FUTURE TRENDS

Report

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Future Trends Report

Future Trends Report, published in English and Arabic by TRENDS Virtual Office in Montreal, stands out as a distinctive publication dedicated to highlighting:
1. the most important forward-looking studies that aim to identify future trends, analyze various variables that may influence these trends, and determine the best future scenarios.
2. the most important applied studies that explore the application of knowledge, scientific theories, and information to solve current problems and overcome future challenges.
3. the most important illustrative and graphic forms that visually summarize significant studies, helping readers understand the trends and challenges of the future world.

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1 Prospective research

AI-Assisted Scientific Discovery: The Case of Large Language Models

Eger, S., Cao, Y., D'Souza, J., Geiger, A., Greisinger, C., Gross, S., ... & Miller, T. (2025). Transforming Science with Large Language Models: A Survey on AI-assisted Scientific Discovery, Experimentation, Content Generation, and Evaluation. arXiv preprint arXiv:2502.05151.

This paper examines the significant impact that large language models (LLMs) are already having on the scientific research process. The authors maintain that LLMs stand to fundamentally alter nearly every phase of research—spanning literature review, ideation, content production, and even the peer review process. Their integration signals a substantial shift, introducing automated tools for information retrieval, experimental design, drafting scientific text, generating visuals, and facilitating scholarly assessment.

The survey begins by mapping the classic research workflow—problem identification, literature review, hypothesis generation, experimentation, data analysis, and dissemination—and shows how LLMs now enhance each phase. In literature reviews, AI-powered platforms enable semantic search, summarization, and comparison across vast corpora, speeding up information extraction and synthesis.

During ideation and experimental planning, LLMs generate hypotheses, suggest protocols, and, with multi-agent systems, even simulate experiments. Although new benchmarks across disciplines (e.g., chemistry, physics, social sciences) gauge these systems' performance, the authors warn that without careful oversight they can reinforce existing paradigms, produce spurious findings, or pose ethical risks. LLMs also excel at drafting scientific text—titles, abstracts, related-work sections, citations, and full manuscripts—which can particularly aid non-native English speakers. Yet issues of originality, factual accuracy, and plagiarism persist: AI-generated bibliographies often exhibit hallucinations, and expanding AI contributions complicate authorship ethics.

The paper further examines LLM-driven multimodal output—figures, tables, posters, slides—and notes their potential to improve scientific communication. However, generating clear, accurate visuals demands well-curated training data, and current tools still face limitations in contextual appropriateness and technical precision.

Finally, the role of LLMs in peer review is explored: they can help assess manuscripts, verify claims, and draft meta-reviews. Still, their deployment raises questions of bias, transparency, and over-reliance on automation. The authors advocate for human-centered design, robust ethical standards, and full transparency to ensure that AI's integration into research workflows bolsters, rather than undermines, scientific integrity.

AI-enabled tools increase efficiency, allowing researchers to extract and synthesize information more rapidly.

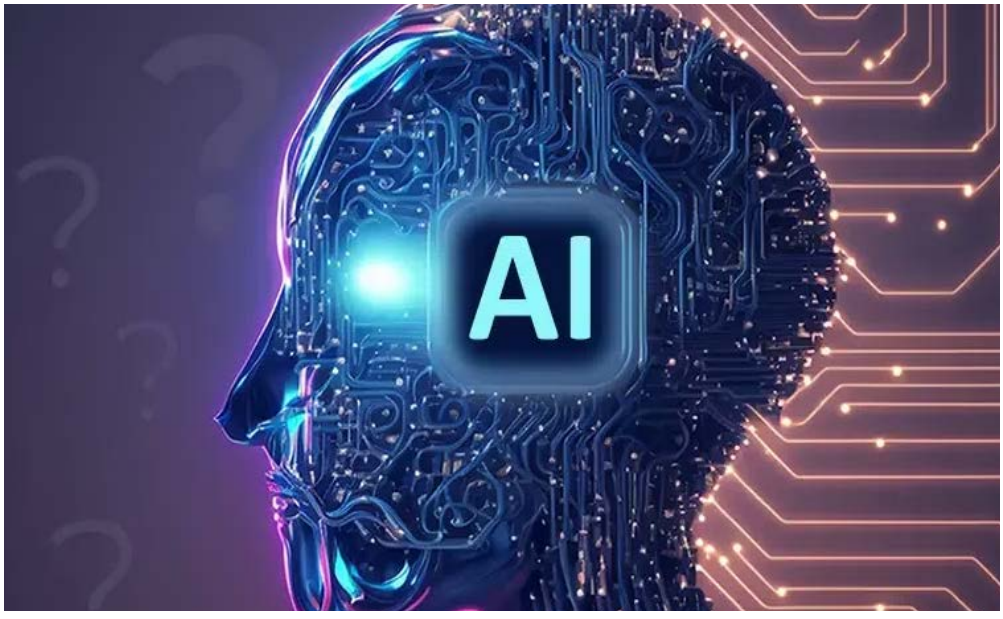
Significant challenges must be addressed to ensure responsible and effective integration of AI tools into research practice.

Prospective research

Agentic AI and Scientific Discovery

Gridach, M., Nanavati, J., Abidine, K. Z. E., Mendes, L., & Mack, C. (2025). Agentic AI for Scientific Discovery: A Survey of Progress, Challenges, and Future Directions. arXiv preprint arXiv:2503.08979.

Agentic AI is transforming scientific research by automating and enhancing core processes such as hypothesis generation, literature review, experiment design, data analysis, and manuscript writing. Powered by advanced language models, these systems are streamlining workflows, accelerating research productivity, and making scientific tools more accessible.



Two main classes of agentic AI systems have emerged. Single-agent models operate independently in structured, feedback-light settings, using large language models to reason and execute tasks. Multi-agent systems assign specialized roles to different agents, simulating collaborative research teams; they excel at interdisciplinary problems but require sophisticated coordination.

These systems also differ in autonomy. Fully autonomous frameworks (e.g., Co-Scientist, ChemCrow) manage end-to-end scientific workflows—from experiment planning to execution—especially in chemistry and materials science. Specialized variants such as ProtAgents (protein modeling) and LLaMP (materials prediction) perform reliably in routine contexts but struggle with novel challenges. Human–AI collaborative models (e.g., Virtual Lab, BioPlanner, CALMS, Agent Laboratory) strike a balance: they offer insights and procedural guidance while researchers retain control over critical decisions.

Automating literature review remains one of the toughest tasks. Tools like SciLitLLM, LitSearch, ResearchArena, and CiteME aim to classify, retrieve, and cite vast publication corpora yet falter in domains demanding deep expertise or interpretive nuance. For example, Agent Laboratory handles experiment execution effectively but underperforms at synthesizing complex literature.

Agentic AI now supports every stage of the research pipeline. In chemistry, platforms such as LLM-RDF and Organa automate experimental protocols; in biology, systems like BIA and CellAgent streamline genomic and single-cell analyses. Bioinformatics and synthetic biology advance via tools like TAIS and CRISPR-GPT, enhancing data interpretation and planning. Underpinning this ecosystem are development frameworks (AutoGen, MetaGPT, Letta) and domain-specific benchmarks (LAB-Bench, MoleculeNet, MatSci-NLP, AlphaFold). Yet, the absence of universal metrics for reliability, interpretability, and user satisfaction remains a barrier.

Despite progress, significant challenges persist. Trustworthiness and calibration are critical to ensure systems behave reliably and generalize beyond training data. Ethical concerns—bias, hallucinations, transparency—are acute in high-stakes fields such as healthcare. Other risks include error compounding, coordination breakdowns, and misalignment with research goals.

In sum, agentic AI offers transformative potential for scientific discovery by automating routine tasks and amplifying human expertise to make research more efficient and accessible. Realizing this potential requires improved literature-review capabilities, robust ethical and evaluative standards, and deeper collaboration between AI systems and human researchers.

