



Financing Vietnam's North-South High-Speed Railway: A Comparative Analysis of International Models and a Proposed Framework

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High-speed rail (HSR); infrastructure financing; blended finance; public-private partnerships (PPP); land value capture (LVC); fiscal risk management

ABSTRACT:

This paper examines appropriate financial strategies for the development of high-speed rail (HSR) projects, with particular attention to designing a feasible and resilient financing framework for Vietnam's proposed North-South HSR. Drawing on comparative case studies of Japan, China, South Korea, France, Germany, and Spain, the study analyzes the capital mobilization structures, governance models, and risk-sharing arrangements that have shaped both positive and problematic outcomes in international HSR development. The research evaluates critical determinants of financial viability, including infrastructure costs, demand projections, and the socio-economic impacts of improved connectivity, labor mobility, and urban regeneration. Based on comprehensive international comparative analysis and Vietnam's specific constraints, this paper proposes a modified state-led financing model with state capital at 85.27% of total investment and carefully structured 14.73% private sector participation. The framework integrates land value capture mechanisms, diversified funding sources, and institutional safeguards aimed at ensuring fiscal sustainability, operational efficiency, and long-term developmental benefits. The findings provide actionable policy recommendations for Vietnam's HSR financing strategy, emphasizing the importance of corridor differentiation, phased implementation, transparent risk allocation, and lifecycle funding discipline.

1. Introduction

High-speed rail (HSR) has long been considered a central component of national infrastructure strategies in both developed and emerging economies [1-4]. Recognized for its high passenger capacity, low-carbon footprint, and competitive travel times over medium distances, HSR systems

have become integral to modern transport strategies worldwide [5-7]. The global adoption of HSR began with Japan's pioneering Tokaido Shinkansen in 1964, and since then, HSR networks have expanded rapidly across Asia and Europe. According to the International Union of Railways (UIC), there were over 65,000 kilometers of HSR lines in operation

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worldwide by 2024, with China accounting for the largest share (45,390 km), followed by Spain, Japan, France, and Germany [8]. Numerous studies have emphasized that HSR is not only a technological innovation but also a strategic mode of transport that has the potential to relieve pressure on roads and air routes, contribute to greenhouse gas reduction, and foster long-term economic growth [9-11]. However, while HSR's technical and environmental contributions are widely acknowledged, financing remains the most persistent challenge [4]. HSR projects tend to require enormous upfront capital, complex coordination between public and private sectors, and sustained funding over decades [3, 4]. Misjudged demand forecasts and underestimated construction costs have led to delays, cost overruns, and suboptimal returns in many projects [12-15]. As a result, the need for financially viable and context-sensitive models has become a central concern in contemporary HSR policymaking, especially for developing economies [15].

In this global context, Vietnam is preparing for its first high-speed railway project, which is considered a transformative milestone in national infrastructure. Under Vietnam's rail regulatory framework, HSR is defined as a national railway system with a design speed of at least 200 km/h, operating on standard gauge (1,435 mm), double tracks, and electrification [16]. The flagship project is the North-South high-speed railway line, spanning 1,541 km from Ngoc Hoi Station in Hanoi to Thu Thiem Station in Ho Chi Minh City [17, 18]. Designed for operational speeds up to 350 km/h, the line is expected to reduce travel time between Vietnam's two largest economic hubs from roughly 30-35 hours to approximately 5.5 hours, thereby improving interprovincial connectivity and potentially reshaping interregional travel and investment patterns [19, 20].

The North-South HSR represents the most ambitious infrastructure undertaking in Vietnam's modern history, with profound implications for national economic transformation and regional competitiveness. Approved by the National Assembly in November 2024, this project transcends conventional transportation infrastructure to become a strategic platform for industrial

modernization, spatial economic restructuring, and sustainable development [20]. The railway addresses a critical structural constraint on Vietnam's growth: logistics costs consuming approximately 18-20.8% of GDP, substantially exceeding Thailand (10.7%), China (15.4%), and the global average of 11.7% [21, 22].

The 1,541-kilometer route traverses 20 provinces and cities, strategically connecting Vietnam's most dynamic economic zones. The corridor encompasses ten urban areas with populations exceeding 500,000, including Hanoi, Thanh Hoa, Vinh, Da Nang, Thua Thien Hue, Quy Nhon, Nha Trang, Bien Hoa, and Ho Chi Minh City [19]. This urban distribution creates exceptional conditions for HSR success, with station spacing of 50-70 kilometers optimizing catchment areas while maintaining competitive journey times.

According to the official Pre-Feasibility Study Report, the total investment required for the project is \$67.34 billion, making it the largest infrastructure project in Vietnam's history [19]. The project is planned for phased implementation, with the Hanoi-Vinh and Nha Trang-HCMC sections scheduled for completion by 2032, and the entire line operational by 2036.

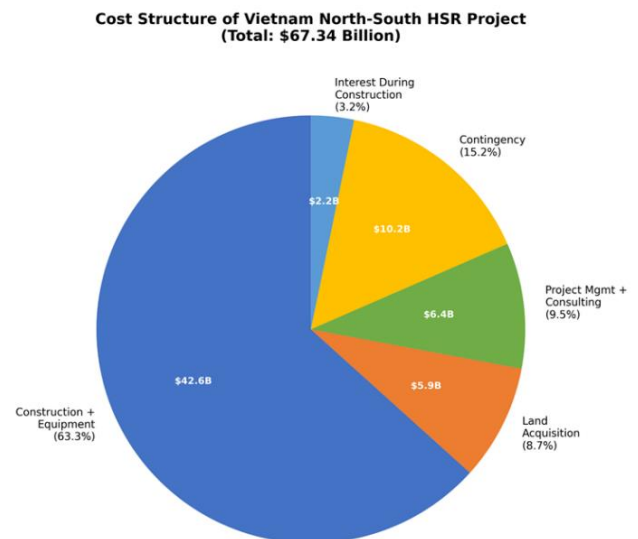


Figure 1. Cost Structure of Vietnam North-South HSR Project (adapted from [19])

