Success of DeepSeek and potential benefits of free access to AI for global-scale use

Samuel Ariyo Okaiyeto[1], Junwen Bai[2], Jun Wang[3], Arun S Mujumdar[4], Hongwei Xiao[1*]

(1. *College of Engineering, China Agricultural University, Beijing 100083, China*;
2. *School of Food and Biological Engineering, Jiangsu University, Zhenjiang 212013, China*;
3. *College of Economics and Management, China Agricultural University, Beijing 100083, China*;
4. *Department of Bioresource Engineering, McGill University, Ste. Anne de Bellevue, Quebec, Canada*)

The introduction of DeepSeek R1, an AI language model developed by the Chinese AI lab DeepSeek, has made a significant impact in the tech world[1]. Within a week of its release, the app surged to the top of download charts, triggered a massive $1 trillion (£800 billion) sell-off in tech stocks, and prompted intense reactions from Silicon Valley. As artificial intelligence (AI) continues to evolve rapidly, it has become a cornerstone of global technological progress, with nations vying to push the boundaries of what AI can achieve. While companies like OpenAI and Nvidia in the United States have led AI research and deployment, the rise of DeepSeek represents a noteworthy shift in the landscape. DeepSeek's innovative use of reinforcement learning (RL) and model distillation has significantly enhanced the reasoning capabilities of large language models (LLMs), while also advancing more efficient algorithms that reduce computing resource and energy consumption. This paper explores the factors behind DeepSeek's success and its broader impact on making AI more accessible and efficient, especially for the developing world. By contributing to AI's global accessibility, China's advancements hold great potential to positively transform diverse sectors, from agriculture to energy and healthcare, supporting the goal of peaceful coexistence and improving life around the globe.

OpenAI's o3 and DeepSeek's R1 represent significant advancements in reasoning models, but R1's open-source nature and cost-efficiency have the potential to challenge America's AI dominance. While o3 excels in coding and complex reasoning tasks, outperforming R1 in benchmarks like Codeforces and SWE-bench Verified, R1 shines in mathematical reasoning and offers a highly cost-effective alternative, being up to 95% cheaper than OpenAI's models[2]. R1's architecture, based on a Mixture of Experts (MoE) design and reinforcement learning, enables efficient computation and advanced reasoning capabilities, including self-verification. Its open-source accessibility fosters community-driven development, democratizing AI and promoting transparency, which could accelerate innovation and break down monopolies. By lowering the barrier to entry and allowing for rapid improvements, R1 positions itself as a strong contender for global AI leadership, potentially disrupting traditional power structures in the field and promoting more widespread access to advanced AI technology[2].

DeepSeek R1 is an advanced AI model built on reinforcement learning (RL) principles, designed to push the boundaries of reasoning and problem-solving capabilities. Unlike traditional models, R1 leverages a Mixture of Experts (MoE) architecture with 671 billion parameters, activating only a fraction of them during each forward pass to optimize computational efficiency. R1's training methodology focuses on reinforcement learning with Group Relative Policy Optimization (GRPO), enabling the model to autonomously develop sophisticated reasoning skills, such as chain-of-thought reasoning and self-verification. DeepSeek-AI (2025)[3] affirms that a standout feature of this self-evolution is the development of advanced behaviors as the model's test-time computation expands. Behaviors like reflection, where the model reassesses and reconsiders its previous steps, and the exploration of alternative problem-solving methods, arise organically. These behaviors are not directly programmed but emerge from the model's interaction with its reinforcement learning environment. This spontaneous development greatly improves DeepSeek-R1's reasoning abilities, allowing it to address more complex tasks with improved efficiency and accuracy.

DeepSeek's success can be attributed to several key factors. First, DeepSeek has pioneered the use of large-scale reinforcement learning (RL) to enhance the reasoning capabilities of LLMs. Unlike traditional methods that rely heavily on supervised fine-tuning (SFT), DeepSeek's R1 model demonstrates that reasoning capabilities can be incentivized purely through RL. This approach allows the model to explore complex problem-solving strategies autonomously, leading to the emergence of sophisticated behaviors such as self-verification, reflection, and the generation of long chains of thought (CoT). The success of DeepSeek-R1-Zero, which achieves performance comparable to OpenAI's o1 series models, underscores the efficacy of this innovative approach. Secondly, DeepSeek-R1, the successor to DeepSeek-R1-Zero, incorporates multi-stage training and cold-start data to further enhance reasoning performance[3]. By fine-tuning the base model with thousands of long CoT examples before applying RL, DeepSeek-R1 addresses the readability and language-mixing issues encountered by DeepSeek-R1-Zero. This iterative training pipeline, which includes reasoning-oriented RL, rejection sampling, and supervised fine-tuning, results in a model that achieves performance on par with OpenAI's o1-1217 on reasoning tasks. DeepSeek has also made significant strides in model distillation, transferring the reasoning capabilities of larger models to smaller, more efficient ones. By fine-tuning open-source models like Qwen and Llama with reasoning

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Biographies: Samuel Ariyo Okaiyeto, PhD candidate, research interest: food drying technology and equipment, Email: samuelariyo496@gmail.com; **Junwen Bai**, Associate Professor, research interest: food engineering, Email: baijunwen@hotmail.com; **Jun Wang**, Lecturer, research interest: futures and agricultural market, Email: cauwanjun@cau.edu.cn; **Arun S Mujumdar**, Professor, research interest: drying fundamental research and applications, Email: arunmujumdar123@gmail.com.