Agentic AI is revolutionizing scientific research from hypothesis generation and literature review, to experimental design, data analysis, and manuscript writing.

Systems like TAIS and CRISPR-GPT are advancing bioinformatics and synthetic biology, enhancing data interpretation and experimental planning.

Prospective research

Threats in Sub-Saharan Africa by 2040

Fondation pour la Recherche Stratégique (FRS) (Feb 2025), “Threats in Sub-Saharan Africa by 2040 – A Prospective Analysis"

Sub-Saharan Africa will be confronted by 2040 with a more complicated and volatile strategic landscape, fueled by a cluster of converging drivers that include climate change, population expansion, structural governance problems, the proliferation of extremist networks, and rising global competition. The several crises playing out in the Sahel, Central Africa, and the Horn of Africa are likely to deepen as regional vulnerabilities compound with international power rivalries.

Climate change will serve as a primary threat multiplier—increasing food and water insecurity, fueling resource-based conflicts, and creating large-scale internal displacement. These are most severe in vulnerable areas like the Sahel, where deteriorating living conditions have already contributed to increased terrorist recruitment. The region's population—likely to double by 2050—will place additional stress on institutions. Lack of corresponding progress in employment, infrastructure, and social services means that rising youth unemployment and urbanization are likely to intensify poverty and social unrest.

The fragility of good governance remains at the center of challenges. This environment has created new challenges for extremist groups, especially Al-Qaeda- and ISIS-linked ones, which exploit local grievances and capitalize on increased freedom of action in uncontrolled territory. New bases of extremism are conceivable by 2040 in specific locations such as northern Mali, while insurgencies will remain prevalent in Nigeria and the Lake Chad Basin.

Simultaneously, international strategic competition is intensifying. China's Belt and Road Initiative, Russian military alignments, and the sending in of private security companies, and Turkey's increasing regional leadership are all resisting Western influence. France's traditional dominance, especially in West Africa, has diminished in the face of recent unilateral pullouts from Mali, Burkina Faso, and Niger. ECOWAS fragmentation—exacerbated by the withdrawal of regime-led armies—has weakened regional cooperation forums.

New and emerging threats also promise to reshape the security environment. The proliferation of drones, cyber capabilities, and AI is reshaping the character of conflict, and environmental shocks threaten critical infrastructure—such as undersea cables along the coast of East Africa. Water issues, such as the Nile, have the potential to escalate to inter-state war. Besides, external actors and non-state actors can increasingly employ hybrid tactics, economic pressure, and information warfare, particularly in strategic regions such as the Horn of Africa.

For France and Europe, this imposes the requirement for a general strategic rebalancing. France is shifting towards military de-escalation and emphasizing locally initiated, cooperative partnerships. Yet over-disengagement carries the risk of abandoning influence to competitors such as Russia and China. It needs to be a subtle, multi-faceted approach—one that ties civil-military programs, soft power, foreign direct investment from the private sector, and more cooperation with regional and African actors together. Finally, the future roles of France and Europe in Africa will depend on their ability to be adaptable and evolve with changing realities in support of African-led solutions to security and development issues.

The crises unfolding in the Sahel, Central Africa, and the Horn of Africa are expected to intensify as regional vulnerabilities are exacerbated by growing international power rivalries.

Rebuilding of trust will require respect for sovereignty, genuine dialogue with civil society, and a conscious move away from condescending attitudes

Prospective research

Five Security Scenarios on Russian War in Ukraine for 2024–2025

Osmolovska, I., Havrylov, V., Maksak, H. (2024), "Five Security Scenarios on Russian War in Ukraine for 2024–2025" GLOBSEC. https://www.globsec.org/what-we-do/publications/five-security-scenarios-russian-war-ukraine-2024-2025?utm_source=chatgpt.com

The GLOBSEC report stipulates five scenarios through which the Russia-Ukraine conflict might progress through 2024 and 2025, with each scenario depending on changing realities on the battlefield, political maneuvering, and the evolving posture of the international community.

Scenario one envisions a prolonged stalemate in which neither Russia nor Ukraine secures a decisive breakthrough. Frontlines harden into attritional trenches, inflicting heavy military and civilian casualties. Ukraine's ability to resist depends on sustained Western military aid, financial backing, and munitions supplies, while Russia exploits its larger manpower and stockpiles to wear down defenses. Over time, donor fatigue or shifting political priorities in Europe and the United States could erode Kyiv's support network, aggravating its humanitarian crisis, overwhelming hospitals, and triggering mass displacement.

The second scenario posits a successful Ukrainian counteroffensive. As Ukrainian forces reclaim territory—perhaps portions of Donbas or even Crimea—morale and diplomatic leverage would surge. Such gains might prompt Western capitals to deepen assistance, but could also provoke Moscow to intensify assaults on civilian infrastructure, deploy new waves of hybrid tactics (including cyberattacks and disinformation), and risk igniting a wider conflagration threatening neighboring states.

In contrast, a third scenario sees Russia mounting a robust resurgence. Through nationwide mobilization, accelerated arms production, and refined tactics, Russian forces could breach Ukrainian lines, reclaim lost ground, and erode Ukraine's military cohesion. As battlefield momentum shifts, Western public opinion might sour amid rising casualty counts and economic pressures—potentially fracturing NATO and EU unity and forcing some to reconsider further engagement.

A fourth outcome envisions a negotiated settlement born of mutual exhaustion or intensified diplomacy. A ceasefire would halt active hostilities but depend on complex territorial concessions—likely dividing Donbas or formalizing control over annexed regions. Such an agreement would remain fragile, prone to renewed clashes if either side retains significant combat capabilities or if backers dispute enforcement mechanisms and accountability for wartime crimes.

The most severe contingency contemplates direct NATO involvement. A miscalculated missile strike on alliance territory or a large-scale cyberattack traced to Russia could trigger Article 5, transforming the conflict into a full-scale Russia–NATO war. The resulting clash would imperil global security, disrupt supply chains, and raise the specter of nuclear escalation with catastrophic humanitarian and economic fallout.

These scenarios illustrate the profound uncertainty facing Ukraine, Russia, and the international community. The report concludes that only continuous Western support, flexible diplomacy, robust deterrence measures, and close international coordination can manage these risks, defend Ukrainian sovereignty, and pursue a lasting resolution.

International cooperation is essential to adequately manage risks, defend Ukrainian sovereignty, and pursue a sustainable resolution that benefits long-term peace and security.

TEXT

Racialized Minorities and Elections: The Case of Canada

Liang, B., & Harell, A. (2025). Understanding the Electoral Participation Gap: A Study of Racialized Minorities in Canada. Politics and Governance, 13.

Referencing their 2025 publication in Politics and Governance, Jiaqi Liang, Joseph A. Hamm, and Kimberly Gross refer to the ever-erratic difference in voting between racially minoritized and White groups in the U.S. This article brings together research from political science, psychology, and public administration to analyze the effect of subjective perceptions of procedural justice—i.e., whether voters perceive electoral procedures as fair and inclusive—on the turnout and participation of minoritized groups.

The authors contend that while contemporary accounts of the participation gap tend to emphasize structural barriers such as voter suppression, onerous ID laws, and abstract social disparities, or motivational individual concepts such as political efficacy, these frameworks may overlook the role of perceived fairness in democratic institutions. Perceptions of procedural justice offer a critical but neglected vantage point for analyzing gaps in participation. When citizens, particularly from traditionally disenfranchised communities, believe that electoral institutions are hostile to them or unresponsive, their intention to participate, even if they possess the necessary resources and knowledge, significantly declines.