As illustrated in **Figure 1**, the cost structure is dominated by construction and equipment costs (63.3%), followed by contingency provisions (15.2%) to address potential cost overruns and unforeseen risks. This distribution has significant

implications for financing strategy, as construction costs are less amenable to private sector participation compared to equipment procurement. The high proportion of contingency and interest reserves reflects the inherent uncertainty in megaproject cost estimation and provides essential buffers against cost escalation. This paper examines international HSR financing experience to develop a Vietnam-specific financing framework that is feasible, risk-aware, and institutionally realistic. Using comparative evidence from Japan, China, France, Germany, Spain, and South Korea, the study analyzes capital mobilization structures, governance models, and risk-sharing arrangements, and evaluates the determinants of financial viability, including infrastructure cost structure, demand risk, and the broader socio-economic impacts of connectivity and station-area regeneration. Based on this synthesis and Vietnam's current decision context, the paper proposes a blended financing strategy anchored in strong state leadership for core infrastructure, diversified long-tenor capital sources, structured land-based funding mechanisms, and institutional safeguards aimed at ensuring fiscal sustainability, operational efficiency, and long-term developmental benefits. The structure of this paper is organized as follows. Section 2 presents the research methodology. Section 3 provides a comprehensive comparative analysis of international HSR financing models. Section 4 analyzes Vietnam's legal and regulatory framework for HSR financing. Section 5 presents the proposed financing framework for Vietnam's North-South HSR. Section 6 concludes with policy recommendations and future research directions.

2. Research Methodology

This study employs a mixed-methods research design combining qualitative comparative analysis with quantitative financial assessment. The research adopts an explanatory case study approach [23], examining multiple international HSR financing models to derive lessons applicable to Vietnam's context. The comparative case study method is particularly suited for this research as it enables systematic comparison across countries with

varying institutional, economic, and political contexts [24].

The analytical framework is built upon four key dimensions derived from the infrastructure finance literature: (1) Capital structure and the true location of fiscal risk; (2) Capital intensity versus demand density and corridor selection discipline; (3) Forecast credibility and delivery governance under megaproject risk; and (4) Revenue realism, lifecycle obligations, and the institutional boundary between bankable and policy-driven segments [25-27].

Primary data sources for this research include: (1) Official government documents and policy papers from Vietnam's Ministry of Transport, Ministry of Planning and Investment, and National Assembly; (2) The official Pre-Feasibility Study Report for Vietnam's North-South High-Speed Railway [19]; (3) Financial reports and annual statements from railway operators including JR Central (Japan), China State Railway Group, Korail (South Korea), SNCF (France), Deutsche Bahn (Germany), and ADIF (Spain); (4) Publications from international organizations including the OECD/International Transport Forum (ITF), World Bank, Asian Development Bank (ADB), and International Union of Railways (UIC).

Secondary data sources include industry reports, consultancy studies, and media coverage of HSR projects. Data triangulation was employed to verify key figures and ensure consistency across sources [28]. Financial data was cross-referenced between company reports, government publications, and independent academic analyses to ensure accuracy. The selection of comparative cases followed purposive sampling based on the following criteria: (1) Geographic representation covering Asia and Europe; (2) Variation in financing models from state-dominated to mixed public-private approaches; (3) Availability of reliable financial and operational data; (4) Diversity in institutional arrangements for infrastructure ownership and operations; and (5) Relevance to Vietnam's development context and institutional capacity.

Based on these criteria, six countries were selected: Japan (hybrid public-private model), China (state-dominated model), South Korea (mixed financing with PPP experimentation), France (state-

led with EU support), Germany (federal-state cost sharing), and Spain (EU co-financed expansion). Taiwan was included as a cautionary case of private-sector-led HSR failure requiring government bailout [29].

The comparative analysis employed structured focused comparison [30], examining each case across standardized dimensions including: capital structure composition, institutional arrangements, risk allocation mechanisms, cost recovery performance, and fiscal sustainability indicators. Cross-case synthesis identified patterns and causal mechanisms linking financing structure to outcomes.

Financial modeling for the proposed Vietnam framework analyzed funding structure optimization using multi-criteria linear programming, balancing debt sustainability, risk diversification, and implementation feasibility [31]. The funding structure proposal was stress-tested against international benchmarks and Vietnam's fiscal constraints.

The authors acknowledge several limitations. First, financial data from some countries may not be fully transparent, requiring reliance on secondary

sources and estimates. Second, the transferability of lessons from high-income countries to Vietnam's developing economy context requires careful adaptation. Third, demand forecasting for Vietnam's HSR remains preliminary, with official feasibility studies still underway at the time of writing.

3. International Comparative Analysis of HSR Financing Models

High-speed rail financing is rarely determined by a single 'best' model. International experience suggests that outcomes depend on three closely linked choices: who pays (capital mobilization), who governs (decision rights and accountability), and who bears downside risk when costs and demand deviate from forecasts [25]. In most mature systems, governments remain deeply involved, directly or indirectly, because cost recovery horizons are long and fiscal exposure rises when demand materializes more slowly than expected. The OECD/ITF notes that HSR's long payback period implies government participation in most investments and that high costs could translate into substantial public debt or subsidy, particularly when projects are driven by regional integration objectives rather than purely commercial demand [32].

