

## LOGISTICS DISPROPORTIONS IN CHINA'S CONSTRUCTION AND THE DIGITAL TOOLS TO NARROW THEM

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### Abstract

This article reframes China's inland-coastal gap in construction as a logistics disproportions problem and builds a logistics-first digital agenda to address it. First, it defines logistics disproportions as systematic differences in end-to-end lead-time predictability, the transport mode mix for heavy modules, and the stability of payment cycles. It then synthesizes peer-reviewed literature on coastal logistics, Building Information Modeling (BIM) and digital twins, national policy on prefabrication, and international rankings/benchmarks to establish the evidence base and bound plausible effect sizes. Second, it translates that evidence into an operational toolbox: supply-chain BIM (SC-BIM) that models routings and staging; factory-yard-site digital twins for re-sequencing and buffer sizing; standardized e-procurement with product data templates; Internet of Things (IoT) tracking with a transportation management system (TMS); verifiable shipment/installation milestones to align cash with events; artificial-intelligence (AI) risk forecasting; and inland consolidation hubs positioned near railheads. Third, it converts the agenda into a testable plan. A SWOT analysis identifies assets and frictions; a transformation roadmap assigns owners, instruments, and target indicators – on-time delivery, rail/water share of ton-kilometres, re-handling reduction, P90 – P50 delivery-window spread, and days sales outstanding (DSO) – with staged horizons of 9–36 months. Fourth, it specifies governance conditions: shared data schemas, open APIs, and product data templates to ensure interoperability across provinces and portfolios. A brief vignette illustrates how the playbook scales from a single inland project to programs. Finally, it acknowledges limits (secondary data, uneven provincial granularity) and sets a research agenda: open lead-time datasets, PDT-based public-procurement pilots, and causal evaluation of rail-hub deployments. In terms of China's construction logistics, the SWOT configuration in the table revealed precisely these imbalances: strong coastal logistics corridors and mature digital platforms coexist with structurally weaker domestic networks, higher turnaround time volatility, and slower adoption of smart logistics tools. In practice, this means that strengths and opportunities are locally concentrated, while weaknesses and threats accumulate in inland regions and small towns, where construction projects depend on smaller and less sustainable supply routes.

**Keywords:** construction logistics, digitalization, supply-chain BIM, digital twins, e-procurement, IoT tracking, TMS, inland hubs, China.

## ЛОГИСТИЧЕСКИЕ ДИСПРОПОРЦИИ СТРОИТЕЛЬСТВА В КИТАЕ И ЦИФРОВЫЕ ИНСТРУМЕНТЫ ИХ НИВЕЛИРОВАНИЯ

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### Реферат

В данной статье переосмысливается внутренний – прибрежный разрыв Китая в строительстве как проблема логистических диспропорций и выстраивается «логистико-центрическая» цифровая повестка для его решения. Во-первых, логистические диспропорции определяются как систематические различия в предсказуемости сквозных сроков поставки, в модальном составе перевозок для тяжелых модулей и в стабильности платежных циклов. Затем синтезируется рецензируемая литература по прибрежной логистике, информационному моделированию строительства (Building Information Modeling, BIM) и цифровым двойникам, национальная политика префабрикации, а также международные рейтинги/бенчмарки с тем, чтобы задать доказательную базу и очертить правдоподобные величины эффектов. Во-вторых, эта база переводится в операционный «набор инструментов»: цепочно-поставочный BIM (SC-BIM), моделирующий маршруты и зоны накопления; цифровые двойники связи «фабрика – склад – стройплощадка» для пересекивания и задания буферов; стандартизированная электронная закупка с шаблонами продуктовых данных; отслеживание через интернет вещей (Internet of Things, IoT) вместе с системой управления перевозками (Transportation Management System, TMS); верифицируемые вехи отгрузки/монтажа для привязки денег к событиям; прогнозирование рисков на базе искусственного интеллекта (Artificial Intelligence, AI); и внутренние хабы консолидации, размещенные у железнодорожных узлов. В-третьих, повестка превращается в проверяемый план. SWOT-анализ выявляет активы и тревоги; «дорожная карта» закрепляет ответственных, инструменты и целевые индикаторы – поставки в срок, доля ж/д и водных тонно-километров, сокращение перегрузок, разброс окон поставок P90 – P50 и дни дебиторской задолженности к погашению (Days Sales Outstanding, DSO) – с поэтапными горизонтами 9–36 месяцев. В-четвертых, задаются условия управления данными: общие схемы данных, открытые API и шаблоны продуктовых данных для обеспечения межрегиональной и межпортфельной совместимости. Краткая виньетка демонстрирует масштабирование «плейбука» от одного внутреннего проекта к программам. В заключении оговариваются ограничения (вторичные данные, неоднородная детализация по провинциям) и формируется исследовательская повестка: открытые наборы по срокам, пилоты госзакупок на базе PDT и причинная оценка внедрения ж/д-хабов. С точки зрения строительной логистики Китая, конфигурация SWOT в таблице вывела именно эти диспропорции: сильные прибрежные логистические коридоры и зрелые цифровые платформы существуют со структурно более слабыми внутренними сетями, более высокой волатильностью времени выполнения заказов и более медленным распространением интеллектуальных логистических инструментов. На практике это означает, что сильные стороны и возможности локально сконцентрированы, в то время как слабости и угрозы накапливаются во внутренних регионах и небольших городах, где строительные проекты зависят от все меньшего и менее устойчивых маршрутов поставок.