Central to their argument is the point that procedural justice is more than outcome fairness; it entails whether the rules of the democratic process are perceived to be fair and whether others perceive their participation as having an impact. The authors name four central components of procedural justice: voice, neutrality, respect, and trustworthiness. Without, or a perceived lack of, any of these, disengagement will be more likely, especially among U.S. groups with a history of marginalization within politics.

Liang and Harell support their claims through reference to empirical studies that connect perceptions of exclusion, institutional distrust, and decreased participation among Black, Latino, and other minoritized citizens. These are placed within a broader context of historical patterns of disenfranchisement as well as contemporary concerns with restrictive voting policies, gerrymandering, and discriminatory political discourse. The authors argue that these are not mere perceptions or irrational; rather, they are actual experiences of exclusion and discrimination.

The conclusion of the article is that the participation gap must be confronted by something larger than piecemeal policy change. Institutional action must be aimed at regaining trust and symbolically—and substantively, for that matter—representing fairness. This involves developing genuinely inclusive procedures, providing a voice to disadvantaged groups, and rectifying past injustices. The authors recommend follow-up research on how quantitative and qualitative approaches can be brought together to more fully investigate the impacts of perceived procedural justice on the political participation of racial and ethnic minorities.

Overall, Liang and Harell present a detailed and penetrating analysis of the electoral participation gap, with the salience of perceived procedural justice to the structure of political participation being especially emphasized. Their cross-disciplinary analysis not only provides a roadmap for future research but also reconfirms the importance of institutional reforms to promote an inclusive and participatory democracy.

Four central components of procedural justice: voice, neutrality, respect, and trustworthiness.

Institutional action must aim to regain trust and demonstrate both symbolic and substantive fairness.

2 Applied research

Large Language Models and Wargaming

Chen, Y., & Chu, S. (2024). Large language models in wargaming: Methodology application and robustness. In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (pp. 2894-2903).

This paper by Yuwei Chen and Shiyong Chu, in the CVPR 2024 Workshop on Adversarial Machine Learning, explores the possibility of incorporating large language models (LLMs) in wargaming systems to make strategic decisions. The authors believe that the sophisticated natural language capabilities and reasoning of LLMs can significantly contribute to planning and executing intricate strategic simulations. These models can analyze text-based information, identify patterns, and generate rational, understandable courses of action in uncertain or hostile environments, making them suitable for the needs of wargaming environments.

Traditional AI systems in wargaming typically rely on rigid rule sets or narrow domain models and struggle to adapt to the fluid, open-ended nature of virtual conflicts. By contrast, large language models (LLMs) offer a more flexible approach. In a commercial simulation environment, the authors tested LLM-enhanced agents under standard wargaming scenarios. The results demonstrated not only improved overall performance metrics—such as mission success rates and resource utilization—but also richer, more human-like interactions. These features enabled more dynamic strategic play, helping analysts anticipate adversary reactions and craft original countermeasures on the fly.

Despite these strengths, the paper highlights significant vulnerabilities. LLMs are prone to adversarial inputs—carefully crafted prompts that induce misleading or biased outputs. Even minor prompt modifications can distort the model's rationale or produce inappropriate tactical recommendations, eroding trust in the system. In a defense context, such weaknesses could have serious consequences, from suboptimal decision paths to outright strategic miscalculations. To mitigate these risks, the authors emphasize the need for robust defenses. Key strategies include adversarial prompt detection, using anomaly-detection algorithms to flag suspicious inputs; enhanced calibration, aligning model confidence levels with true performance; and stress-testing for consistency, verifying that outputs remain stable under a variety of plausible question framings and operational conditions.

Robustness is particularly critical in wargaming, where credibility depends on accurate information processing and rational response under uncertainty. Without these safeguards, LLMs risk not only being deceived but also amplifying existing cognitive or strategic biases embedded in their training data.

Beyond wargaming, the authors note that LLMs are increasingly integrated into planning, policy analysis, and operational decision support. Consequently, a clear understanding of both their capabilities and limitations is essential. The paper calls for further research into defensive architectures—such as adversarially trained models and real-time integrity monitoring—to ensure AI-enhanced decision making remains reliable and secure in high-stakes environments.

In conclusion, this study positions LLMs as powerful yet vulnerable tools for strategic simulations. Their ability to generate insights and adaptively reason underpins their promise, but their susceptibility to manipulation underscores the imperative for resilient system design and meticulous oversight. Safe, reliable deployment in national security settings will hinge on marrying these models' innovative strengths with rigorous protections against adversarial threats.

LLMs offered a flexible solution that improved performance and simulated human-like activity, enabling more sophisticated strategic play and helping to anticipate adversary reactions.

Successfully deploying LLMs in strategic environments requires ensuring they are used safely and reliably.

Applied research

Financial Consequences of Geopolitical Turmoil and Trade Restrictions

Oliinyk, O., Grytsyshen, D., Romanchenko, Y., Tokarchuk, O., & Sedliakivska, K. (2025). Financial Consequences of Geopolitical Turmoil and Trade Restrictions. African Journal of Applied Research, 11(1), 439455-.

This article explores the multifaceted and dynamic relationship between geopolitical tension and financial impacts on international and domestic economies. The authors specifically address the overlap of sanctions as a tool of modern geopolitical policy and their secondary economic and humanitarian consequences. Using a qualitative approach based on content analysis and grounded theory, the study adopts a constructivist perspective to examine how geopolitical events cascade through economic systems and reconfigure financial geographies.

The paper argues that geopolitical events—though rooted in politics—carry broad economic repercussions far beyond combat zones. Sanctions, designed to punish wrongful conduct or deter aggression, often pit political objectives against the economic interests of both the sender and target. By imposing measures on governments, firms, and individuals, sanctions can trigger unintended side effects that dilute their intended impact. This tension lies at the heart of ongoing geoeconomic and geopolitical transformations in an interconnected world. Geopolitical instability profoundly affects major economic sectors. Energy markets, in particular, experience price volatility, supply-chain disruptions, and realignments as states navigate sanctions or conflict. Foreign-exchange flows shift as nations reroute exports and imports to bypass closed markets, while stock indices react sharply to heightened uncertainty, reflecting investor anxiety and eroded confidence in economic forecasts. These dynamics underscore the profound interconnectedness of today's economies, where turmoil in one region can ripple across the globe.

Beyond economic costs, the study highlights the humanitarian and moral dimensions of sanctions. Broad measures against entire economies exacerbate social inequality, strain public health systems, and can contravene international humanitarian norms. The authors contend that policymakers must balance geopolitical aims with civilian protection, crafting sanctions that include clear safeguards to mitigate harm to vulnerable populations and adhere to universal legal standards.

For global businesses and financial institutions, these findings carry critical implications. Firms operating in multiple jurisdictions must integrate geopolitical risk into strategic planning, investment decisions, and compliance frameworks. A nuanced understanding of how political shifts affect trade flows, capital markets, and regulatory regimes is essential to maintain resilience and competitive advantage. Meanwhile, policymakers are urged to deploy economic tools like sanctions judiciously, informed by a deep appreciation of their systemic consequences.

Ultimately, this paper enriches the literature on geopolitics and economics by offering a comprehensive analysis of how political tensions and trade restrictions influence financial performance. It calls for a more sophisticated, ethically grounded approach to sanctions and for businesses to cultivate a heightened geopolitical awareness. In doing so, it lays a foundation for more effective policy design and corporate strategies that safeguard both economic stability and humanitarian principles in an increasingly volatile world.

Geopolitical instability impacts large economic activity sectors.

Geopolitical events, although primarily political in nature, have far-reaching economic consequences that extend much beyond the actual theaters of war.

Applied research

Geopolitical Tensions vs. Corporate Investment

Dissanayake, R., Mehrotra, V., & Wu, Y. (2018). Geopolitical risk and corporate investment. SSRN Electronic Journal, 143-.