***Corresponding author: Hongwei Xiao**, Professor, research interest: agricultural products processing technology and equipment. College of Engineering, China Agricultural University, No.17, Qinghua East Road, Beijing 100083, China, Tel: +86-10-62736900, Email: xhwcaugxy@163.com.

data generated by DeepSeek-R1, DeepSeek has created distilled models that outperform non-reasoning models like GPT-4o across various benchmarks. This approach not only democratizes access to advanced reasoning capabilities but also reduces the computational resources required for deployment, making AI more accessible and scalable.

By developing state-of-the-art AI models independently, DeepSeek reduces China and other developing countries' dependency on American AI technologies. DeepSeek's ability to produce models that rival OpenAI's in performance demonstrates that China can compete at the highest levels of AI research and development. Nvidia's dominance in the AI hardware market, particularly in GPUs, has been a significant barrier to entry for other nations[4]. However, DeepSeek's focus on model distillation and efficient training pipelines reduces the reliance on massive computational resources. By optimizing the use of available hardware and developing smaller, more efficient models, DeepSeek challenges Nvidia's monopoly and paves the way for more diverse and accessible AI hardware solutions. This will help the developing world access AI for their development in diverse fields ranging from agriculture to energetics to medical treatment. We believe this contribution will have a huge influence on the betterment of life around the globe, leading to peaceful coexistence.

DeepSeek's commitment to open-source innovation, as evidenced by the release of DeepSeek-R1-Zero, DeepSeek-R1, and their distilled models, fosters global collaboration in AI research. By sharing their advancements with the research community, DeepSeek encourages the development of alternative AI ecosystems that are not dominated by American companies. This open-source approach not only accelerates innovation but also creates a more level playing field for AI research worldwide. DeepSeek's use of large-scale RL without supervised fine-tuning represents a significant departure from traditional AI training methods. This approach allows the model to develop reasoning capabilities autonomously, leading to the emergence of sophisticated behaviors that are not explicitly programmed. In contrast, OpenAI's models rely heavily on supervised data and fine-tuning, which can limit their ability to explore novel problem-solving strategies. DeepSeek's multi-stage training pipeline, which includes cold-start data, reasoning-oriented RL, and supervised fine-tuning, addresses the limitations of pure RL approaches. This iterative process not only enhances reasoning performance but also improves the readability and coherence of the model's outputs. OpenAI's models, while highly performant, do not employ such a comprehensive training pipeline, potentially limiting their ability to handle complex reasoning tasks as effectively.

DeepSeek's focus on model distillation allows for the creation of smaller, more efficient models that retain the reasoning capabilities of larger models. This approach reduces the computational resources required for deployment, making advanced AI more accessible. In contrast, OpenAI's models are typically large and resource-intensive, requiring significant computational power for training and inference. Nvidia's GPUs, while powerful, are expensive and not always accessible to researchers and developers outside of well-funded institutions. DeepSeek's commitment to open-source innovation is a significant advantage over OpenAI's closed ecosystem. By releasing their models and training pipelines to the public, DeepSeek fosters collaboration and accelerates the pace of AI research. OpenAI, on the other hand, has been criticized for its lack of transparency and limited access to its models, which can stifle innovation and create barriers to entry for smaller research teams. Based on the game change brought by DeepSeek, OpenAI released a new o3-mini model, which is free to the public. At the same time, Microsoft also released the o1 inference model for free to all Copilot users.

The success of DeepSeek has not only challenged America's AI dominance but also had a significant impact on the ambitious "Stargate Project", a $500 billion AI infrastructure initiative announced by President Donald Trump. The "Stargate Project", a collaboration between Oracle, SoftBank, and OpenAI, aims to build the largest artificial intelligence infrastructure in U.S. history[5]. However, the rapid advancements made by DeepSeek, particularly in the areas of reinforcement learning and model distillation, have raised questions about the viability and necessity of such a massive investment in AI infrastructure. The "Stargate Project" was envisioned as a way to solidify America's position as the global leader in AI by creating a state-of-the-art AI infrastructure that would support the development of next-generation AI models. However, DeepSeek's success has demonstrated that cutting-edge AI technology can be developed without the need for exorbitant investments in infrastructure. By leveraging efficient training pipelines and model distillation techniques, DeepSeek has shown that it is possible to achieve state-of-the-art performance with significantly lower computational resources. This has led to a reevaluation of the Stargate Project's goals, as some critics argue that the project may no longer be necessary in light of DeepSeek's breakthroughs.

