

A FOUR-GATE FRAMEWORK FOR SCREENING FRONTIER TECHNOLOGY COMMERCIALIZATION, WITH EVIDENCE FROM THE CHINESE MARKET

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Abstract: Frontier technology concepts arrive in waves and attract capital far ahead of revenue. Their outcomes then diverge sharply, and existing tools explain that divergence poorly. Technical readiness scales measure engineering progress only. Hype cycle models describe expectations without testing them. This paper argues that a frontier concept must pass four gates in sequence, namely engineering, economics, capital, and culture. It first proposes a typology of three capital market paths, which are the earnings backed path, the story and event driven path, and the long dated option path. It then defines four observable gate tests and a screening matrix built on technology maturity and demand authenticity. Seven cases are examined using audited filings, prospectuses, and official industry statistics. The evidence shows that the decisive gate is capital, because a firm can post record engineering results and still fail the self financing test. Two measurement problems are quantified. Headline market size figures use broad definitions that exceed core industry figures by a factor of about 2.8, and a reported return to profit can conceal a negative operating result once non recurring items are removed. The paper closes with four cultural mechanisms that amplify frontier technology hype in the Chinese market, together with screening rules for investors, firms, and policy makers.

Keywords: Technology commercialization; Demand validation; Hype cycle; Technology readiness; Capital markets; Industrial policy

1 INTRODUCTION

Frontier technology concepts arrive in waves. Quantum computing, commercial space launch, high bandwidth memory, and the metaverse all drew capital, local government programmes, and media attention inside a short window. Their outcomes then diverged sharply.

High bandwidth memory delivered results quickly. Industry revenue rose from 4.35 billion dollars in 2023 to about 30.7 billion dollars in 2025, and shipments rose from 1.5 billion gigabytes to about 4.1 billion gigabytes over the same period [1]. The largest supplier reported record annual results for 2025, with revenue of 97.15 trillion won and net profit of 42.95 trillion won, and it attributed the record mainly to demand for memory aimed at artificial intelligence workloads [2]. Commercial launch presents a different picture. One leading private launch firm reported 2025 revenue of 52.10 million yuan against a net loss of 1.711 billion yuan [3]. Quantum computing sits in a third position, where the direction is visible and revenue is still small. Virtual land and collectible tokens largely vanished once capital withdrew.

Two dimensions cannot explain this divergence. Technical maturity and market demand are both necessary, and neither is sufficient. Two further forces operate. Capital markets construct a story that assigns value before evidence exists, and social psychology amplifies that story through imitation. This paper therefore uses four dimensions, namely engineering, economics, capital, and culture.

The term paper tiger is used here in a narrow sense. It describes a concept that looks formidable while carrying no commercial load. It does not mean that the science is weak, and it does not mean that the engineering is dishonest. It means that no buyer pays a repeated and unsubsidized price, and that no identified constraint would soon produce one.

The paper makes five contributions. First, it proposes a typology of three capital market paths and links each to a distinct financial signature. Second, it defines four commercialization gates with tests that can be read from public filings. Third, it builds a screening matrix on technology maturity and demand authenticity, and it attaches three decision questions to that matrix. Fourth, it quantifies two measurement problems that inflate headline evidence. Fifth, it identifies four cultural mechanisms that amplify frontier technology hype in the Chinese market.

Section 2 reviews related work. Section 3 presents the three capital market paths. Section 4 defines the four gates. Section 5 presents the screening matrix. Section 6 reports case evidence and headline inflation. Section 7 analyses amplification in the Chinese market. Section 8 gives implications and limitations, and Section 9 concludes.