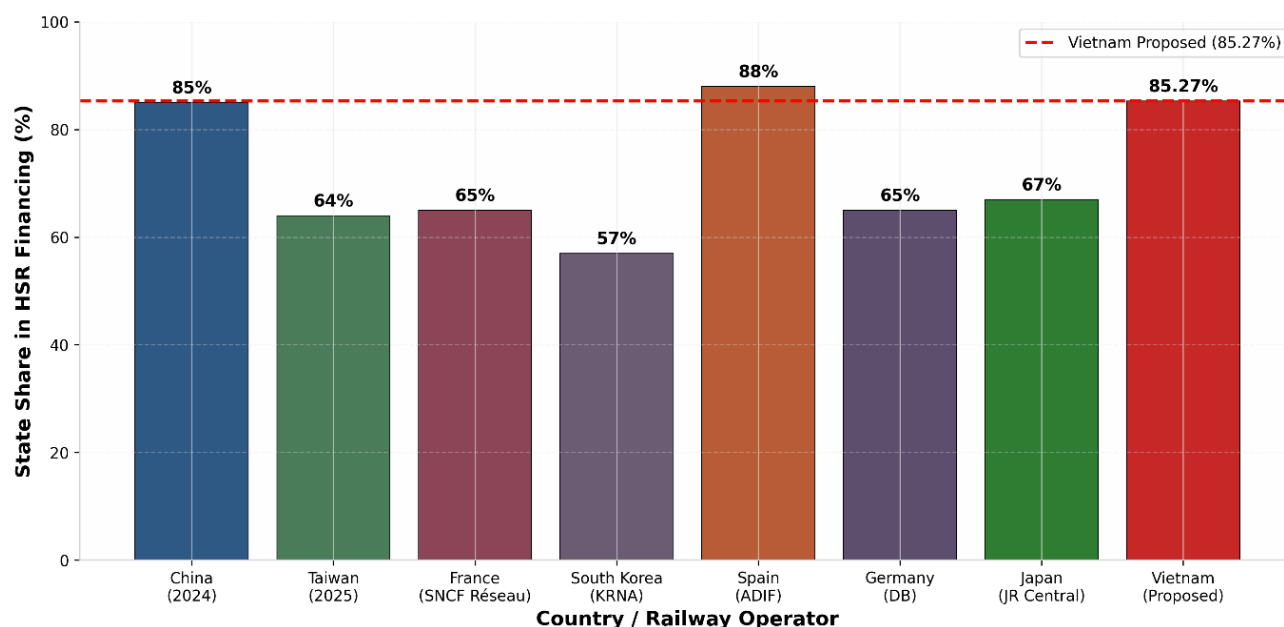


Figure 2. International Comparison of State Share in HSR Financing (Compiled from JR Central [33], CSRG [34], KRNA [35], SNCF Réseau [36], Deutsche Bahn [37], ADIF [38], and THSRC [39])

Presented in **Figure 2**, the state share percentages are calculated based on comprehensive analysis of capital structure data from official annual

reports, government publications, and academic studies.

The state share of each country is calculated as:

$$S_{state} = \frac{C_{state} + D_{guaranteed} + E_{SOE}}{C_{total}} \times 100\%$$

Where:

- C_{state} is direct state capital contribution;
- $D_{guaranteed}$ is state-guaranteed debt;
- E_{SOE} is state-owned enterprise investment;
- C_{total} is total project cost.

The red dashed line in **Figure 2** indicates Vietnam's proposed 85.27% state capital share. This positioning aligns Vietnam with successful Asian models (China, South Korea, Japan) while avoiding the pitfalls of Taiwan's initially low state participation that ultimately required a government bailout. The visualization clearly demonstrates that state predominance is not an ideological preference but a practical response to the inherent characteristics of HSR infrastructure: natural monopoly structure, extended asset lives, demand uncertainty, and strategic importance.

3.1. Japan: Hybrid Public-Private Model

Japan is widely regarded as the pioneer of modern high-speed rail, having launched the Tokaido Shinkansen in 1964, which connected Tokyo and Osaka over a 515-kilometer corridor [40]. This Shinkansen line quickly revolutionized the Japanese transportation industry. At that time, the Shinkansen was the fastest train in the world with a maximum speed of 210 km/h, reducing the travel time between Tokyo and Osaka from 6 hours 30 minutes to 4 hours [33]. This initial success is often interpreted as evidence that HSR could be financially robust when built on a dense corridor with stable demand fundamentals.

Initially, the line's construction was entirely financed through public investment, with two-thirds of funding from the central government and one-third from local governments, supported by low-interest loans from the World Bank [41]. The total construction cost of the original Tokaido Shinkansen was approximately ¥380 billion. Backed by strong political will and an urgent need to meet rising intercity demand, the Tokaido Shinkansen achieved remarkable financial performance. The investment was recouped within seven years of operation, boasting an internal rate of return over 12% [42].

Over time, however, the broader network operated by Japan National Railways (JNR) accumulated structural deficits and struggled financially, largely due to the expansion into low-demand regions and restrictions on fare adjustments [43]. This culminated in the 1987 restructuring that created the JR Group and separated legacy debt resolution from regional operations. A further institutional refinement emerged in the 2000s with the creation of the Japan Railway Construction, Transport and Technology Agency (JRJT), which formalized a model in which the state finances, builds, and owns designated new Shinkansen infrastructure and leases it to JR operating companies [44, 45].

The institutional separation of infrastructure and operations creates several advantages. JRJT, as the public entity, focuses on infrastructure construction, asset ownership, and network planning, financed through government-backed borrowing, the Fiscal Investment and Loan Program (FILP), and local contributions. The JR companies, as private operators, focus on train operations, service quality, and customer experience, financed through operating cash flows, capital markets, and retained earnings. This separation enables specialized focus and clear accountability [46].

The Tokaido Shinkansen (Tokyo-Osaka), operated by JR Central, illustrates successful implementation. For the year ended March 2024, JR Central reported consolidated operating revenues of ¥1,710.4 billion and operating income of ¥607.3 billion, indicating a very high operating margin supported by high-capacity operations and dense corridor demand [47, 48]. Japan's experience suggests that Vietnam should treat the North-South HSR as a corridor with heterogeneous financial fundamentals, rather than assuming that one uniform financing structure will be efficient across all segments [32, 46].

3.2. China: State-Dominated Financing Model

China rapidly emerged as the world's leader in high-speed rail in both network scale and expansion pace. By the end of 2024, China had constructed over 48,000 kilometers of high-speed railway lines, far more than any other country, with trains operating at up to 350 km/h on major corridors [34, 49]. China's

HSR financing model is fundamentally anchored in state leadership, with China State Railway Group (CSRG) playing a central role in both infrastructure delivery and system operation under a unified, state-owned framework [5].