DeepSeek's success has significant implications for China's scientific research system. By demonstrating that Chinese researchers can develop state-of-the-art AI models independently, DeepSeek strengthens China's position as a global leader in AI research. This success not only enhances China's technological capabilities but also boosts the confidence of Chinese researchers and institutions in their ability to compete on the global stage. DeepSeek's innovative approaches to AI research, particularly in reinforcement learning and model distillation, encourage interdisciplinary collaboration within China's scientific research system. By bringing together experts from computer science, mathematics, and cognitive science, DeepSeek fosters a more holistic approach to AI research that can lead to breakthroughs in other fields as well. DeepSeek's commitment to open-source innovation has the potential to transform China's scientific research system. By sharing their advancements with the global research community, DeepSeek promotes a culture of collaboration and transparency that can accelerate the pace of innovation. This open-source approach not only benefits AI research but also sets a precedent for other scientific disciplines to follow.

Furthermore, DeepSeek's success enhances China's global influence in the field of AI. By developing models that rival those of American companies, DeepSeek demonstrates that China is a serious contender in the global AI race. This success not only boosts China's technological reputation but also strengthens its position in international negotiations and collaborations related to AI and other advanced technologies. However, it is worth noting that China's tech policies have played a crucial role in supporting young innovators and researchers in the field of AI[6]. The Chinese government has invested heavily in AI research and development, providing funding, resources, and infrastructure to support cutting-edge projects[7]. This support has enabled young researchers to pursue ambitious projects like DeepSeek, which require significant computational resources and expertise. China's tech policies also encourage entrepreneurship and innovation among young people.

Initiatives like the "Mass Entrepreneurship and Innovation" policy provide funding, mentorship, and resources to young entrepreneurs, enabling them to turn their ideas into viable businesses[8]. This support has created a vibrant ecosystem of startups and research initiatives, including DeepSeek, that are pushing the boundaries of AI research.

China's tech policies promote a culture of collaboration and knowledge-sharing among young researchers. By encouraging interdisciplinary collaboration and open-source innovation, these policies create an environment where young researchers can learn from each other and build on each other's work. This collaborative approach not only accelerates the pace of innovation but also fosters a sense of community and shared purpose among young researchers. China's tech policies also focus on providing access to education and training in AI and related fields[9]. By investing in STEM education and offering specialized training programs, these policies ensure that young people have the skills and knowledge needed to succeed in the field of AI. China leads in global STEM graduates with 3.57 M graduates (39.41%) in 2020, followed by India with 2.55 M (28.15%). The United States ranks third with 820k graduates (9.05%), while Russia, Indonesia, and Brazil contribute 52 k (5.74%), 300 k (3.31%), and 238 k (2.63%), respectively. Mexico, France, Germany, Iran, and Japan also make notable contributions, each accounting for between 2.12% and 2.44% of the total. Collectively, China and India dominate, representing over 67% of the global STEM graduate output, underscoring their pivotal roles in the global STEM workforce. The data, sourced from the OECD and national statistical yearbooks, underscores China's dominant role in producing STEM graduates, with other countries contributing significantly but at lower levels. These numbers reflect the global diversity in STEM education, with China and India standing out for their large contributions to the pool of graduates[10]. These trends highlight China's dominance in graduate numbers, the US's continued leadership in AI innovation, the EU's academic strength in AI, and India's rapid growth in AI talent. This focus on education and training has created a pipeline of talented young researchers who are driving innovation in AI and other advanced technologies.

In conclusion, the rise of DeepSeek and its innovative advancements in AI present a transformative shift in the way AI is deployed globally. DeepSeek's novel approaches, especially in reinforcement learning and model distillation, demonstrate that cutting-edge AI technology does not have to be confined to a select few nations or corporations. By reducing reliance on massive computational resources and fostering a collaborative, open-source ecosystem, DeepSeek is democratizing access to powerful AI models, enabling a more diverse and inclusive global AI landscape. This marks a potential shift in the power dynamics of AI development, as the success of DeepSeek's models like R1 demonstrates that nations outside the traditional AI strongholds can rise to prominence through ingenuity and strategic investments in talent and research. Furthermore, DeepSeek's success not only highlights the growing capabilities of Chinese research in AI but also underscores the importance of supportive government policies that empower innovation. China's proactive stance in AI research and development has created an environment where young researchers can thrive, contributing to a global conversation about AI that is no longer dominated by a single country or a handful of corporations. As DeepSeek continues to push the boundaries of AI, the potential for new collaborations, breakthroughs, and the dismantling of monopolistic structures is on the horizon. This signals a promising future for more equitable and dynamic AI development worldwide, where competition drives progress and innovation across the globe.

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