2 RELATED WORK

2.1 Adoption, Maturity, and Readiness

Diffusion research explains how new products spread. Rogers linked adoption to relative advantage, compatibility, and trialability [4]. Bass expressed the same idea as a growth model with an innovation term and an imitation term [5]. Moore argued that many technology products stall between early adopters and the mainstream market [6]. Christensen showed that simpler and cheaper entrants can displace incumbents [7]. Utterback and Abernathy found that industries converge

on a dominant design before volume production becomes efficient [8]. Technology readiness levels give a nine step ladder for engineering maturity [9]. That ladder is standard in aerospace and in public funding, and it carries no information about willingness to pay. Work on experience curves supplies the missing price dimension, since unit cost often falls as a power law in cumulative production [10-11].

2.2 Expectations and Hype

A second literature studies expectations. The hype cycle presents a stylized path from a trigger to a peak of inflated expectations, then to a trough and a plateau [12]. Dedehayir and Steinert tested that model against vendor databases and found that many technologies do not follow the stylized shape [13]. Van Lente and colleagues proposed a theory in which hype is produced by promises that circulate among interested actors [14]. Borup and colleagues described expectations as performative, because expectations attract resources and thereby change what becomes possible [15].

2.3 Capital Cycles and Narrative

Perez showed that technological development and financial capital move on coupled cycles, and that an installation phase driven by finance normally precedes a deployment phase driven by production [16]. Kindleberger and Aliber documented the recurring structure of manias and their collapse [17]. Shiller argued that economic narratives spread like contagions and move real investment [18]. Nanda and Rhodes Kropf found that firms funded in hot markets are more likely to fail and also more likely to be highly innovative, which means that capital abundance changes the composition of what gets built [19].

2.4 Herding and Cultural Setting

Informational cascades explain why rational agents imitate. Bikhchandani, Hirshleifer, and Welch showed that a short sequence of early choices can lock a population into one option [20]. Bikhchandani and Sharma reviewed herd behaviour in financial markets and distinguished intentional herding from spurious clustering [21]. Hofstede supplied a comparative account of cultural dimensions, including uncertainty avoidance and long term orientation, which shape how strongly such cascades run [22].

2.5 Value Capture

Teece argued that innovators capture value only when appropriability conditions and complementary assets favour them [23]. Chesbrough and Rosenbloom showed that the business model determines which share of created value a firm keeps [24]. Adner and Kapoor demonstrated that an innovation waits on complements held by other firms [25].

2.6 Research Gap

These literatures are usually applied separately. Readiness scales sit with engineers. Hype models sit with strategists. Capital cycle work sits with financial economists. Cultural work sits with sociologists. A paper tiger is produced by the interaction of all four, so a screening instrument must combine them. This paper builds that combination and grounds it in verified financial evidence.

3 THREE CAPITAL MARKET PATHS

When a frontier concept becomes hot, three patterns recur. Each has a distinct financial signature, and Table I summarizes them.

The first path is earnings backed. Demand exists, capacity is tight, and reported results confirm the story within a few quarters. High bandwidth memory followed this path. Large language models increased data movement requirements faster than conventional memory could serve them, and the new component solved a bottleneck that buyers already measured. Industry revenue grew about sevenfold in two years [26], and the leading supplier posted a 44 percent net margin for 2025 [27].

The second path is story and event driven. The narrative is vivid, the events are photogenic, and valuations respond to policy announcements rather than to revenue. Commercial launch followed this path. Official statistics put the 2025 Chinese commercial space market at 2.83 trillion yuan under a broad definition [28]. Firm level results look very different. The leading private launch firm earned 52.10 million yuan in 2025 while losing 1.711 billion yuan, and its launch service gross margin was negative in each of the three reported years [29].

The third path treats the technology as a long dated option. The ceiling is high, the payoff is distant, and investors accept a low probability of a very large result. Quantum computing sits here. A listed Chinese quantum firm reported 2025 revenue of 310 million yuan, up 22.53 percent, and a reported net profit of 5.39 million yuan after four consecutive loss years [30]. Research spending reached 123 million yuan, which was 39.7 percent of revenue [31].