This article outlines how rising geopolitical tensions impact business investment choices in America. Utilizing the Geopolitical Risk Index (GPR) built by Caldara and Iacoviello (2018), the authors gauge the impact of geopolitical uncertainty on firm-level capital expenditures over a long period from 1985 through 2017. The paper's pivotal hypothesis is that geopolitical risk constitutes a new form of uncertainty with significant implications for firm investment, especially in cases where investments are irreversible or financially costly to reverse.

The empirical study shows that heightened geopolitical risk leads to a marked decline in business investment. For instance, a one-standard-deviation rise in the GPR index cuts average investment by 13.2% over the following five quarters. This impact endures well beyond the initial spike in uncertainty and remains robust after controlling for macroeconomic and policy uncertainty, indicating that geopolitical risk operates through a unique channel.

A key contribution is the paper's distinction between geopolitical threats (GPT)—rising tensions or conflict threats—and geopolitical acts (GPA)—actual conflicts or interventions. The authors find that threats exert a deeper, longer-lasting drag on investment than acts themselves. In other words, firms are more hampered by uncertainty about potential future events than by the events once they occur. The study also identifies which firms are most vulnerable. Capital-intensive companies, with largely irreversible investments, show the smallest responses to rising GPR. In contrast, multinationals with substantial foreign exposure cut investment more sharply than domestically focused firms, reflecting the complexity and cost of adjusting fixed international operations to shifting political risks.

Interestingly, while geopolitical risk depresses investment, it does not materially affect corporate dividend payments. This suggests that firms treat geopolitical shocks as temporary when managing shareholder returns. Rather than reduce dividends—which could signal distress or undermine confidence—managers preferentially scale back investment plans.

Overall, the paper illuminates a crucial but underexplored link between geopolitical risk and firm behavior. It demonstrates that firms actively adjust capital spending in response to international political tensions, especially when risks threaten long-term strategic projects. By highlighting the persistent and asymmetric effects of geopolitical threats, this study enriches both theoretical investment literature under uncertainty and practical understanding of global corporate finance in an era of elevated political volatility.

Geopolitical risk constitutes a new form of uncertainty with significant implications for firm investment.

A one-standard-deviation increase in the GPR index reduces the average investment by 13.2% over the subsequent five quarters.

Applied research

Geopolitics and International Research Cooperation

Bamberger, A., & Huang, T. Y. (2025). From irreversible openness to protectionism: geopolitics and international research cooperation in the European Union. Journal of Education Policy, 40(1), 1943-.

This article discusses the shift in the EU's international research cooperation strategy, marked by rising geopolitical tension. Stepping back from critical geopolitics and the spatial politics of (re)bordering, the authors trace the historical evolution of European science policy from promoting liberal internationalism and open cooperation to a more security-oriented and selective regime around the strategic autonomy of the EU.

From 2012 to 2022, the EU pursued an integrative international research policy grounded in globalization, open science, and cross-border collaboration. Horizon 2020 exemplified this openness by fostering partnerships beyond EU borders, supporting large-scale projects with global reach. However, this one-way model of openness weakened as external threats and internal strains emerged. Bamberger and Huang describe a growing geopolitical consciousness in EU research policy, driven by concerns over espionage, technology leakage, and critical vulnerabilities in open scholarship infrastructure.

Several catalytic events accelerated this shift. Russia's occupation of Crimea in 2014 and its full-scale invasion of Ukraine in 2022 raised immediate security alarms, prompting the EU to reduce dependencies on adversarial states. Simultaneously, high-profile cyber-attacks linked to Chinese actors, illicit technology transfers, and academic freedom challenges in Hungary led EU policymakers to reassess potential research collaborators—regardless of their nominal alignment. These incidents spurred the European Commission to reconceive openness not as an unconditional principle but as contingent upon political and strategic alignment.

Bamberger and Huang argue that the EU has begun to "re-border" its science space, drawing clearer lines between "like-minded" partners and strategic risks. This is evident in the introduction of more rigorous security screening under Horizon Europe, tighter controls on foreign researchers' access to sensitive domains, and the strengthening of links between research programs and industrial competitiveness agendas. Rather than abandoning global cooperation, the EU is adopting a protective paradigm—engaging selectively with international actors while safeguarding its intellectual property, critical technologies, and core academic values.

Importantly, this recalibration does not signify a retreat from genuine collaboration. Instead, it acknowledges the increasingly complex interdependence of science, technology, and geopolitics. As strategic competition intensifies in fields like artificial intelligence, biotechnology, and quantum research, the EU seeks to strike a careful balance between openness and resilience. The authors caution, however, that these protective measures—while bolstering security—risk undermining the foundational ethos of global scientific collaboration and the free flow of knowledge that drives innovation.

Ultimately, Bamberger and Huang's analysis offers a timely examination of the EU's geopolitical realignment in science policy, illustrating its evolution from an ideal of scientific cosmopolitanism toward a more strategic, conditional model of international cooperation that reflects contemporary global uncertainties.

Between 2012 and 2022, the EU adopted an international research policy based on globalization, open science, and cross-border knowledge sharing.

Global uncertainty is pushing a once-open research structures towards more strategic, selective partnerships.

Applied research

Nuclear Energy: Intellectual Property at the Center of Geopolitical Battles

Meyer, T. (2025). Patents for power: Intellectual property and the geopolitics of nuclear energy technologies. Nuclear Engineering and Technology, 103470.

In this paper, Meyer argues that intellectual property (IP) lies at the heart of the geopolitical struggle over civilian nuclear power. Moving beyond traditional analyses of uranium supply chains, proliferation risk, and nuclear alignments, he shows that patents on reactor technologies increasingly dictate which countries may develop, export, or acquire nuclear capabilities—and thus sustain global technological hierarchies.

Drawing on science and technology studies and international relations, Meyer employs Barnett and Duvall's power typology to demonstrate that patents function not merely as legal safeguards for innovation but as instruments of structural and institutional power. Control over essential technological know-how enables patent holders to set access conditions, shape markets, and constrain rivals' freedom in the nuclear arena.

To substantiate this claim, the study builds an unprecedented database of over 35,000 nuclear-energy patents issued worldwide since 2000, categorized by filing country, reactor type, safety systems, fuel-cycle technology, and patent office jurisdiction. Contrary to the perception that Russia dominates the market solely through a state-backed export strategy, Meyer's data reveal that the United States, France, Japan, and the United Kingdom still hold substantial patent portfolios—and that emerging powers such as South Korea and China are rapidly increasing their patent filings.

