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THOUGHT LEADERSHIP BRIEF

Radical Novelties in Critical Technologies: How do China, the US and the EU fare?

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Photo by Vinicius Vieira ft on Pexels

KEY POINTS

- Relying on simple patent counts gives a distorted view of technological power. To see the real picture, we must track radical novelties—patents can be considered most groundbreaking (not patented before) and worth replicating.
- The US leads in quantum technology and generative AI, while China excels in specific AI subfields like aerial vehicles. China also leads in many semiconductor areas, but the US holds an edge in high-value design related fields.
- China has secured its position as a powerhouse in manufacturing and deployment, leading in applied AI and semiconductor packaging, while actively moving up the value chain into foundational research.
- The EU struggles with fragmentation. While it possesses pockets of scientific excellence, it lacks the integrated scale needed to compete for overall leadership against the US and China.

ISSUE

Technological innovation has moved beyond simple economic competition; it is now the primary engine of strategic power. This battle is currently concentrated in three critical, interconnected fields: artificial intelligence (AI), semiconductors, and quantum computing. Advances in one often unlock new capabilities in the others, meaning leadership in this triad largely dictates global influence.

Traditional metrics like patent counts or R&D spending are often misleading. They can be inflated by incremental improvements or strategic filing behaviors that do not reflect true innovation. To get a more accurate picture, we used a Large Language Model (LLM) to analyze patents from the major US, European, and international offices (USPTO, EPO, and PCT) filed between 2019 and 2023. We specifically looked for radical novelties—innovations that appeared for the first time in our dataset (dating back to 1979) and were subsequently replicated in at least five other patents. This method filters out the noise and highlights the genuine breakthroughs that shape the future.

ASSESSMENT

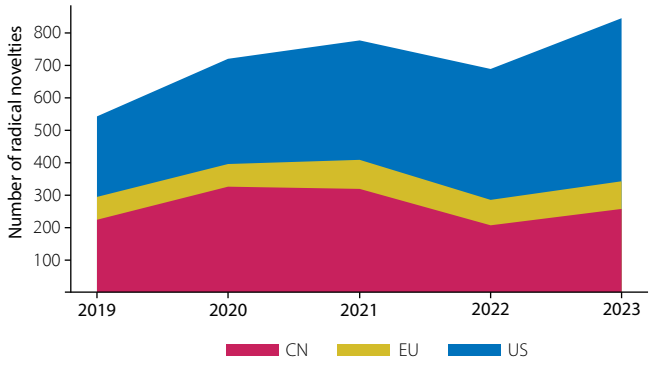
Artificial Intelligence

The general trend in AI reveals a clear hierarchy: the United States leads, China follows closely, and the EU lags behind.

The United States is the primary source of radical innovation, dominating the core technologies that define the frontier. American strength lies in general purpose subfields like machine learning, natural language processing, and generative AI. Because the US ecosystem combines massive datasets with advanced computing infrastructure, it effectively sets the standards for the rest of the world.

China's strength is different but complementary. It leads the world in applied subfields, specifically computer vision, image processing, and aerial vehicles. These are the technologies essential for integrating AI into the real economy—manufacturing, transport, and infrastructure. However, China is not restricted to application; data shows it is increasingly producing radical innovations in foundational areas, slowly narrowing the gap with the US.

Figure 1. Evolution of radical novelties in AI (2019-2023)



Source: Bruegel based on WIPO.

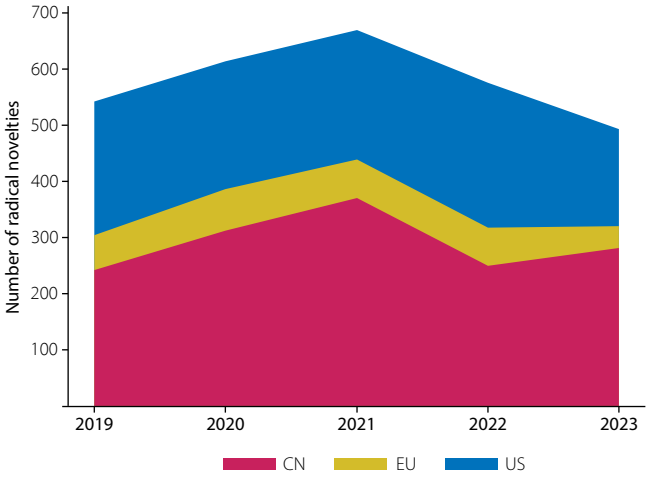
Semiconductors

In semiconductors, China has a strong position when compared with the EU, and even the US. The landscape is defined by a sharp division of labor across the value chain.