The three paths are not fixed categories. A concept can move between them, and the direction of movement is the useful signal. A long dated option becomes earnings backed when a cost or performance threshold is crossed, which is what happened to memory when model training raised the value of data movement. A story driven case becomes earnings

backed when a hard capability is demonstrated, and reusable launch is the current test of that transition. Movement in the other direction is also common. An earnings backed case can slip toward a story once a shortage clears and capacity overshoots demand.

Table 1 Three Capital Market Paths and Their Financial Signatures

Path	What drives the price	Financial signature	Representative case	Main failure mode
Earnings backed	Order books, capacity tightness, reported margin	Revenue and margin rise together within a few quarters	High bandwidth memory [21], [22]	Cyclical overbuild after the shortage clears
Story and event driven	Policy statements, launch events, national comparison	Revenue small, loss large, gross margin negative	Commercial launch [24], [26]	Liquidity stress when funding tightens
Long dated option	Distant payoff and strategic importance	Small revenue, high research intensity, subsidy dependent profit	Quantum computing [27]	Option expires before the payoff arrives

Source: authors, from the sources cited in each row.

4 THE FOUR COMMERCIALIZATION GATES

A concept must pass four gates in sequence. Figure 1 shows the sequence, and Table II gives the test at each gate. The order matters, because passing a later gate cannot repair a failure at an earlier one.

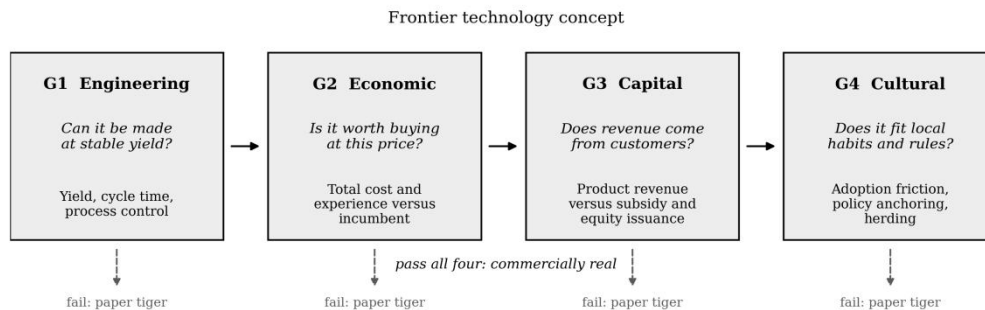


Figure 1 The Four Commercialization Gates

Note: Failure at any gate returns the concept to the paper tiger classification.

4.1 Gate One, Engineering

A laboratory sample and stable volume production are separated by a wide gap. Yield is the usual measure. Reported yield for high bandwidth memory has been in the range of 50 to 60 percent, with a production cycle of about two quarters [28]. Graphene purification, qubit control, and process scaling present comparable engineering problems. These problems are not solved by publication volume, and they are the reason many concepts stop here.

4.2 Gate Two, Economics

A new technology can displace an incumbent along only two routes. It can deliver the same experience at a substantially lower cost, or it can deliver substantially better performance at the same cost. A concept that satisfies neither route asks the buyer to pay more for more trouble. Consumer virtual reality headsets illustrate the failure. Comfort was limited, prices were not low, available applications were few, and ordinary meetings remained easier on existing conferencing software. Reported segment results are consistent with that reading, since one platform accumulated roughly 80 billion dollars of operating losses while quarterly segment revenue stayed below one billion dollars [29].

4.3 Gate Three, Capital

The capital gate asks one question. Does the money come from customers? A business that depends on subsidy, on repeated equity rounds, or on grants is not yet standing on its own. Two measurements make this gate operational. The first is the ratio of research spending to revenue. The second is the composition of reported profit. Section 6 applies both. Revenue growth alone does not pass this gate. A firm can multiply revenue from a very small base while its losses widen faster, and the ratio between the two is what matters. Two ratios are therefore reported in Section 6. The first is cumulative research spending divided by cumulative revenue over the reporting period. The second is reported net profit compared with net profit after non recurring items are removed. Both ratios are available in any audited filing, and both are harder to present favourably than a growth rate. A firm that fails on both ratios is dependent on external funding regardless of how fast its top line moves.