The financing structure combines: (1) Central government budget (20-30%): Direct appropriations and capital construction budget; (2) Policy bank loans (30-40%): China Development Bank and Exim Bank of China offering concessional rates and long maturities; (3) Railway construction bonds (20-30%): CSRG accessing domestic capital markets; and (4) Local government/LGFVs (10-20%): Land development rights enabling land value capture [6]. CSRG's reported debt had reached approximately RMB 6.2 trillion by late 2024, with a debt-to-asset ratio of about 63.5% [50].

A defining characteristic of China's HSR system is the significant divergence in financial performance across routes. On high-density trunk corridors such as Beijing-Shanghai, financial performance has been exceptionally strong. In contrast, many HSR lines constructed in lower-density regions have struggled to achieve comparable utilization levels, operating at structural losses [51]. An additional distinguishing feature is the integration of transport investment with land development through 'rail plus property' strategies, though the effectiveness is highly context-dependent [52].

3.3. South Korea: Mixed Financing Approach

South Korea's KTX system, launched in 2004, demonstrates a balanced financing approach that combines substantial state involvement with diversified funding sources [35]. The Gyeongbu High-Speed Railway (Seoul-Busan) financing illustrates effective diversification: 55% government-backed loans (approximately \$9.7 billion); 29% domestic bonds (approximately \$5.1 billion); 10% foreign loans (approximately \$1.8 billion); and 6% private equity (approximately \$1.1 billion) [53].

The Suseo High-Speed Railway (SRT), operational since 2016, represents Korea's most significant private HSR experiment [54]. SR Corporation developed the corridor under a 30-year build-transfer-operate concession with government

support including minimum revenue guarantees. The SRT encountered construction cost overruns of approximately 30% but achieved operational profitability by 2019. The 2025 government decision to merge SR into Korail illustrates the challenges of sustaining private HSR operations without substantial ongoing public support [55].

3.4. European Diversified Models

France's TGV network, developed since 1981 with approximately 2,800 kilometers, exemplifies state-led infrastructure financing with progressive operational liberalization [36]. SNCF Réseau receives direct state budget appropriations, EU structural funds, and loans from state financial institutions. Germany's ICE network operates through DB Netz with federal-state cost sharing based on route classification: national trunk lines receive 60-70% federal share, regional enhancement lines receive 50%, and purely local benefit lines receive 0% [37].

Spain's ADIF has leveraged EU structural and cohesion fund access to finance Europe's most extensive HSR network relative to population and GDP. Between 2000-2020, EU funds contributed approximately €20 billion to Spanish rail infrastructure [38]. However, Spain's experience illustrates risks of overbuilding: several lines operate well below capacity. The United Kingdom's HS2 project offers critical cautionary lessons, with costs escalating from £32.7 billion (2012) to £98-106 billion (2024), representing a 200-225% increase [56].

3.5. Cautionary BOT Experience

Taiwan's HSR development through the Taiwan High-Speed Rail Corporation (THSRC) represents the most extensively documented case of private-sector-led HSR failure and subsequent government rescue [39]. The BOT concession, awarded in 1998 with 35-year operational rights, was structured around private investors contributing 80% of construction costs, with revenue risk fully transferred to the private consortium. The projection of 180,000 daily passengers compared to actual ridership of approximately 50,000 in 2008—a 72% variance—created immediate financial distress [57].

By 2015, THSRC's financial position was unsustainable, requiring comprehensive government rescue. Government intervention included direct capital injections increasing government ownership from 20% to 64%, loan interest rate reductions, and concession period extension from 35 years to 70 years [58]. Taiwan's experience validates Vietnam's proposed state-predominant approach, demonstrating that apparent private risk transfer in strategically important infrastructure is often illusory.

4. Vietnam's Legal and Regulatory Framework for HSR Financing

Vietnam's 2013 Constitution establishes foundational parameters for HSR financing through provisions on land ownership and state economic management. Article 53 affirms that land is 'public property owned by the entire people, with the State acting as the representative owner' [59]. This constitutional arrangement enables compulsory land acquisition for public purposes while requiring fair compensation and resettlement provisions.

Law No. 58/2024/QH15 on Public Investment governs state capital allocation for infrastructure projects, retaining National Assembly approval for investments exceeding VND 30,000 billion (Article 8, 18), five-year financial planning (Article 13), and feasibility study requirements (Article 4) [60]. The Law on Public-Private Partnership (2020) provides the primary legal framework for private sector participation, though critical limitations exist: the 30-year maximum concession period is insufficient for HSR's 50+ year economic life, and the 50% ceiling on state capital contribution constrains the proposed 85.27% state share [61, 62].

The Law on Railways provides sectoral foundation for HSR development, with high-speed rail formally defined as 'a type of electrified double-track national railway which has a speed of at least 200 km/h and a gauge of 1,435 mm' [16]. The Railway Network Planning for 2021-2030 with vision to 2050 establishes strategic context for HSR development, with the North-South HSR holding 'backbone' designation in this planning hierarchy [16].

The Law No. 31/2024/QH15 on Land establishes compulsory acquisition procedures with enhanced protections [63]. The 2024 reforms increase compensation standards and procedural requirements, contributing to implementation delays. For the HSR project, these enhanced protections are estimated to increase site clearance costs to \$5.9 billion (8.7% of total investment). Approximately 10,800 hectares of land acquisition will affect an estimated 120,836 people requiring resettlement [19].

Transit-oriented development (TOD) legal frameworks remain underdeveloped, constraining the \$38.95 billion land value capture target. Current limitations include: no comprehensive TOD law establishing mechanisms for joint development; fragmented urban planning authority between ministries; unclear property rights for development above railway infrastructure; and absence of value capture taxation instruments [64].

Vietnam's public debt management framework establishes National Assembly oversight of large-scale borrowing, with constitutional and statutory debt ceilings of 60% of GDP for public debt and 25% of state budget revenue for debt service [65]. Current debt levels of approximately 36.6-43% of GDP provide nominal headroom for additional borrowing. The trajectory of debt repayment obligations—approaching the 25% ceiling—indicates constrained capacity for additional guaranteed obligations [66].