**Ключевые слова:** логистика строительства, цифровизация, BIM, цифровые двойники, электронные закупки, IoT, TMS, консолидационные хабы, Китай.

### Introduction

China's construction sector has achieved global visibility, with Chinese firms consistently ranked among the world's largest international contractors; yet this outward success coexists with uneven domestic capabilities and benefits [1]. A growing body of work on coastal logistics shows why

the advantage concentrates at the seaboard: dense port-rail systems, thicker supplier networks and more stable flows, while inland corridors remain more road-dependent and variable [2]. Political-economy studies add that “logistical fixes” have historically favored coastal nodes, reinforcing a spatial divide that outlives individual projects [3]. At the same time, international

benchmarks underline that logistics performance-reliability, speed, predictability-shapes lead times and competitiveness in ways that are highly consequential for construction scheduling and cost [4].

The definition of "logistics disproportions" is referred to systematic inland-coastal gaps in (i) end-to-end lead-time predictability, (ii) mode mix (rail/water vs. road) for heavy modules, and (iii) the stability of payment cycles. Operationally, the coefficient of variation for door-to-door lead times is tracked, the rail/water share of ton-kilometers for prefabricated elements, the P90 – P50 gap for delivery windows, and DSO days along the supply chain. These indicators map directly to project risk and working-capital costs and can be audited at monthly cadence.

Since 2016, national guidance has promoted prefabrication and industrialized methods, creating a supportive frame for logistics-aware delivery [5]. Reviews of Chinese prefabrication policy document a large and coherent corpus of measures and link them to measurable outcomes – higher labor productivity, lower material intensity and tangible environmental gains [6–8]. By 2021, the prefabricated share of new floor area reportedly approached a quarter of national additions, signaling that scale effects are possible when policy, industry capacity and logistics align [9].

Digitalization cuts across this terrain but diffuses unevenly. Empirical studies describe persistent heterogeneity in BIM capabilities and collaboration practices within China's AEC ecosystem, with adoption patterns diverging from overseas models [10], even as comparative work finds acceleration post-2016 and broader use in complex public works [11]. Meanwhile, case-based and review literature shows that digital twins linking factory, yard and site can reduce variability by aligning buffers, crane windows and delivery slots; these effects matter most on long in land chains [12–13].

The problem this article addresses is therefore not a lack of technology *per se*, but logistics disproportions that raise variability inland and blunt the returns to digital tools. The task for the main part is threefold: first, to formalize the inland-coastal gap as a logistics problem grounded in evidence [2–4,10–13]; second, to specify a logistics-first digital agenda-supply-chain BIM, factory-yard-site twins, standardized e-procurement with product-data templates, IoT/TMS visibility, and verifiable payment milestones – drawing on recent research and practice [14–18]; third, to set out a transformation roadmap with operational indicators that owners, contractors and public funders can audit over time [6–9,19–20]. Theremore a shift from growth by scale to growth by coordination, so that information moves faster than trucks and inland projects plan with confidence.