4.4 Gate Four, Culture

A technology that conflicts with local habits, work practice, or regulation will not diffuse even when the first three gates are passed. This gate also works in the opposite direction, because a favourable cultural setting can accelerate adoption and can also inflate expectations. Section 7 treats that asymmetry in detail.

Table 2 The Four Gates, Their Tests, and the Observable Evidence

Gate	Question	Observable test	Evidence used in this paper
G1 Engineering	Can it be produced at stable yield and acceptable cycle time?	Reported yield, production cycle, process control	Memory yield of 50 to 60 percent and a cycle of about two quarters [28]
G2 Economic	Is total cost and experience clearly better than the incumbent?	Either much cheaper at equal experience or much better at equal cost	Consumer headset segment losses against flat segment revenue [29]
G3 Capital	Does revenue come from customers rather than from subsidy or new equity?	Research spending over revenue, and profit composition after removing non recurring items	Three year research spending at 3,920 percent of cumulative revenue [24], and a reported profit that turns negative once non recurring items are removed [27]
G4 Cultural	Does the technology fit local habits, work practice, and rules?	Adoption friction, policy anchoring, speed of imitation	Policy wording in the national work report [30] and public warnings about valuation [31]

Source: authors. Each test is applied to public evidence in Sections 4 and 5.

5 THE SCREENING MATRIX AND THREE QUESTIONS

Two axes are sufficient for a first screen. The first axis is technology maturity, which the readiness literature already operationalizes [6]. The second axis is demand authenticity, which the four gate tests operationalize. Figure 2 plots seven cases, and Table III states the four zones.

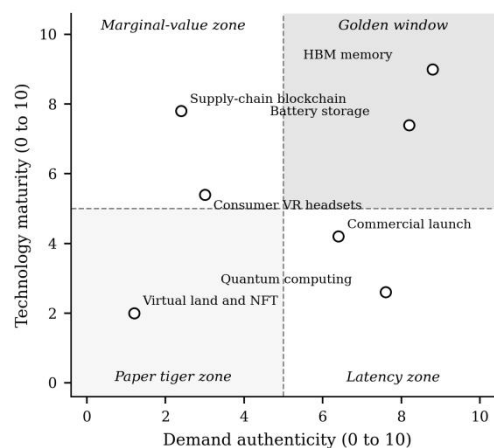


Figure 2 Screening Matrix for the Seven Cases.

Note: Scores are assigned by the authors from the public evidence cited in Section 6.

The golden window holds cases where maturity and demand are both high. Pain points are real, cost has crossed the buyer decision level, the supply chain is competing for volume, and results appear quickly. High bandwidth memory sits here. The latency zone holds cases where demand is real and maturity is not yet sufficient. The correct response is patience with a defined trigger rather than cancellation. Quantum computing sits here, and the trigger conditions are verifiable technical metrics rather than announcements.

The marginal value zone holds cases where the technology works and the problem is not important. Supply chain traceability built on distributed ledgers is the standard example, since the design adds steps without adding much value. An early analyst forecast expected 90 percent of such initiatives to lose momentum, and the stated reason was that teams started from the technology and then looked for a problem [32].

The paper tiger zone holds cases with neither maturity nor real demand, where price is set by narrative and by the flow of funds. Virtual land and collectible tokens sit here.

TABLE 3 The Four Screening Zones, with Criteria and Recommended Response

Zone	Criteria	Diagnostic evidence	Recommended response
Golden window	High maturity and real demand	Revenue and margin rise together, capacity is tight	Fund scaling, and monitor the risk of cyclical overbuild
Latency zone	Real demand and	Stated willingness to pay, one measurable	Stage the investment, and define a

Zone	Criteria	Diagnostic evidence	Recommended response
	insufficient maturity	blocking constraint that is improving	verifiable technical trigger
Marginal value zone	High maturity and weak demand	Working deployments that create little measured value	Redirect to an adjacent problem that buyers already pay for
Paper tiger zone	Weak maturity and weak demand	Price driven by narrative and fund flow, no unsubsidized repeat purchase	Stop, and do not treat the case as merely early

Source: authors, following the zone definitions in Section 5.