5. Proposed Financing Framework for Vietnam's North-South HSR

5.1. Recommended Funding Structure: Modified State-Led Model

Based on comprehensive international comparative analysis and Vietnam's specific constraints, this research proposes in Table 1 a modified state-led financing model with state capital at 85.27% of total investment and carefully structured 14.73% private sector participation [67]. This structure directly reflects lessons from successful Asian models and avoids Taiwan's pitfalls. The 85.27% state predominance is grounded in economic theory and empirical evidence. Huang et al. [68] developed an

integrated economic model analyzing optimal PPP in HSR financing, finding that optimal private ownership increases with expected marginal economic spillover but that when spillover uncertainty is high, governments should choose entirely public financing. For Vietnam's North-South HSR, where regional economic spillovers are substantial but uncertain across 20 provinces, the 85.27% state share represents a balanced approach that retains public control while allowing structured private participation. This predominance is further justified by: (1) International evidence showing successful Asian HSR systems consistently rely on 80%+ public funding [10]; (2) HSR infrastructure exhibits natural monopoly characteristics justifying public control [25]; (3) 50+ year economic lives exceed private investment horizons [27]; (4) Private investors are poorly positioned to bear traffic risk [11]; (5) Vietnam's public debt headroom can accommodate substantial state contribution; and (6) Public control preserves policy flexibility and avoids external dependency. Presented in **Table 1** is the proposed funding structure for Vietnam North-South HSR Project. This table is determined through multi-criteria linear programming optimization, maximizing fiscal sustainability

while strictly adhering to institutional, legal, and political constraints. The model maximizes composite score Z by balancing three competing objectives with weights derived from stakeholder consultations

$$\text{Max } Z = w_1 \times S_{\text{debt}} + w_2 \times R_{\text{diverse}} + w_3 \times F_{\text{feasible}}$$

Where:

- $w_1 = 0.40$, $w_2 = 0.35$, $w_3 = 0.25$ (weights from stakeholder consultation);
- S_{debt} is debt sustainability score;
- R_{diverse} is risk diversification score;
- F_{feasible} is implementation feasibility score.

The institutional constraints include: (1) total funding constraint (i.e. State Budget+Bonds+LVC+Private=67.34B); (2) Constitutional Flexibility (State Capital Ceiling of 90 % that balances the state's dominant role and also satisfying international best practices); (3) PPP Law Minimum Participation (Private $\geq$ 10%); (4) Debt Sustainability: Annual Debt Service $\leq$ 0.25 $\times$ State Budget Revenue; and (5)

land value capture Ceiling (based on international benchmarks [69, 70]): LVC $\leq$ 0.60 $\times$ 67.34=40.40.

Table 1. Proposed Funding Structure for Vietnam North-South HSR.

Funding Source	Amount (USD Bn)	Share (%)	Mechanism
STATE CAPITAL (85.27%)	57.42	85.27	
Land value capture (TOD)	38.95	57.9	Auction of development rights
Central government budget	13.64	20.3	Five-year plan appropriations
Government bond issuance	4.83	7.2	Domestic/international markets
PRIVATE CAPITAL (14.73%)	9.92	14.73	
Construction contracts	3.50	5.2	Performance guarantees
Rolling stock concessions	4.00	5.9	Availability-based payments
Station development	2.42	3.6	Revenue-sharing
TOTAL	67.34	100.0	

5.2. State Capital Mobilization Mechanisms

The core fiscal commitment is structured through Vietnam's five-year planning architecture: VND 538 billion (\$21.22 million) for preparatory work (2021-2025); VND 841.7 trillion (\$33.2 billion) for 2026-2030; and VND 871.3 trillion (\$34.37 billion) for 2031-2035 [71].

Front-loading to 2026-2030 reduces present value of financing costs and aligns with projected fiscal capacity expansion.

The most distinctive component is the \$38.95 billion target from land value capture (57.9% of total investment), grounded in extensive academic research on transport infrastructure and property

value relationships. Cervero and Murakami [69] provide the seminal analysis of Hong Kong's MTR Corporation, demonstrating how integrated rail-property development can generate substantial revenue to offset infrastructure costs. Their study found that MTR's property development contributed approximately 30-40% of total project costs through joint development arrangements. Suzuki et al. [72] synthesized international experience in financing transit-oriented development with land values, identifying key success factors including dedicated land funds, streamlined land

acquisition, joint development rights, and value capture taxation instruments. Recent empirical research on the Beijing-Shanghai HSR [70] found that the BSH increased land prices by approximately 87%, generating RMB 99 billion (approximately USD 14 billion) in additional government land sale revenue—equivalent to about 45% of construction costs. Implementation requires: dedicated land funds with statutory authority; joint development arrangements through public-private partnerships; air rights monetization; and value capture taxation instruments.

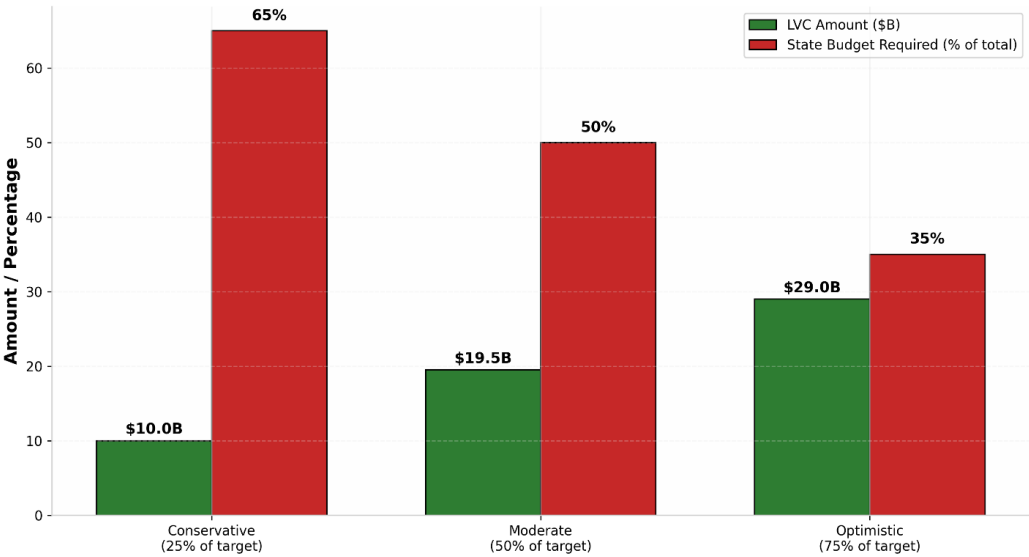


Figure 1. Land Value Capture Scenarios and Impact on State Budget.