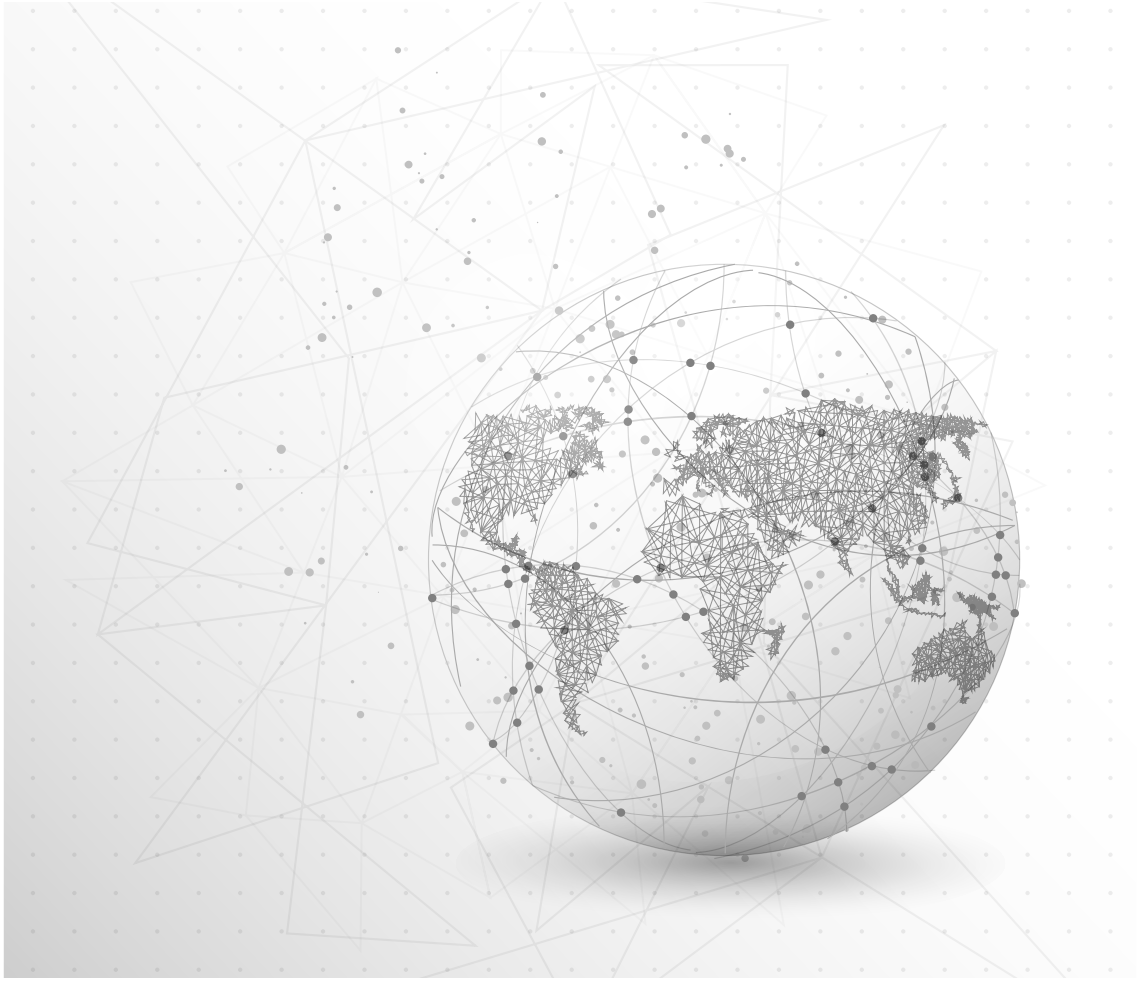
Meyer further examines how exporting states use patents strategically, filing not only in their domestic markets but also in potential client countries. This pre-emptive approach allows suppliers to shape the legal and technological terms of future projects, positioning themselves advantageously in tender processes while limiting recipients' technological autonomy. In this way, the global IP system becomes a contested battlefield in the wider game of energy supremacy. Recipient nations, meanwhile, seek to reclaim agency via indigenization policies. India and China, for example, have bolstered domestic nuclear innovation to reduce reliance on foreign IP and evade licensing constraints. While these efforts appear technical or economic, they are fundamentally political, underscoring the imperative to break geopolitical dependencies and assert sovereign control over energy futures.

Meyer's analysis frames IP as a critical—but often overlooked—vector of geopolitical power in nuclear energy. Patents, he contends, are far from apolitical tools; they advance strategic national interests. This insight calls for a re-examination of existing IP frameworks and greater awareness of the political stakes embedded in technological hegemony and global energy governance.

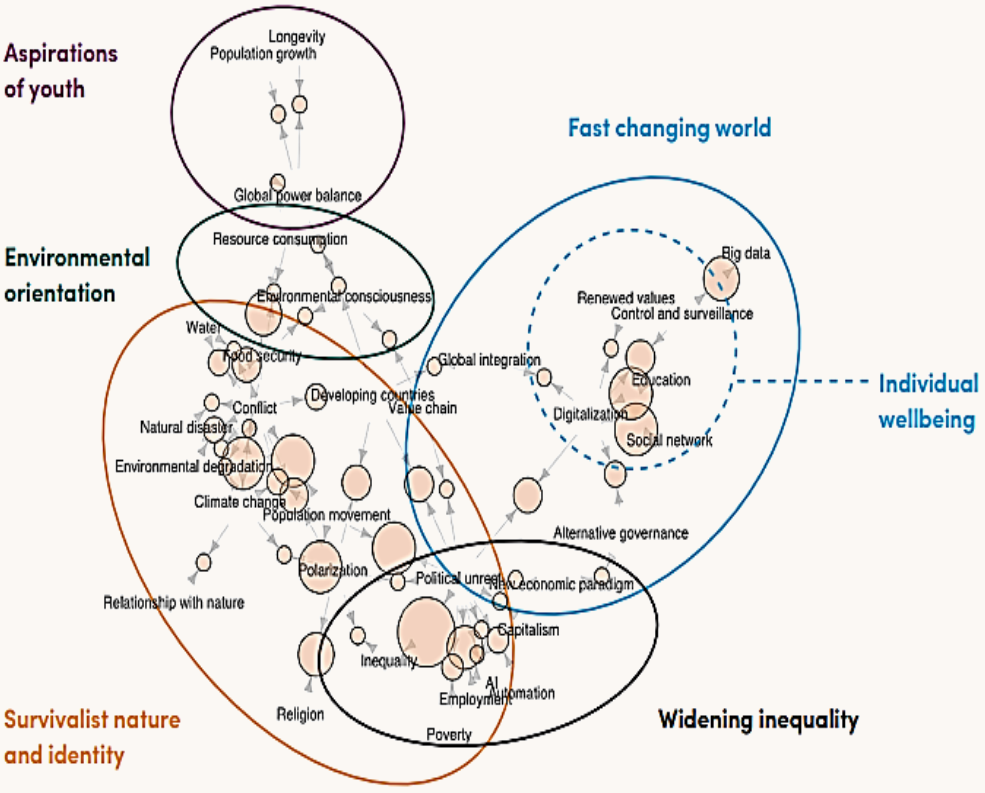
Patents on nuclear reactor technologies determine the conditions under which countries are permitted to develop and sustain global technological power hierarchies.

Control of key technological proficiency allows countries the ability to define access guidelines, decide upon markets, and restrict others' liberty in the nuclear arena.