Three questions compress the test for practical use. First, if capital stops promoting the technology, will users still buy it because it saves money or raises output? Second, is the total cost and experience of the new solution clearly better than the existing one? Third, does company profit come from selling products and services, or from subsidy and from issuing shares? A concept that fails all three should be avoided.

6 CASE EVIDENCE AND HEADLINE INFLATION

6.1 Two Contrasting Financial Profiles

Figure 3 shows the growth of high bandwidth memory. Revenue rose from 4.35 billion dollars in 2023 to about 30.7 billion dollars in 2025, and shipments grew alongside revenue rather than instead of it [21]. Simultaneous growth in volume and in price is the clearest available signature of real demand, because a purely speculative episode raises price without raising volume.

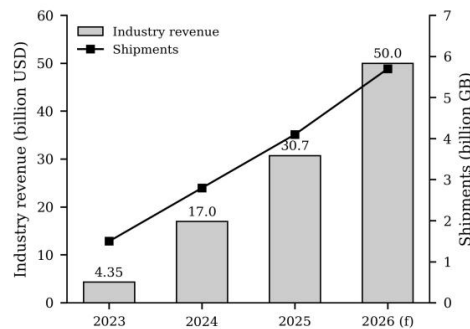


Figure 3 Global High Bandwidth Memory Industry Revenue and Shipments, 2023 to 2026, on a Three Supplier Basis [21].

Note: The 2026 value is a forecast.

Figure 4 shows the opposite profile for the two Chinese cases. Panel (a) plots revenue, research spending, and net loss for the launch firm across three years. Revenue reached 52.10 million yuan in 2025 after growing about elevenfold, and the net loss widened by about 95 percent to 1.711 billion yuan [24]. Cumulative research spending over the three years was 2.365 billion yuan, which equals about 3,920 percent of cumulative revenue [24]. Accumulated undistributed profit stood at negative 5.955 billion yuan, the debt ratio rose from 31.79 percent to 54.99 percent, and operating cash flow was negative 1.221 billion yuan [24]. Rapid revenue growth therefore coexists with a clear failure at the capital gate.

Panel (b) decomposes the quantum firm result. Reported net profit for 2025 was 5.39 million yuan, which ended four consecutive loss years. Net profit after removing non recurring items was negative 43.80 million yuan, and the company attributed the improvement partly to government grants and investment income [27]. Research spending of 123 million yuan was about 23 times the reported profit. The headline therefore reads as a turning point while the operating result remains negative.

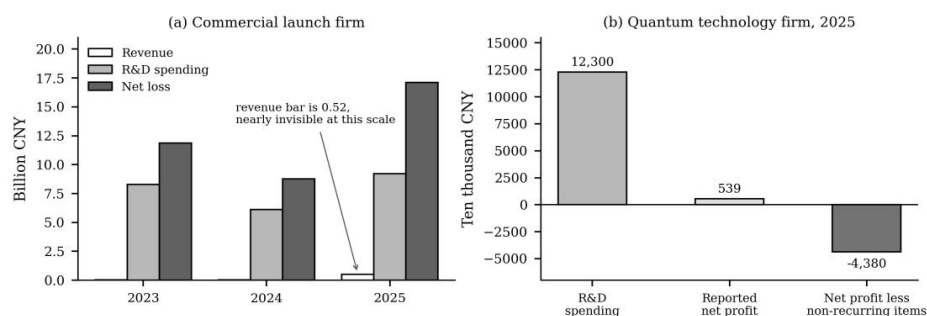


Figure Financial Profiles that Fail the Capital Gate

Note: Panel (a) shows the launch firm across three years [24]. Panel (b) decomposes the quantum firm result for 2025 [27].

