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A Critical Observation of SpaceX's Founding Phase

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Abstract: Since the 21st century, the global aerospace industry has transitioned from state monopoly to public-private collaboration, giving rise to the "New Space Economy." SpaceX, founded in 2002, emerged as a pivotal disruptor, evolving from a struggling startup to the world's most valuable private aerospace firm. This study conducts a critical single-case analysis of SpaceX's formative decade (2002–2012), spanning its founding to the Dragon spacecraft's historic ISS docking. Using process tracing, systematic literature review, and critical discourse analysis, the paper examines SpaceX's entrepreneurial origins, growth strategy, financing models, digital capability building, and organizational evolution. The findings reveal that while SpaceX's success stemmed from iterative innovation, vertical integration, milestone-based government financing, and mission-driven culture, it was highly contingent on Elon Musk's personal wealth, favorable geopolitical timing, and extreme risk tolerance. Critical limitations include overreliance on government contracts, autocratic leadership vulnerabilities, and unsustainable work intensity. Drawing on these insights, the study provides actionable recommendations for Chinese hard tech startups, emphasizing the need to balance long-term vision with fi nancial discipline, build strategic partnerships, foster inclusive organizational cultures, and proactively engage with regulators. This research contributes to a nuanced understanding of hard tech entrepreneurship, highlighting both replicable best practices and context-specifi c constraints of the SpaceX model.

Keywords: SpaceX; Hard Tech Entrepreneurship; Startup Strategy; Public-Private Partnership; Iterative Innovation; Entrepreneurial Financing

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1. Introduction

1.1 Research Background and Signifi Cance

Since the 21st century, the global aerospace industry has shifted from state monopoly to public-private collaboration, driven by technology convergence and ecosystem integration, leading to the "New Space Economy" and over 90% reduction in space access costs. SpaceX, founded in 2002, is a key disruptor, evolving from a struggling startup to the world's most valuable private aerospace company, illustrating hard tech entrepreneurship.

Amid China's push for technological self-reliance, hard tech startups in semiconductors, AI, biomedicine, and aerospace face barriers like protracted R&D cycles, high capital needs, and innovation-market misalignment. While existing research documents SpaceX's successes, few studies critically examine its model's limitations and generalizability to non-US contexts. This study addresses this gap by analyzing SpaceX's early strategies to identify replicable best practices and context-specifi c advantages, off ering insights for Chinese hard tech startups in long-cycle growth.

1.2 Rationale for Selecting the First 10 Years of SpaceX's Start-up Period

This study focuses on SpaceX's formative decade (2002-2012), from its founding to the Dragon's historic ISS docking. This period represents the complete "0-to-1" lifecycle of a hard tech startup, marked by launch failures, near-bankruptcy, and the NASA CRS contract. Three justifications support this timeframe: it captures opportunity identification, technological iteration, and market validation; strategic decisions laid the foundation for SpaceX's dominance; and post-2012, SpaceX entered a scaling phase outside early-stage entrepreneurship research.

1.3 Research Methods and Data Sources

This paper uses a single-case study method, integrating process tracing, systematic literature review, and critical discourse analysis. Data is triangulated from three sources: 10 peer-reviewed academic articles on SpaceX and aerospace entrepreneurship indexed in the Web of Science Core Collection, primary documents (e.g., SpaceX and NASA reports), and authoritative media. This multi-source verification ensures reliability and validity, while the critical framework allows a nuanced assessment of SpaceX's model's strengths and weaknesses.

2. Entrepreneurial Origin and Development Process

2.1 Identification and Origin of Innovation and Entrepreneurship Opportunities

SpaceX's genesis traces to Elon Musk's 2001 "Mars Oasis" project, which aimed to send a mini-greenhouse to Mars to reignite public interest in space exploration. While attempting to purchase refurbished Russian intercontinental ballistic missiles (ICBMs) for the mission, Musk discovered a critical market inefficiency: traditional aerospace contractors charged exorbitant prices despite rockets' manufacturing costs accounting for 2% of total launch expenses. The root cause, he concluded, was the industry's reliance on disposable rocket architecture.