3 The future in numbers

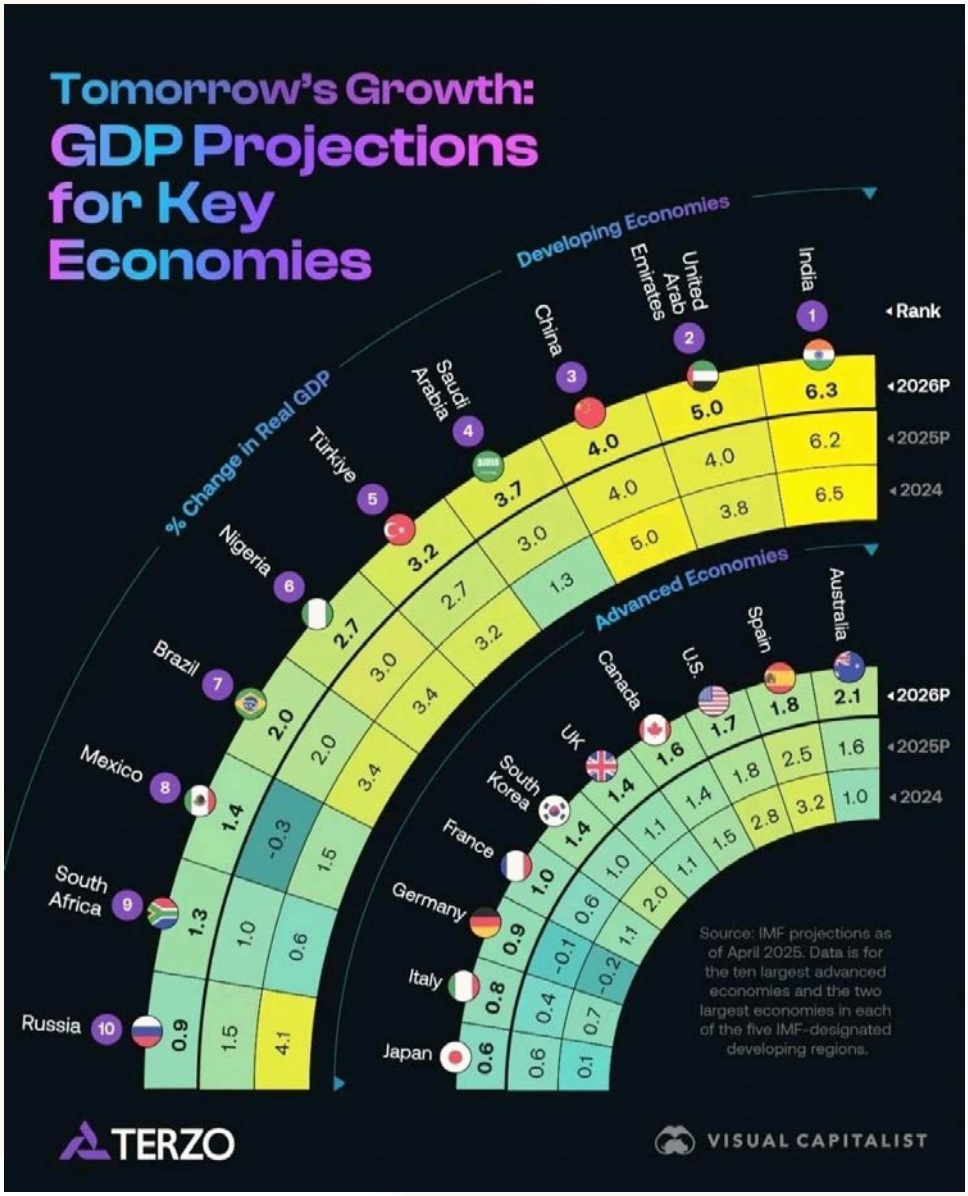


Interlinkages of Changes in Society by 2050: Culture and Governance

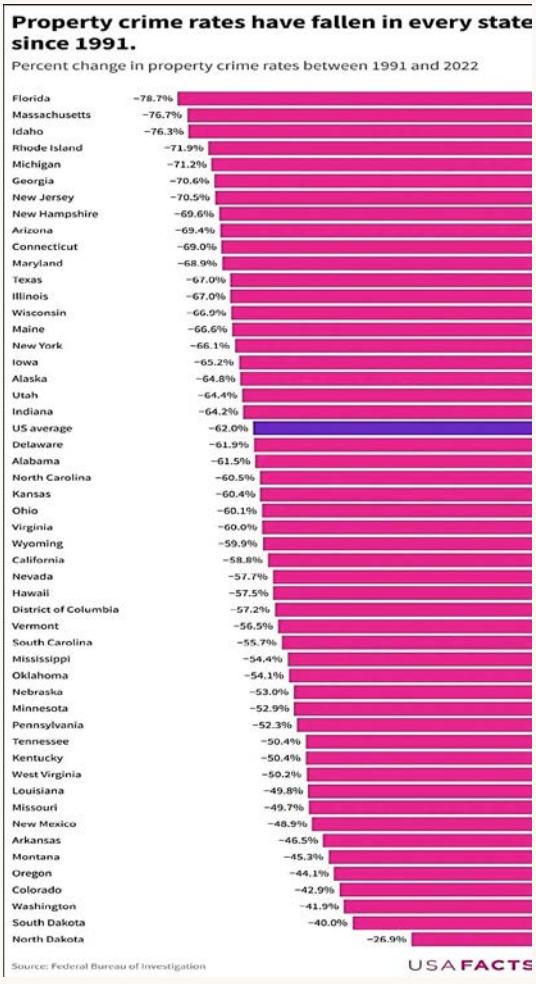


Source: Global Foresight Survey of Potential Changes in Society by 2050.