The pattern is not specific to one market. The consumer immersive computing case shows the same gate two and gate three failure inside a very well funded firm, since roughly 80 billion dollars of cumulative segment operating losses accompanied quarterly segment revenue below one billion dollars [29]. Distributed ledger traceability shows the same gate two failure at industry scale [32]. What differs across markets is not the mechanism but the amplitude, and Section 7 argues that amplitude is where cultural setting enters. Reading the two Chinese cases beside these international cases therefore separates a general commercialization problem from a local amplification problem.

6.2 Three Mechanisms That Inflate Headline Evidence

Screening fails when the inputs are inflated. Three mechanisms recur, and Table IV quantifies each from the sources used above.

The first mechanism is definitional scope. The widely quoted 2.83 trillion yuan figure for the Chinese commercial space market uses a broad definition that includes satellite applications and induced effects. The same source reports a core industry figure of 1.01 trillion yuan for the same year, and core industry growth of about 7 percent against 21.7 percent for the broad measure [26]. The ratio between the two definitions is about 2.8, and the growth rates differ by a factor of three.

The second mechanism is profit composition. A reported return to profit can rest on grants and investment income rather than on operations, as panel (b) of Figure 4 shows [27]. The third mechanism is estimate dispersion. Independent research houses have published very different values for the same memory market and year, and the spread across published 2025 estimates is wide enough to change any conclusion drawn from a single figure [21]. A screening process should therefore record which definition, which profit line, and which estimating house produced each input.

Table 4 Three Mechanisms that Inflate Headline Evidence, with Quantified Examples

Mechanism	How it operates	Quantified example	Screening remedy
Definitional scope	A broad market definition absorbs downstream applications and induced effects	Commercial space market of 2.83 trillion yuan on the broad definition against 1.01 trillion yuan for core industry, and growth of 21.7 percent against about 7 percent [26]	Require the core industry figure and the definition used
Profit composition	Grants, investment income, and other non recurring items convert a loss into a reported profit	Reported net profit of 5.39 million yuan against negative 43.80 million yuan after removing non recurring items [27]	Read the adjusted line first, and treat the headline as secondary
Estimate dispersion	Independent research houses publish materially different values for the same market and year	Published estimates for the 2025 memory market differ widely across houses on a three supplier basis [21]	Report a range and name the estimating house

Source: authors, from [21], [26], and [27].

7 AMPLIFICATION IN THE CHINESE MARKET

Frontier technology concepts spread faster and reach higher valuations in the Chinese market than a purely financial account would predict. Capital supply is one reason. Four cultural mechanisms operate alongside it, and Table V links each mechanism to the relevant literature.

The first mechanism is a preference for tangible assets. Trust attaches more readily to things that can be seen and touched. In technology investment this favours hard assets such as chips, rockets, and equipment over pure software, and it makes those categories easier to overprice.

The second mechanism is fear of falling behind. Once a concept is labelled a future trend, participation feels safer than abstention. Uncertainty avoidance in the comparative cultural literature describes the same disposition [19].

The third mechanism is policy anchoring. Confidence in national strategy is high, which makes official wording a strong signal. The 2025 national work report both supported the safe and healthy development of emerging industries including commercial space and the low altitude economy, and called for the cultivation of future industries including biomanufacturing, quantum technology, embodied intelligence, and sixth generation communication [30]. A concept that acquires this kind of endorsement faces a much lower barrier to participation, which is efficient for genuine industries and costly for weak ones.

The fourth mechanism is rapid herding. Once a view becomes common, funds and sentiment converge quickly, and valuation separates from fundamentals. The informational cascade literature predicts this pattern, since a short sequence of early choices can lock in a population [17-18].