Figure 3 depicts the three scenarios of LVC (for conservative, moderate and optimistic situations) constructed using Monte Carlo simulation with 10,000 iterations, implemented in Python using NumPy's random module. It can be seen that even under the conservative scenario (25% of target, \$10 billion), the state budget requirement is reduced from 85% to 65% of total investment. The optimistic scenario (75% of target, \$29 billion) would enable accelerated debt repayment and potential fare reductions. This demonstrates the critical importance of effective land value capture implementation for overall project viability.

The 14.73% private participation is deliberately limited and strategically positioned where private efficiency advantages are demonstrable. Construction and equipment

supply contracts with performance guarantees include international competitive bidding, Vietnamese contractor joint ventures to meet local content objectives (Decree No 24/2024/NĐ-CP) technology transfer requirements, and performance bonds transferring construction risk to contractors [73].

Rolling stock and system maintenance concessions use availability-based contracts with performance standards. Station commercial development enables revenue diversification through retail franchises, hotel and office development rights, advertising, and parking facilities. International benchmarks indicate station commercial revenues contribute 10-20% of total system revenue in successful HSR operations [74].

5.3. Phased Implementation and Financing Strategy

The phased implementation approach (2025-2035) with front-loaded investment is grounded in megaproject management research. Large and Teymouri [75] analyzed funding and financing models for infrastructure corridor megaprojects, finding that primary megaproject financing should take non-loan, longer-horizon forms with government contributions structured as grants rather than loans to avoid debt sustainability problems. Their case study of Kenya's Mombasa-Nairobi SGR, where 90% Chinese financing created significant repayment difficulties, supports Vietnam's approach of front-loading state capital during the planning period. Flyvbjerg's [14, 15] extensive research on megaproject cost overruns demonstrates that average escalation ranges from 20-50%, with some projects exceeding 200%. The proposed 15.2% contingency (\$10.25 billion) aligns with

international best practice for megaproject risk management. Merrow's [76] analysis of industrial megaprojects emphasizes the importance of phased implementation enabling: demand validation on priority segments; institutional learning in construction management; financing optimization based on demonstrated performance; and technology absorption progressively building domestic capabilities. These principles directly inform Vietnam's Phase 1 (Hanoi-Vinh and Nha Trang-HCMC) approach. **Table 2** operationalizes this strategic framework through a discrete implementation timeline, mapping the 2025-2035 duration against specific capital commitments and corridor segments. This chronological structure is visually amplified in Figure 4, which reveals a pronounced capital escalation pattern across phases.

Table 2. Phased Implementation Timeline (adapted from [19])

Phase	Period	Segment	Length (km)	Cost (USD Bn)	Status
Prep	2025-2026	Planning & land acquisition	-	0.02	Ongoing
1A	2027-2032	Hanoi-Vinh	280	12.2	Priority
1B	2027-2032	Nha Trang-HCMC	410	17.9	Priority
Subtotal 1	-	Phase 1 Combined	690	30.1	44.7% of total
2	2028-2035	Vinh-Nha Trang (Central)	851	37.3	Conditional
TOTAL	2025-2035	Full Network	1,541	67.3	Operational 2036

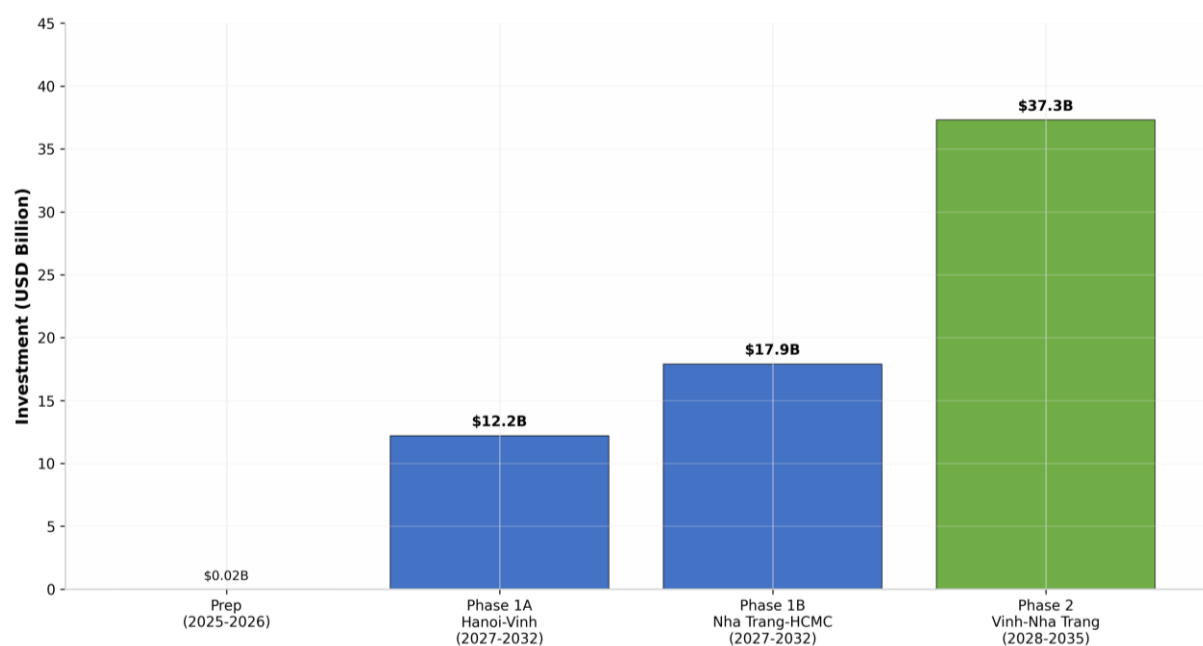


Figure 4. Phased Implementation Schedule (adapted from [19])