This insight revealed a disruptive entrepreneurial opportunity: developing reusable rockets to cut launch costs by an order of magnitude, thereby democratizing access to space. Unlike traditional aerospace firms focused on incremental government contracts, Musk anchored SpaceX's mission to "making humanity a multi-planetary species." This transcendent vision served as a powerful magnet for top talent and patient capital, differentiating SpaceX from conventional startups (Muegge & Reid, 2019).

Critical Analysis: While Musk's opportunity identification was prescient, it was highly contingent on his unique position as a wealthy serial entrepreneur with access to networks and capital unavailable to most founders. His ability to personally absorb $140 million in losses during the early years created a buffer that no ordinary hard tech startup could replicate.

2.2 Development Process in the Founding Period

SpaceX was founded in June 2002 with Musk investing $100 million from his PayPal proceeds. Initially operating from a warehouse, its first rocket was the Falcon 1. The company faced setbacks, with three failed launches from 2006 to 2008, draining funds and forcing Musk to inject another $40 million. The fourth Falcon 1 launch in September 2008 succeeded, becoming the first private liquid-fuel rocket to reach orbit. This attracted NASA, which awarded a $1.6 billion contract for ISS resupply in December 2008. Later milestones included the Falcon 9 debut in 2010 and Dragon-ISS docking in 2012, solidifying SpaceX's role in aerospace.

Critical Analysis: SpaceX's survival was not solely due to technological prowess but also to extraordinary luck and timing. The fourth Falcon 1 launch succeeded with only hours of funding remaining; a single additional failure would have resulted in bankruptcy. Furthermore, the NASA CRS contract was awarded during a period when the US government was seeking to reduce its dependence on Russian Soyuz spacecraft following the retirement of the Space Shuttle program, creating a unique geopolitical window of opportunity.

2.3 Evaluation of the Founder and Team Capabilities

SpaceX's survival and success are inextricably linked to Musk's entrepreneurial leadership. As a serial entrepreneur with proven expertise in scaling technology ventures, he combined exceptional technical intuition with ruthless execution. His ability to decompose audacious long-term goals into incremental, measurable objectives kept the team focused amid repeated failures. Equally critical was his extraordinary resilience: during the 2008 crisis, he simultaneously navigated SpaceX's near-collapse and Tesla's financial troubles, demonstrating unparalleled pressure tolerance.

Musk also assembled a world-class core team, poaching top engineers from Boeing, Lockheed Martin, and NASA. These individuals shared his vision and embraced a high-risk, high-reward work culture. SpaceX's flat organizational structure—with minimal management layers and direct communication channels between engineers and executives—enabled rapid decision-making and agile problem-solving, a stark contrast to the bureaucratic hierarchies of traditional aerospace incumbents.

Critical Analysis: While Musk's leadership was instrumental to SpaceX's success, it also created significant vulnerabilities. His autocratic decision-making style, while efficient in crisis situations, has led to costly strategic missteps. Furthermore, the company's overreliance on Musk's personal brand and leadership creates a substantial succession risk, with no clear plan for leadership continuity.

3. Enterprise Growth Strategy Analysis

3.1 Strategic Disassembly Based on Ganz's Four-Element Model

Ganz's Four-Element Strategic Model posits that a firm's competitive advantage derives from the alignment of four interdependent choices: customer, technology, competition, and organization. This framework provides a systematic lens to analyze SpaceX's early-stage strategy.

Customer Choice: SpaceX adopted a dual-track "government + commercial" customer strategy. In its nascent stage, when the commercial launch market was underdeveloped, government contracts provided stable cash flow and credibility. NASA's CRS contract was transformative, not only delivering $1.6 billion in revenue but also validating SpaceX's technology in a high-stakes regulatory environment. Concurrently, SpaceX targeted underserved commercial segments, particularly small satellite operators ignored by incumbents. This hybrid model balanced short-term survival with long-term market expansion, with commercial customers gradually accounting for a growing share of revenue as the industry matured.

Technology Choice: SpaceX's technology strategy centered on "cost leadership through reusability." Rejecting the industry's obsession with cutting-edge but expensive aerospace-grade components, it prioritized modular design, commercial off-the-shelf (COTS) parts, and vertical integration. By manufacturing 80% of rocket components in-house, SpaceX reduced supply chain costs and accelerated iteration cycles. The cornerstone of its technology roadmap was reusable rocket technology, which promised to slash launch costs by 90% by recovering and refurbishing first-stage boosters (Zimcik, 2017). This focus on cost reduction rather than absolute performance was the defining disruptive feature of SpaceX's innovation.