The four mechanisms compound. Bubbles inflate faster and deflate harder. Practitioners have made the same point publicly. At a July 2026 science forum, a leading quantum physicist described the current capital enthusiasm as a very large bubble and proposed a national third party evaluation body with a gold standard of verifiable metrics, including single qubit fidelity, two qubit control capability, and demonstrated quantum computational advantage [31]. He drew an explicit analogy to commercial launch, where firms are expected to show hard capability such as rocket recovery before listing [31]. This proposal is a direct institutional response to the measurement problems in Table IV.

Two clarifications are needed here. These mechanisms are descriptive rather than evaluative, and each has a productive

form. A preference for tangible assets directs capital toward manufacturing capability that many economies struggle to fund. Trust in policy shortens coordination time for genuine infrastructure. The mechanisms become costly only when they operate without a verification step, because they then apply the same acceleration to strong and weak projects. This is why the remedy proposed in Section 8 is a verification requirement rather than a reduction in enthusiasm.

Table 5 Four Amplification Mechanisms in the Chinese Market

Mechanism	Behavioural expression	Effect on valuation	Related literature
Preference for tangible assets	Hard technology is trusted more readily than software	Chips, rockets, and equipment are easier to overprice	Expectation formation and performativity [12]
Fear of falling behind	A future trend label makes participation feel safer than abstention	Entry occurs before evidence, so price leads fundamentals	Uncertainty avoidance [19]
Policy anchoring	Official wording is read as endorsement of a whole category	Barriers to participation fall for strong and weak projects alike	Narrative contagion [15] and capital cycles [13], [16]
Rapid herding	Consensus forms quickly and funds converge	Valuation separates from fundamentals, and reversal is sharp	Informational cascades [17], [18] and manias [14]

Source: authors. Mechanisms follow Section 7, and literature links follow Section 2.

8 IMPLICATIONS AND LIMITATIONS

8.1 For Investors

The word frontier is not evidence. The two axes should be applied before commitment, and the three questions in Section 5 give a short version. The capital gate deserves priority, because it is the gate that record engineering results can hide. A reported profit should be read after non recurring items, and a market size figure should be read on the core industry definition.

8.2 For Firms

Effort belongs on cost reduction, yield improvement, and measured customer value rather than on concept construction. Capital markets remember prior claims, and their patience is short. The launch case is instructive, because revenue grew about elevenfold and the market still faces a company whose research spending exceeds cumulative revenue by more than a factor of thirty nine [24].

8.3 For Policy Makers

Endorsement is a double edged instrument. Applied well it accelerates an industry, and applied broadly it manufactures bubbles. Two design choices follow. Endorsement should attach to verifiable capability rather than to a category label, and independent technical evaluation should precede financial privileges such as listing. The gold standard proposal in Section 7 is one concrete form of that design [31].

8.4 Limitations

Four limitations apply. The sample contains seven cases selected purposively, so no statistical claim is made. Scores on the two axes are assigned by the authors, and the rubric is published so that a reader can rescore any case from the cited sources. Several inputs are analyst estimates or industry association figures rather than audited data, and the market size figures in particular lack a unified statistical standard. Finally the evidence window ends in the middle of 2026, and cases in the latency zone may clear their constraints after that point.

9 CONCLUSION

Technical breakthrough is a starting point rather than a conclusion. A frontier concept becomes a business only after it passes four gates, which are engineering, economics, capital, and culture. This paper defined tests for each gate and combined them with a two axis screening matrix. Applied to seven cases with verified public evidence, the framework separates a golden window case from a latency case, a marginal value case, and a paper tiger case.

Three findings stand out. The capital gate is decisive, because a firm can report record engineering progress and still depend entirely on external funding. Headline evidence is systematically inflated by definitional scope, by profit composition, and by estimate dispersion, and each of these can be corrected cheaply. Cultural amplification is strong enough to require institutional remedies rather than advice alone. Future work should register scores before outcomes are known, should widen the sample to regulated sectors, and should test whether a published technical standard measurably reduces valuation dispersion.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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