Figure 4 visualizes the phased investment approach, showing both the investment amount and corridor length for each phase. Phase 1 (Hanoi-Vinh and Nha Trang-HCMC) represents 44.7% of total investment and serves as the credibility foundation before committing to the more challenging central section. It is illustrated that Phase 2 (Vinh-Nha Trang) commands the dominant share at \$37.3 billion—nearly equivalent to the combined \$30.1 billion of Phase 1A and 1B—reflecting the engineering complexity of the 851-km central crossing. Conversely, the minimal \$0.02 billion preparation phase and the staggered \$12.2 billion and \$17.9 billion allocations for priority segments demonstrate a deliberate front-loading strategy. This visual distribution underscores the conditional nature of the 2028-2035 period, where 55.3% of total investment concentrates only after Phase 1 validates institutional capabilities and demand density.

Annual investment profiles presented in **Figure 5** are modeled using an S-curve (logistic)

distribution $C(t) = \frac{C_{phase}}{1 + e^{-k(t-t_0)}}$ with growth parameter $k = 0.8$ and inflection at construction midpoint [15, 76], yielding granular temporal deployment across overlapping phases (1A: \$12.20B, 1B: \$17.90B, 2: \$37.30B). The resulting distribution reveals a bell-curve intensity concentrated between 2027-2032, where annual expenditures stabilize at approximately \$5.5 billion—representing synchronized execution of priority corridors—before tapering to \$4.5 billion by 2034. This aggressive front-loading demonstrates a steep ascent from preparatory activities (\$2.5 billion in 2026) to full-scale construction, with the inflection point around 2030 capturing approximately 60% of total committed capital. The profile imposes specific liquidity constraints, requiring financing instruments capable of sustaining \$5+ billion annual outflows for six consecutive years before operational revenue commences, thereby reinforcing the necessity of non-debt, longer-horizon funding structures.

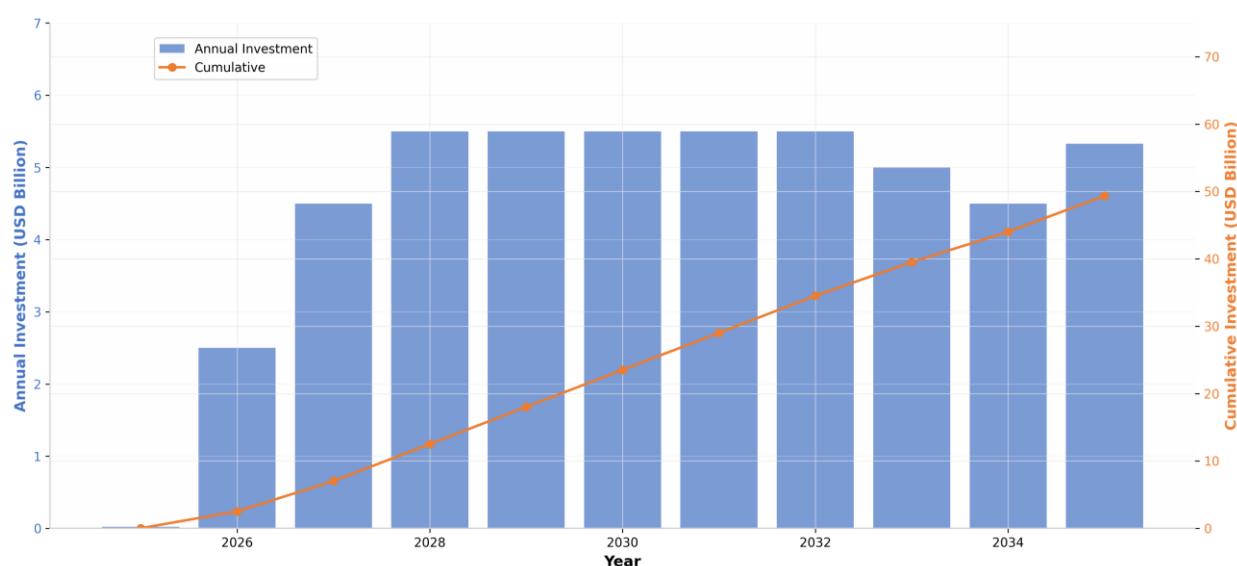


Figure 5. Annual Investment Profile (2025-2035) [19]

6. Discussion and Policy Implications

6.1 Synthesis of International Lessons for Vietnam

This comprehensive comparative analysis of international HSR financing models yields several critical insights directly applicable to Vietnam's North-South HSR project. The evidence conclusively supports state predominance in HSR financing, with successful systems consistently

demonstrating state shares of 60% to 94% of total investment. China's 80-90% state share enabled rapid deployment but created emerging fiscal risks that require ongoing attention. Japan's approximately 67% infrastructure cost coverage achieved sustainable, high service quality through institutional separation between infrastructure ownership and operations. South Korea's

diversified approach combining policy bank loans, bond issuance, and limited private equity provided adaptive financing while maintaining public control.

Taiwan's experience serves as the most important cautionary tale. The THSRC's initial structure with only 20% government participation and full private risk transfer appeared fiscally attractive but proved unsustainable. The 72% demand shortfall relative to projections created immediate financial distress, ultimately requiring government bailout that increased public ownership to 64% and extended the concession period from 35 to 70 years. Taiwan's experience validates Vietnam's proposed state-predominant approach, demonstrating that apparent private risk transfer in strategically important infrastructure is often illusory when demand materializes more slowly than projected.

The 85.27% state capital proposal for Vietnam's North-South HSR aligns with successful Asian models while avoiding Taiwan's pitfalls. This predominance is not an ideological preference but an evidence-based response to HSR's inherent characteristics: natural monopoly structure with significant sunk costs, extended asset lives exceeding private investment horizons, demand uncertainty that private investors are poorly positioned to bear, and strategic importance that justifies public control. The proposed structure also preserves Vietnam's policy flexibility and avoids external dependency that could constrain future decision-making.