Competition Choice: SpaceX pursued a differentiated low-cost strategy to disrupt the entrenched monopoly of Boeing and Lockheed Martin's United Launch Alliance (ULA). Initially, it targeted the small satellite launch market, a niche overlooked by incumbents focused on large government payloads. By demonstrating reliable, low-cost launches with Falcon 1, SpaceX built brand equity and scaled up to the medium-lift market with Falcon 9. Its ability to undercut ULA's prices by 50% while offering higher launch frequencies allowed it to rapidly capture market share, breaking the decades-old government contractor monopoly.

Organizational Choice: SpaceX's organizational design was optimized for speed and innovation. Its flat structure eliminated bureaucratic red tape, enabling engineers to escalate issues directly to Musk. The company fostered a mission-driven culture that celebrated risk-taking and normalized failure as a learning opportunity. Generous equity incentives aligned employee interests with long-term company success, attracting talent willing to trade job security for the chance to revolutionize space exploration.

Critical Analysis of Ganz's Four-Element Strategy: SpaceX's strategic alignment came with significant trade-offs and context dependencies. First, its customer strategy was overly reliant on government largesse, with over 70% of 2012 revenue coming from NASA contracts, creating vulnerability to policy shifts. Second, the COTS parts approach initially caused reliability issues and raised safety concerns as the company entered human spaceflight. Third, its competitive advantage was as much a product of ULA's monopoly-induced inefficiency as its own innovation—a condition not present in more competitive industries. Finally, its high-intensity, mission-driven culture led to extreme work demands, high turnover, and a lack of diversity, which may hinder long-term innovation.

3.2 Technological Innovation and Business Growth of Startups

SpaceX's innovation followed an iterative "test-fail-learn" cycle, contrasting with the traditional aerospace industry's "design-build-test-fly" approach. Rooted in Silicon Valley's agile principles, this methodology compressed R&D timelines and reduced costs. For example, the Merlin engine underwent over 100 design iterations in five years, with each test informing improvements.

This iterative innovation drove business growth. The 2008 Falcon 1 success validated SpaceX's capabilities and secured the NASA CRS contract. The 2010 Falcon 9 debut expanded its market to medium and heavy payloads, enabling competition in commercial satellite launches. By 2012, SpaceX had over 40 launch contracts worth $4 billion, with revenue rising from zero to over $200 million and employees growing from 100 to 1,800.

Crucially, SpaceX embedded failure into its innovation process. As Vittori et al. (2024) note, systematically analyzing failures and iterating rapidly was a key competitive advantage, with each failure leading to design improvements that enhanced reliability and cut costs over time.

Critical Analysis: While the "test-fail-learn" model worked well for SpaceX, it is not universally applicable to all hard tech industries. In sectors such as nuclear energy or pharmaceuticals, where failure can have catastrophic consequences, a more cautious approach to innovation is necessary. Furthermore, the model requires significant financial resources to absorb the costs of repeated failures, which most startups do not have.

3.3 Development Potential

By 2012, SpaceX had laid the groundwork for exponential growth. Its reusable rocket technology roadmap promised to further disrupt the launch market, opening up new opportunities in satellite internet, space tourism, and deep space exploration. The success of the Dragon spacecraft positioned SpaceX to compete for NASA's Commercial Crew Program, which aimed to restore U.S. human spaceflight capability. Additionally, its vertical integration model and manufacturing expertise gave it a sustainable cost advantage over competitors.

4. Entrepreneurial Finance and Financing Strategy Analysis

4.1 Financial Situation in the Start-up Period

SpaceX's early financial history was characterized by extreme volatility and existential risk. From 2002 to 2008, the company generated no revenue and relied entirely on Musk's personal investment. By the third Falcon 1 failure in August 2008, Musk had poured $140 million into SpaceX, nearly depleting his entire net worth. The company was days away from bankruptcy when the fourth Falcon 1 launch succeeded, a turnaround that has become legendary in entrepreneurial circles.