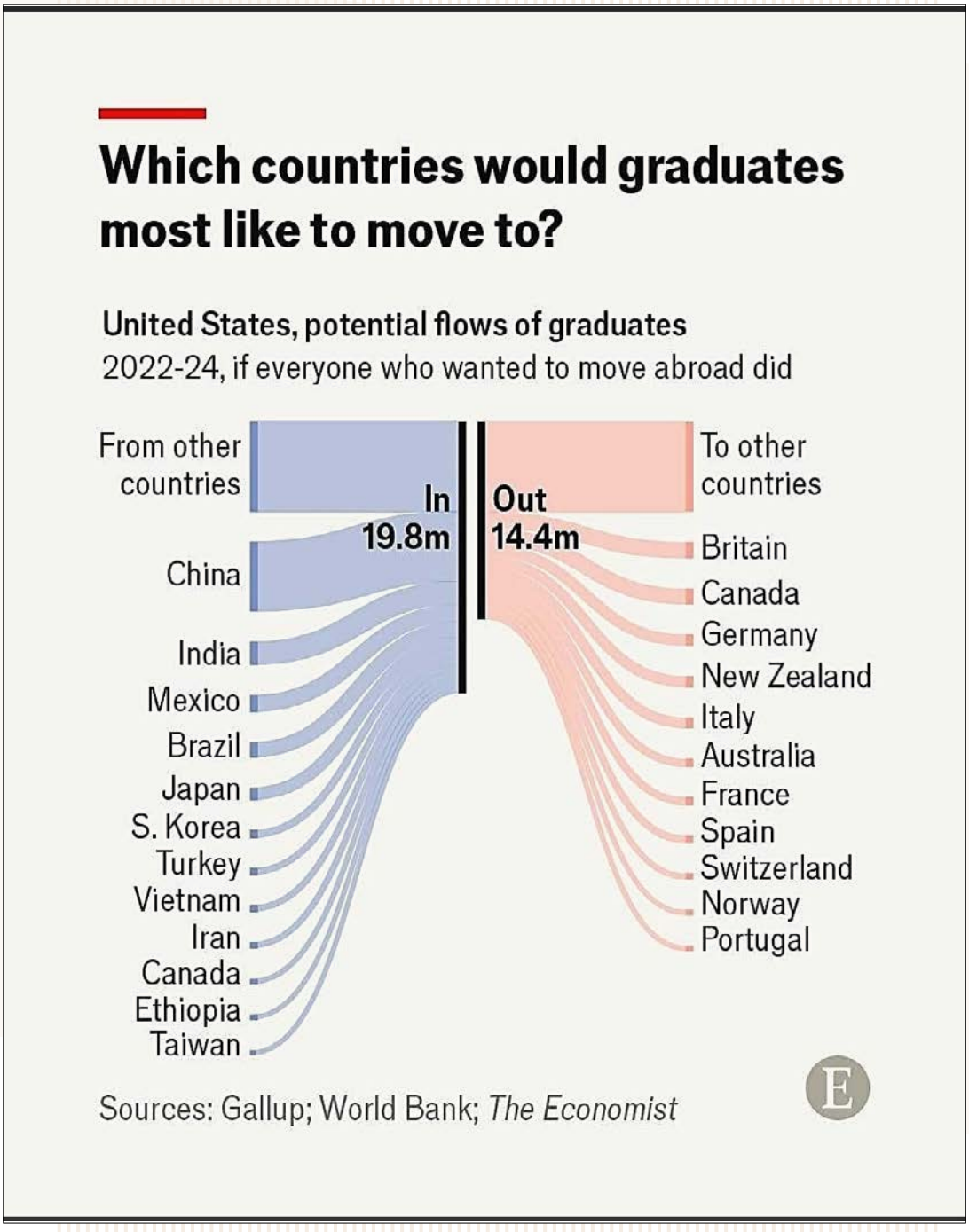
The World's Most Educated Countries



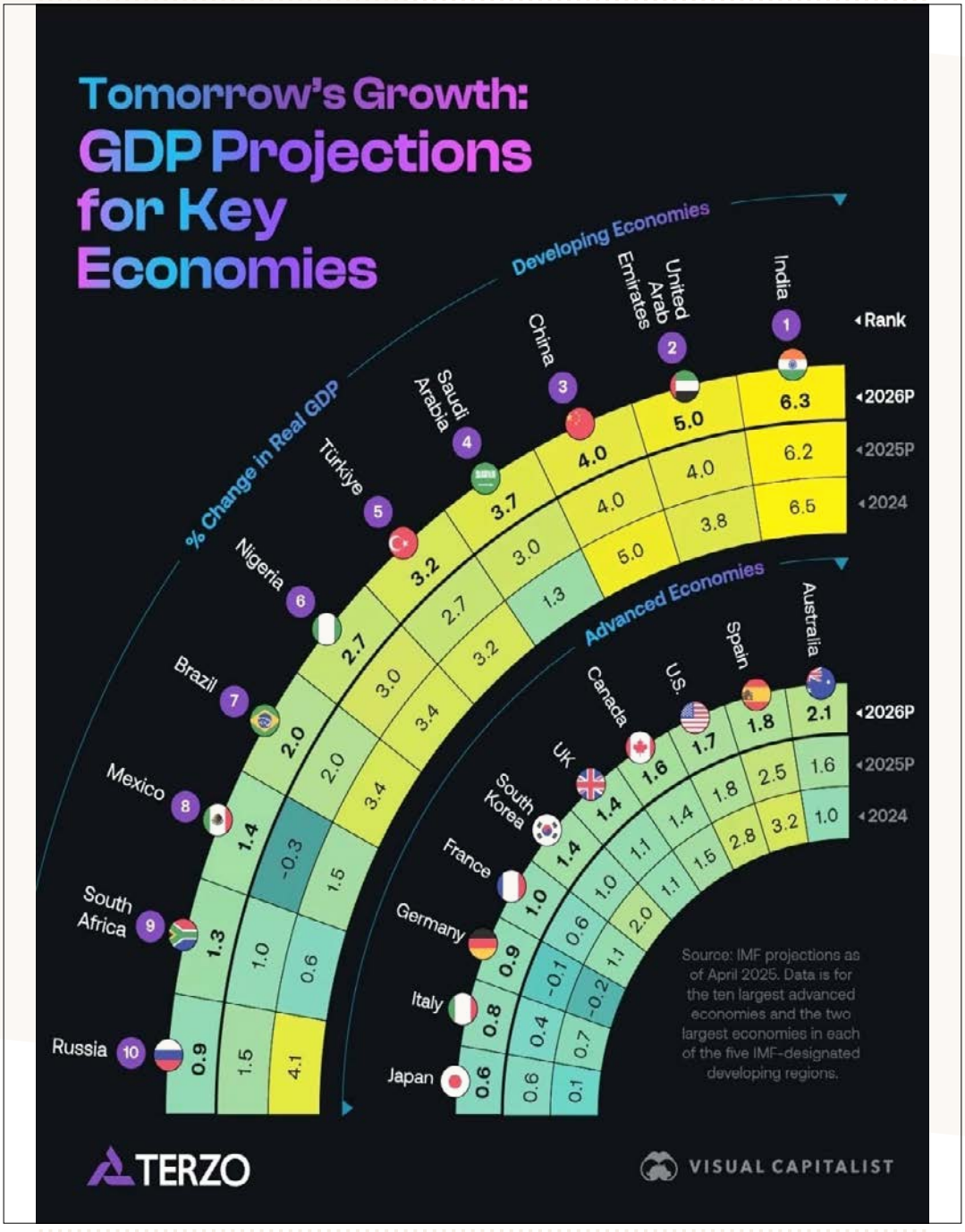
Race and Income Linked to Predictions about the Size of the Social Classes in 2050