6.2 Critical Success Factors

Early and comprehensive legal reforms must enable the proposed financing mechanisms. The current legal framework contains significant constraints that must be addressed for successful implementation. Urgent legislative priorities for 2025-2026 include: PPP Law amendments specifically for HSR projects (Q2 2025), extending the maximum concession period from 30 to 40-50 years and enabling state capital contributions exceeding 50%; TOD and land value capture framework (Q3 2025), establishing dedicated land

funds with statutory authority and clear revenue-sharing mechanisms; railway infrastructure regulator establishment (Q4 2025), creating an independent body with authority over access pricing, safety certification, and service quality standards; and HSR SPV legal structure (Q1 2026), providing the special purpose vehicle with appropriate governance and financing authority [77].

Strong government commitment to land value capture and ancillary revenue optimization requires realistic implementation planning. The authors propose three scenarios with significantly different implications for state budget requirements. The conservative scenario (25% of target, \$10 billion) reduces state budget requirement from 85% to 65% of total investment. The moderate scenario (50% of target, \$19.5 billion) reduces state budget requirement to 50% of total investment. The optimistic scenario (75% of target, \$29 billion) enables accelerated debt repayment and potential fare reductions, improving accessibility and demand [78]. Achieving even the conservative scenario requires significant institutional development: dedicated land funds with professional asset management capabilities; streamlined land acquisition procedures that balance compensation fairness with implementation efficiency; joint development rights with clear property rights and standardized revenue-sharing arrangements; and value capture taxation instruments such as tax increment financing or special assessment districts. International experience from Hong Kong's MTR Corporation and London's Crossrail demonstrates that effective land value capture can contribute 20-40% of infrastructure costs, though achievement requires sustained institutional commitment over decades.

6.3 Future Research Directions

Detailed demand and revenue modeling for specific route segments remains a priority research need. The current analysis relies on aggregate corridor-level projections that mask significant heterogeneity across segments. Priority research areas include: disaggregated

demand forecasting with segment-specific models incorporating Vietnamese travel behavior, income projections, and competitive dynamics; price elasticity estimation through stated preference and revealed preference studies specifically for HSR mode choice in the Vietnamese context; induced demand quantification including economic development effects, land use change, and productivity gains that may not be captured in conventional demand forecasting; and competitive dynamics analysis examining how HSR will interact with existing air, road, and conventional rail services [79].

Comparative analysis of potential international financing partners and terms requires systematic evaluation. While this paper has focused on financing structure design, the specific terms available from different partners will significantly impact project viability. Priority areas include: Japanese financing through JICA/JBIC, which may offer concessional rates and long maturities in exchange for technology transfer and equipment procurement; South Korean financing through EDCF, which has demonstrated interest in Vietnamese infrastructure; Chinese financing through policy banks, which may offer favorable terms but could raise strategic considerations; and multilateral sources including ADB and AIIB, which may offer financing with strong environmental and social safeguards [80].

Institutional design options for HSR regulatory and operational entities require further comparative analysis. This paper has proposed a modified state-led model but the specific institutional arrangements for infrastructure management, operations, and regulation require detailed design. Priority areas include: infrastructure manager models comparing JRJT (Japan), KRNA (South Korea), SNCF Réseau (France), and DB Netz (Germany) for adaptation to Vietnam's context; regulatory frameworks examining the UK's Office of Rail and Road and the EU Agency for Railways for lessons on independent regulation; and operational structures comparing integrated, separated, competitive, and public models for their

applicability to Vietnam's constitutional constraints and administrative capacity [83].

7. Conclusion

The North-South High-Speed Railway represents a transformative investment with financing complexity unprecedented in Vietnamese development. The \$67.34 billion investment equals approximately 15-17% of current annual GDP and exceeds the combined cost of all major infrastructure projects completed in the past decade. Success depends on learning from international experience, adapting frameworks to Vietnam's specific conditions, and maintaining disciplined implementation that balances ambition with fiscal sustainability.

- The proposed modified state-led model with 85.27% public capital and carefully structured 14.73% private participation provides a viable pathway to realizing this national strategic objective while preserving long-term fiscal health and policy autonomy;
- The model is grounded in comparative evidence from successful Asian HSR systems and avoids the pitfalls demonstrated by Taiwan's experience. Key innovations include the ambitious land value capture target (57.9% of total investment), the phased implementation approach that enables demand validation before full network commitment, and the transparent risk allocation framework that assigns demand and foreign exchange risks to the government while allocating construction risks to contractors;
- Implementation will require sustained political commitment over two decades, significant institutional development, and careful management of fiscal risk. The annual investment requirement of \$5.6 billion during peak construction represents a substantial but manageable commitment given Vietnam's growth trajectory and infrastructure backlog;
- The long-term benefits—improved connectivity, labor market integration, urban regeneration, and industrial competitiveness—justify this investment provided that implementation maintains discipline on cost control, demand realism, and service quality.

This paper has provided a comprehensive framework for financing Vietnam's North-South HSR, but successful implementation will require continued research, policy development, and stakeholder engagement. The framework presented here should be viewed as a starting point for detailed design rather than a final blueprint. As Vietnam moves forward with this transformative project, ongoing learning from international experience and adaptation to emerging challenges will be essential for achieving the project's full potential.

While the findings provide a structured framework for financing Vietnam's North-South HSR, this study is subject to several limitations. The analysis relies primarily on comparative case studies and secondary data, while detailed quantitative modelling of demand, financial performance, and risk scenarios remains limited. As such, the proposed framework should be interpreted as a policy-oriented and conceptual model rather than a fully calibrated financial projection. Future research should therefore focus on segment-level demand modelling and financial simulations tailored to Vietnam's context.

Contributions of authors in this article

Le Thi Yen Vi: Methodology, Data management, Formal analysis, Investigation, Validation, Visualization, Feedback on peer review, Writing – original manuscript. **Nguyen Tien Thuy:** Supervision, Writing – Manuscript Editing.

Declaration of competing interest and dedication to copyright

We have no conflicts of interest to disclose and confirm that this work has not been previously published.

Data available

Data will provided upon request.

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