The 2008 NASA CRS contract marked a turning point in SpaceX's financial fortunes. The $1.6 billion contract, paid incrementally upon mission completion, provided a stable revenue stream that allowed the company to scale operations and invest in next-generation technology. In 2010, SpaceX raised its first external funding round of $20 million from Founders Fund, valuing the company at $275 million. Subsequent rounds in 2011 and 2012 brought total external funding to $170 million, with investors including Draper Fisher Jurvetson and Google Ventures.

Despite these infusions, SpaceX remained unprofitable throughout its first decade. The company reinvested nearly all revenue into R&D and manufacturing capacity expansion, prioritizing long-term growth over short-term profitability. This "burn rate" strategy was typical of hard tech startups, where significant upfront investment is required to overcome technical barriers and achieve economies of scale.

4.2 Analysis of Financing Process and Financing Method Choice

SpaceX's financing strategy evolved in three distinct phases, reflecting the changing risk profile of the company as it progressed from technical validation to commercialization.

Founder Self-Financing Phase (2002–2008): In the pre-revenue technical validation stage, SpaceX was unable to attract external venture capital, which typically avoids high-risk, long-cycle hard tech projects. Musk's willingness to invest his entire fortune was critical to the company's survival. This approach gave him complete control over strategic decisions, allowing him to prioritize long-term vision over investor demands for quick returns. However, it also exposed the company to existential risk, as a single additional failure would have resulted in bankruptcy.

Government Contract Financing Phase (2008–2010): NASA's CRS contract represented a novel form of "milestone-based" financing for hard tech startups. Unlike traditional government grants, which are awarded upfront with minimal accountability, the CRS contract tied payments to specific technical and operational milestones. This model de-risked the investment for both SpaceX and the government: NASA only paid for successful missions, while SpaceX gained access to capital without diluting equity. As King et al. (2024) argue, this public-private partnership model has become a blueprint for stimulating innovation in capital-intensive industries.

Venture Capital Financing Phase (2010–2012): With the technical success of Falcon 1 and Falcon 9 and the security of the NASA contract, SpaceX became an attractive investment for venture capital firms. The 2010 Founders Fund round marked the beginning of a series of increasingly large funding rounds that would eventually value the company at over $100 billion. Venture capital provided the capital needed to scale manufacturing, accelerate R&D on reusable rockets, and expand into new markets. In addition to capital, investors brought valuable industry connections and management expertise, helping SpaceX transition from a startup to a mature enterprise.

Beyond these traditional methods, SpaceX explored innovative financing mechanisms for its long-term Mars colonization goals. Harris and Wonglimpiyarat (2023) highlight the potential of cryptocurrency, initial coin offerings (ICOs), and crowdfunding as alternative funding sources for deep space missions. While SpaceX did not adopt these methods in its early years, they represent promising avenues for future hard tech ventures pursuing transformative, capital-intensive projects.

Critical Analysis: SpaceX's financial strategy was too risky for most startups. Its survival without revenue for six years relied on Musk's personal wealth, a rare advantage. The "burn rate" model demands continuous external financing, risking founder control dilution and a short-term growth focus. While the milestone-based financing model is promising, it has limitations. Government contracts are competitive and politically influenced, making them unreliable for startups. The model also requires government technical expertise to set and evaluate milestones, which is often lacking. In countries with underdeveloped procurement systems, it may be unfeasible.

This capital-driven innovation model has inherent drawbacks: first, it is extremely difficult to replicate, as it depends on a unique combination of a charismatic founder, favorable market conditions, and patient capital; second, if a company cannot achieve sustainable profitability eventually, it will face liquidation by capital; third, as the company scales, the founder's vision often conflicts with investors' short-term profit motives; and fourth, it requires investors to have deep technical understanding of frontier technologies, a capability that is still rare in most markets.

5. Digital Capability and Enterprise Organizational Growth

5.1 Construction of Digital Capability

SpaceX's digital transformation was a cornerstone of its ability to innovate rapidly and reduce costs. The company integrated digital technologies across the entire product lifecycle, from design and manufacturing to testing and launch operations.

In the design phase, SpaceX employed advanced computer-aided design (CAD) and computer-aided engineering (CAE) tools to create fully digital prototypes of rockets and spacecraft. Engineers could simulate thousands of launch scenarios, identify potential failures, and optimize designs before physical prototypes were built. This digital-first approach cut design cycles by 50% and reduced the number of costly physical tests. A centralized product data management (PDM) system ensured that all teams worked from the same up-to-date design files, eliminating errors and improving collaboration.