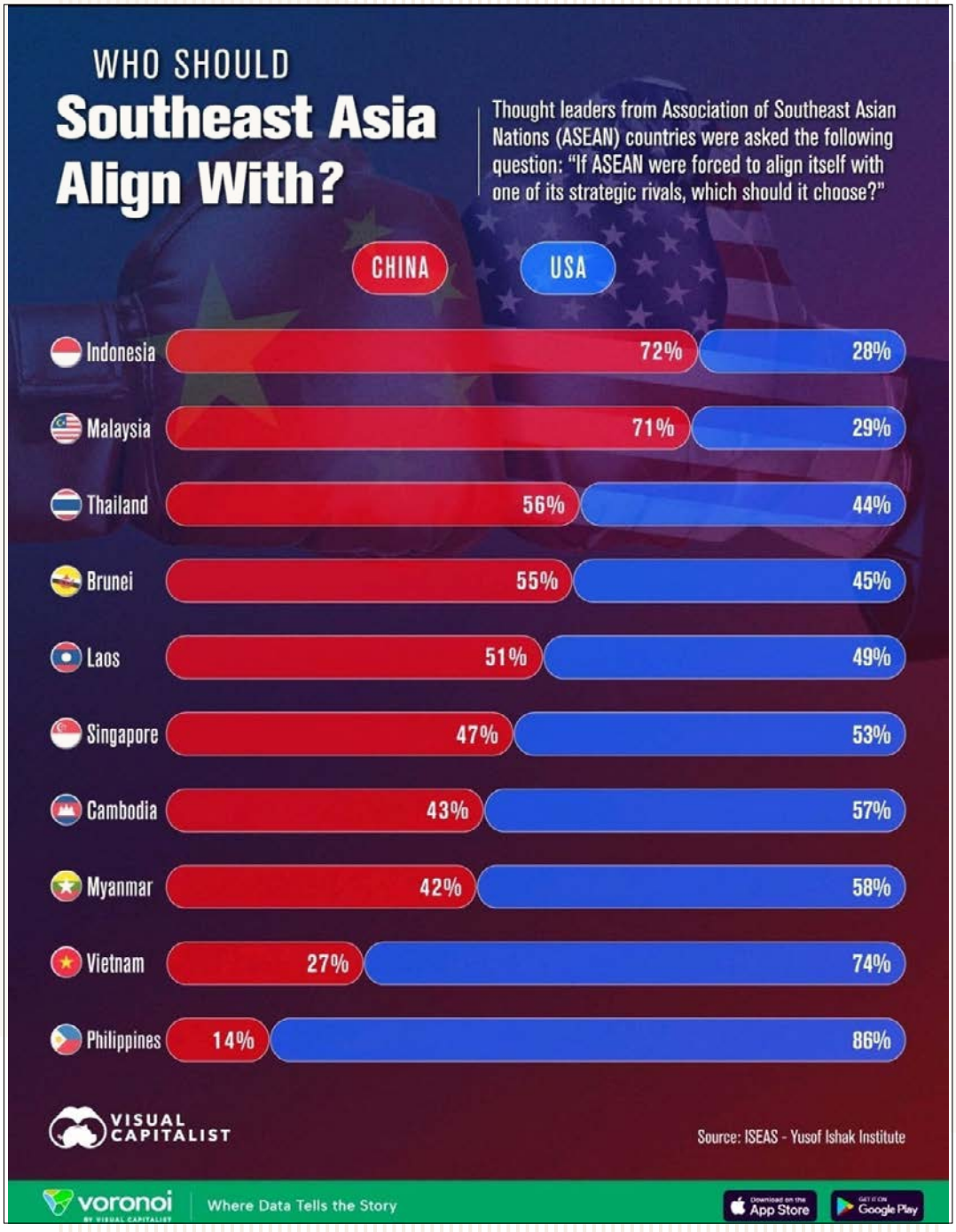
The World's Most Educated Countries



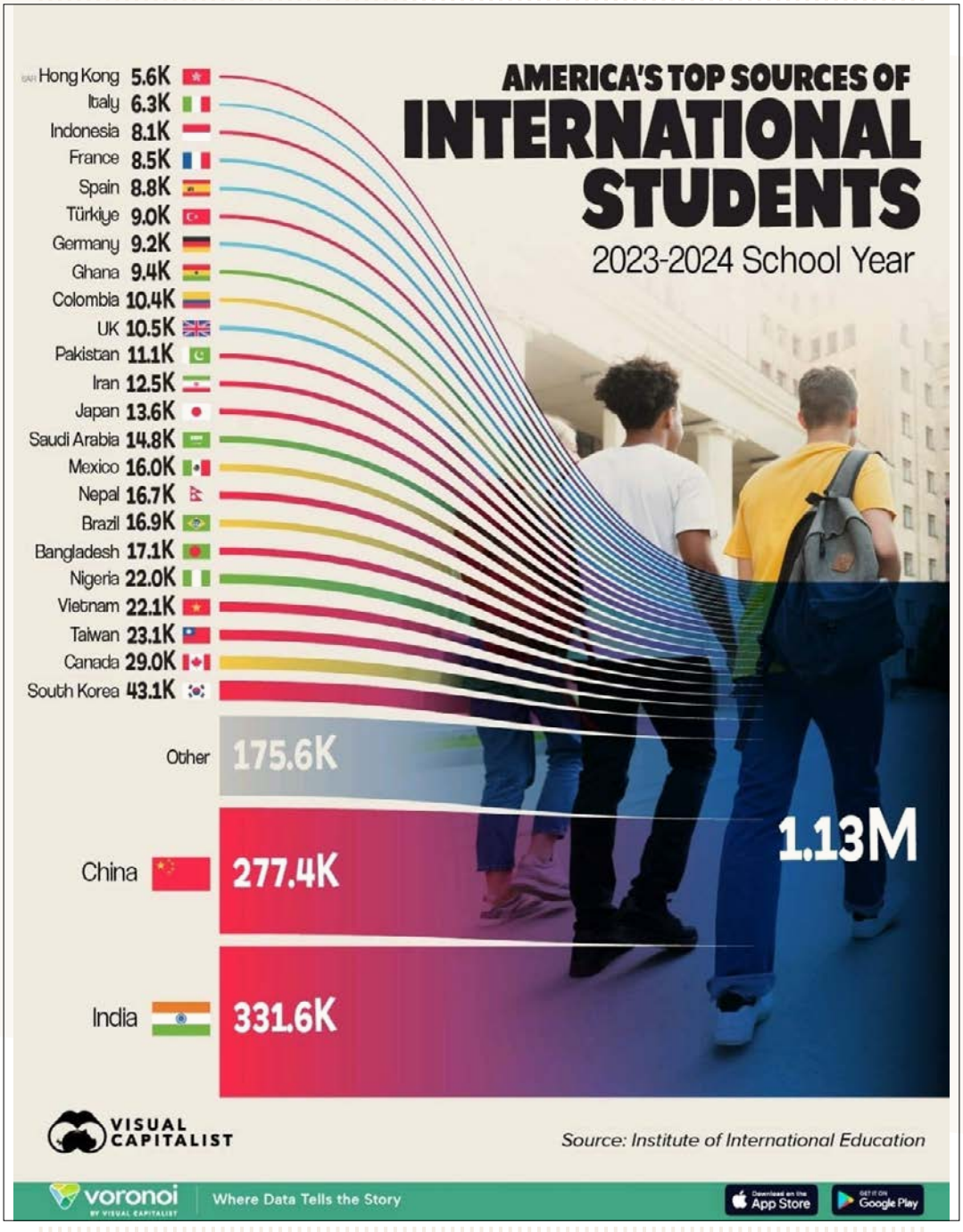
The World's $12.5 Trillion Underground Economy



ChatGPT's Rising Traffic vs. Other Top Websites



The Energy Demand of U.S. Data Centers (2023-2030P)



BREAKING DOWN

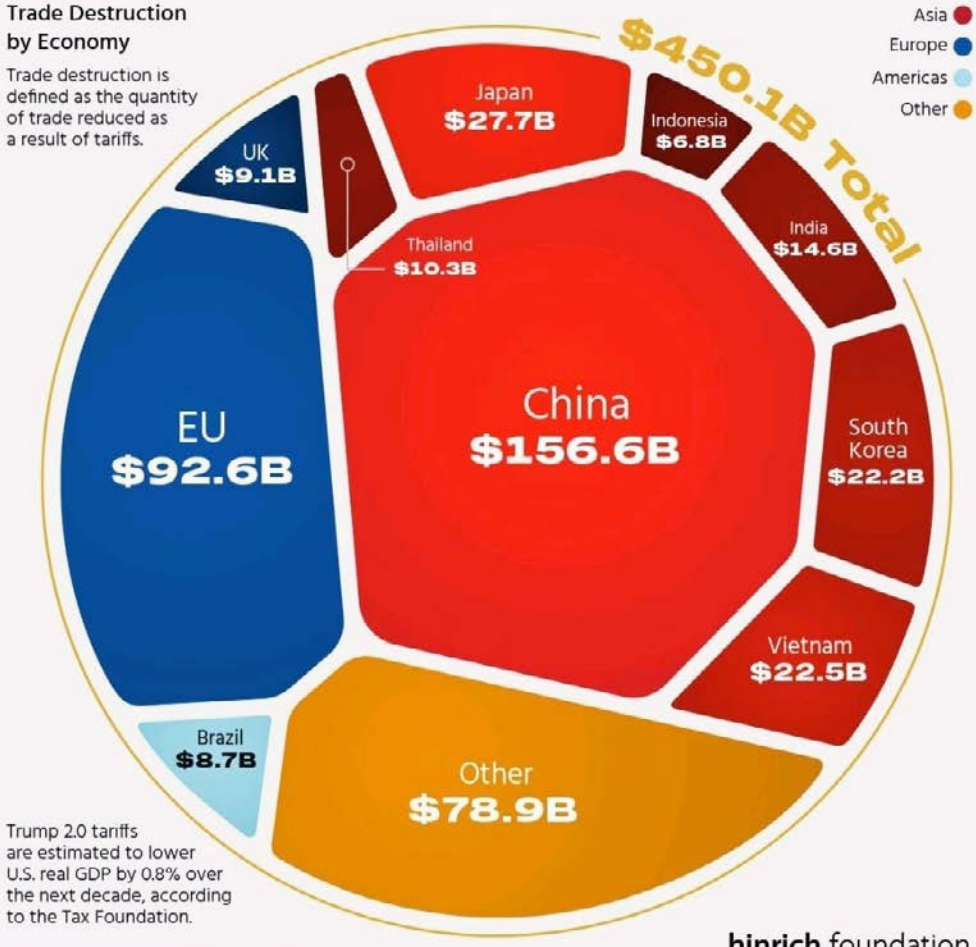
$450.1 Billion of Trade Destruction

from Trump 2.0 Tariffs

The UN has crunched the numbers projecting the ripple effects of Trump's May 12th tariffs using its new Trade Intelligence and Negotiation Adviser (TINA) simulator. Which economies are bracing for the biggest hits?

Trade Destruction by Economy

Trade destruction is defined as the quantity of trade reduced as a result of tariffs.



Trump 2.0 tariffs are estimated to lower U.S. real GDP by 0.8% over the next decade, according to the Tax Foundation.

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Source: United Nations Trade Intelligence and Negotiation Adviser. May 12th, 2025.
*Note: Data includes 170 countries plus the 27 EU member states that were threatened with tariffs from April 2025 onward. Canada and Mexico are excluded, as they were targeted in earlier rounds of Trump 2.0 tariffs.