shaping international affairs. As the Fourth Industrial Revolution unfolds and technology's strategic importance grows, companies will play a significant role alongside nation-states and international organisations from a geotechnological point of view, as technology democratises governance, upon which the nation-states have had a monopoly up until the past century.

However, this new paradigm also manages to show risks, particularly in security and governance, addressing transparency issues and establishing effective regulations are imperative to prevent technology from overcoming governance structures. Looking ahead, the discourse on geotechnology prioritises global governance and the evolving global role of non-state actors.

To summarise, geotechnology offers a more nuanced point of view on power dynamics, urging us to adapt to the realities of the digital age for effective global governance. While it offers an up-to-date critical geopolitical view, it is not meant to replace other paradigms, but complement them as it takes its place alongside traditional geopolitics and geoeconomics as crucial tools aimed at analysing modern global political and economic dynamics.

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