The United States dominates the upstream segment: design and architecture. This is where the industry's value is largely captured. By controlling the brains of the chips, US firms determine performance and energy efficiency, allowing them to exert influence over the global trajectory of the industry even without domestic manufacturing dominance.

China, conversely, has become the leader in manufacturing innovation. Its radical novelties are concentrated in memory devices, display technologies, and manufacturing. These are critical for expanding production capacity and improving yields. State support and a massive local market have allowed China to strengthen its position significantly in these physical aspects of the supply chain.

Figure 2. Evolution of radical novelties in semiconductors (2019-2023)



Source: Bruegel based on WIPO.

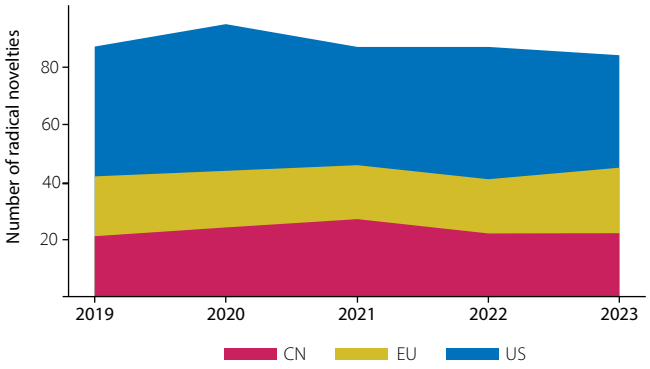
Quantum Computing

The trend in quantum computing is more concentrated, with the United States currently holding the advantage in building functional systems.

US innovation is focused on hardware, system and control technologies. These are the complex engineering hurdles that must be cleared to turn theoretical physics into scalable, commercial computers.

China has historically focused on quantum cryptography, cybersecurity and communication—areas with immediate security applications. However, the data shows a shift. China is now expanding its innovation into quantum hardware, signaling a strategic intent to compete directly with the US in general-purpose quantum computing. The EU occupies an intermediate position, contributing meaningfully to hardware networking and photonics research but lacking the commercial scale to lead.

Figure 3. Evolution of radical novelties in quantum computing (2019-2023)



Source: Bruegel based on WIPO.

IMPLICATIONS

There is a distinct divergence in how the superpowers innovate. The United States leads in the abstract and systemic layers, while China leads in the physical and deployment layers. This creates a dependency. The US controls the intellectual chokepoints, but China controls the capacity to scale these innovations into tangible products. For business leaders, this means true decoupling is nearly impossible without massive economic pain.

Another finding is China's movement upstream. In both AI and quantum computing, China is no longer just an applier of technology; it is beginning to produce radical novelties in foundational domains. If this trend continues, the traditional separation of labor—where the West invents and the East manufactures—will collapse. Challenges the long-held assumption that the US will always maintain a qualitative edge. If China achieves parity in foundational research while retaining its manufacturing dominance, the balance of technological power will shift decisively in its favor.

For the European Union, the data serves as a warning. Having excellence in niches like sensors or robotics is not enough to secure strategic autonomy. In technologies that require massive capital and data integration, fragmentation is a fatal flaw. Without a unified market or a coordinated strategy to scale its innovations, Europe risks becoming a rule taker, adopting standards set by US architecture or Chinese manufacturing specifications. To remain relevant, EU policy must shift from funding scattered research projects to building integrated ecosystems that can support scale.

Finally, innovation policy needs to be more surgical. Simply increasing R&D budgets or filing more patents is a blunt instrument. The US needs to protect its edge in design while desperately trying to rebuild manufacturing innovation. China needs to continue its push into basic research to reduce its vulnerability to Western design restrictions. For both, the battle is no longer about who spends the most, but who can sustain radical innovation across the entire technology stack.



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Alicia holds a PhD in Economics from George Washington University and has published extensively in refereed journals and books. She is also very active in international media.

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