In manufacturing, SpaceX was an early adopter of additive manufacturing (3D printing) technology. 3D printing allowed the company to produce complex, high-performance components that would be impossible or prohibitively expensive to manufacture using traditional methods. For example, the Merlin engine's combustion chamber was 3D printed as a single piece, reducing the number of parts from over 100 to 1 and cutting manufacturing time from months to days. SpaceX also implemented digital manufacturing execution systems (MES) to automate production lines, track inventory in real time, and improve quality control.

In testing and launch operations, SpaceX leveraged big data and artificial intelligence (AI) to monitor rocket performance. Thousands of sensors on each rocket generated terabytes of data during flight, which was analyzed in real time to detect anomalies and inform design improvements. AI algorithms were used to optimize rocket landing trajectories, significantly increasing the success rate of first-stage booster recoveries. This data-driven approach to engineering allowed SpaceX to continuously improve its products at a pace unmatched by traditional aerospace firms.

Critical Analysis: While SpaceX's digital capabilities are impressive, they also create new vulnerabilities. The company's reliance on digital systems makes it susceptible to cyberattacks, which could have catastrophic consequences for launch operations.

5.2 Organizational Growth

SpaceX evolved from a linear to a matrix structure as it grew, while keeping its flat, agile culture. Initially, with under 100 employees, Musk managed directly for fast, bureaucracy-free decisions. By 2012, with over 1,800 staff, this became unsustainable, leading to a matrix organization with functional departments and cross-functional project teams. This balanced expertise and focus, enabling efficient management of multiple programs. SpaceX maintained flat management, with only three to four levels between engineers and Musk, and weekly all-hands meetings encouraged open communication and direct challenges.

SpaceX's organizational culture was defined by its mission-driven focus, bias for action, and tolerance for failure. Employees were motivated by the opportunity to work on transformative projects rather than just financial compensation. The company celebrated risk-taking and viewed failures as valuable learning experiences, a mindset that was essential for innovation in a high-risk industry. This culture attracted top talent and fostered a high-performance environment where employees were willing to work long hours and take on significant responsibility.

Critical Analysis: The matrix structure, while effective for managing complex projects, can also lead to confusion and conflict over roles and responsibilities. Furthermore, SpaceX's flat management style, while promoting agility, can result in a lack of clear career paths for employees, contributing to high turnover. The company's culture of extreme work intensity has also been linked to mental health issues among employees, raising questions about the long-term sustainability of this model.

5.3 Founder's Growth

SpaceX's success was also a story of Elon Musk's personal growth as an entrepreneur and leader. When he founded SpaceX, Musk was a successful internet entrepreneur with no experience in aerospace engineering or large-scale manufacturing. Over the course of the first decade, he transformed himself into a world-class aerospace executive, mastering the technical complexities of rocket science and learning to manage a rapidly growing organization.

Musk's leadership style evolved from hands-on micromanagement to a more strategic approach. In the early years, he was deeply involved in every aspect of rocket design and testing, often working alongside engineers on the factory floor. As the company grew, he learned to delegate operational responsibilities to trusted lieutenants, focusing his attention on long-term strategy, vision, and key technical decisions. He also developed expertise in government relations, navigating the complex regulatory landscape of the aerospace industry and building strong partnerships with NASA and other government agencies.

Critical Analysis: While Musk's personal growth was impressive, his leadership style remains highly controversial. His tendency to make impulsive decisions and set unrealistic deadlines has led to significant delays and cost overruns on several projects. Furthermore, his public statements on social media have sometimes created legal and reputational risks for the company, highlighting the dangers of overreliance on a single charismatic leader.

6. Countermeasures for the Startups and Suggestions

6.1 Challenges Faced by Enterprises in the Start-up Period

SpaceX's early struggles highlight the universal challenges facing hard tech startups. First and foremost is technical risk: hard tech innovation involves pushing the boundaries of science and engineering, and failure is inevitable. SpaceX's three launch failures are a testament to the difficulty of developing new technologies in complex, high-stakes industries. Second is financial risk: hard tech startups require massive upfront capital investment, and revenue generation is often delayed by years. Many promising ventures fail not because of flawed technology, but because they run out of money before achieving commercial viability.

Third is talent acquisition: hard tech startups compete with large, established companies and academic institutions for top technical talent. Attracting and retaining skilled engineers and scientists is particularly challenging for early-stage startups, which often cannot match the salaries and benefits offered by incumbents. Fourth is market access: hard tech products often require regulatory approval and face high barriers to entry, especially in industries like aerospace, healthcare, and energy. Building relationships with customers, regulators, and industry partners is critical for success.

Fifth is the inherent tension between founder vision and capital interests. As startups scale, investors often push for short-term profits at the expense of long-term transformative goals. This conflict can derail the original mission of the company, especially in frontier tech sectors where breakthroughs require decades of sustained investment.

6.2 Development Suggestions

Drawing on SpaceX's experience and its limitations, this paper offers five key recommendations for hard tech startups seeking sustainable growth. First, adopt a long-term vision but maintain financial discipline. While a clear, inspiring mission is essential for motivating employees and attracting investors, startups must also manage their cash flow carefully and avoid overreliance on a single source of funding. SpaceX's near-bankruptcy in 2008 serves as a cautionary tale about the dangers of excessive financial risk-taking.

Second, focus on core technology but build strategic partnerships. Instead of trying to do everything in-house, startups should identify their core competencies and partner with other companies or research institutions for non-core activities. This can reduce costs, accelerate development, and mitigate technical risks. While SpaceX's vertical integration strategy was successful, it required significant capital and expertise that most startups do not have.

Third, build a diverse and inclusive organizational culture. While mission-driven cultures are effective for driving innovation, they must also prioritize employee well-being and work-life balance. A diverse workforce brings different perspectives and experiences, leading to better decision-making and innovation. Startups should also establish clear career paths and professional development opportunities to retain top talent.

Fourth, engage proactively with regulators and policymakers. Hard tech industries are often heavily regulated, and startups that fail to understand and comply with regulations can face significant delays and costs. By engaging with regulators early in the development process, startups can help shape regulations that are supportive of innovation while ensuring public safety.

Fifth, strategically balance founder vision with investor expectations. Founders should seek out patient capital from investors who share their long-term vision, rather than those focused solely on quick returns. They should also structure financing rounds to preserve voting control and protect the company's core mission. Additionally, startups should proactively identify and demonstrate real-world use cases for their technology to validate their value proposition to both investors and the public, as SpaceX did with Starlink.

6.3 Two Development Paths and Countermeasures

After successfully navigating the start-up phase, hard tech startups typically face two strategic options: independent growth or acquisition. The independent growth path is suitable for companies with proprietary technology, large addressable markets, and access to sufficient capital. SpaceX chose this path, leveraging its technological advantages to become a dominant player in the global aerospace industry. Startups pursuing independent growth should focus on scaling operations, expanding into new markets, and building sustainable competitive advantages. They should also invest in building strong management teams and corporate governance structures to reduce reliance on the founder.

The acquisition path is a viable alternative for startups with valuable technology but limited access to capital or market reach. Being acquired by a larger company can provide access to resources, distribution channels, and customer bases that would be difficult to build independently. For example, many semiconductor and biotech startups are acquired by larger firms that can commercialize their technology more effectively. Startups considering acquisition should focus on developing clear, defensible intellectual property and building relationships with potential acquirers early on. They should also negotiate favorable terms that preserve the autonomy of the founding team and ensure the continued development of the technology.

7. Enlightenment

SpaceX's first decade of innovation and entrepreneurship offers both valuable lessons and important caveats for Chinese hard tech startups operating in an increasingly competitive global landscape. On the one hand, SpaceX demonstrates that long-term vision, iterative innovation, and public-private partnerships can drive transformative change in even the most entrenched industries. Its success shows that hard tech startups can disrupt incumbents by redefining the problem and focusing on customer needs rather than incremental improvements.

SpaceX's breakthrough represents a paradigm shift in how frontier innovation is funded and executed. For the first time, private capital has successfully led a megaproject that was previously the exclusive domain of nation-states. This has not only accelerated the development of the aerospace industry and spawned a whole ecosystem of related businesses but has also deepened the integration between capital and technology to an unprecedented degree. It has proven that with the right model, social capital can be mobilized to tackle humanity's grand challenges, breaking the ideological shackles that certain industries must be controlled by the state.

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