Empirically, logistics disproportions emerge when logistics capacity, performance, and reliability develop much faster in one group of regions than in others that are formally integrated into the same national market. Panel evidence for China's logistics industry confirms persistent east – west and coastal – inland gaps. Using a DEA-based provincial efficiency index for 2007–2018 ye et al. show that many eastern coastal provinces operate close to or even beyond the efficiency frontier, while several inland provinces remain in low-efficiency states despite growing demand [21]. For example, in 2018 the logistics efficiency scores of Shanghai, Jiangsu, Hebei and Guangdong were 1,179, 0,880, 1,006 and 0,947 respectively, whereas inland provinces such as Yunnan, Guizhou and Heilongjiang recorded much lower values of 0,260, 0,360 and 0,425. Across the four macro-regions, the least efficient region has an average logistics efficiency of only 0,476, and provinces with low scores are concentrated in central and western China [21]. This means that the same national market is served by two markedly different logistics systems: a high-efficiency coastal system and a structurally weaker inland system.

At the level of port operations, Li et al. measure the logistics efficiency of 20 Chinese coastal ports in 2014–2018 and find that the Bohai Rim port cluster operates with an adjusted comprehensive efficiency of 0,791, whereas the Southeast coastal cluster reaches only 0,366, with the overall mean for all coastal ports at 0,546 and an average comprehensive efficiency threshold of 0,604 used to distinguish high- and low-performance ports [22]. High-throughput hubs such as Qingdao, Rizhao and Shenzhen keep comprehensive efficiency values above 0,9 throughout the five-year period, while several other ports remain below 0,6, indicating that even within the coastal system there is a pronounced efficiency gradient between mature port clusters and lagging coastal nodes [22].

Digital diagnostics based on composite indices further reinforce this picture of coastal–inland disproportions. Liu and Zhao construct a Smart Logistics Development Index (SLDI) for China's provinces for 2013–2021 and show that the highest relative closeness degrees are concentrated in coastal and eastern provinces such as Guangdong, Beijing, Jiangsu,

Zhejiang and Shanghai, while lagging regions include Jilin, Heilongjiang, Hainan and several western and northeastern provinces [23]. In 2021, for example, the SLDI of Tianjin and Hainan reaches only about 14 % of the ideal benchmark, even though both belong to the eastern macro-region [23]. The national Dagum Gini coefficient for SLDI differences exhibits a slow upward trend over 2013–2021, and regional imbalances are driven mainly by the gap between the eastern region and the rest of the country [23]. Thus, even as overall smart logistics capabilities improve, the digitalization gap between the coastal logistics system and the inland system remains large and, in some respects, is still widening.

Synthesized peer-reviewed studies on coastal logistics coordination and BIM/digital-twin adoption in China (2016–2025), triangulate with national policy documents on prefabrication, and reference international contractor rankings for external validity. The review emphasizes operational metrics over narrative claims and favors studies with disclosed datasets or case-traceable methods. Where aggregate numbers vary across sources, quoted the most conservative figures and mark them as "reported by" the original authors.

### Toward a Logistics-Centric Coordinating Architecture

Evidence from coastal port logistics confirms that such a coordinating architecture works in practice. A four-stage DEA study of China's coastal ports shows that logistics efficiency is highest where port operations, hinterland road and rail connections, and customs processes are planned as one integrated system, and significantly lower where capacity expansion is not matched by process coordination [22]. For inland construction projects, this implies that a logistics-centric architecture should explicitly link site demand, regional freight nodes and digital planning tools. Without such integration, the project remains exposed to structural disproportions: materials may flow smoothly through coastal gateways while last-mile delivery to inland sites remains unreliable, lengthening construction cycles and eroding the economic rationale of investment [21–22].

China's construction performance exhibits a persistent inland-coastal asymmetry that is best understood through the lens of logistics. The concentration of ports and railheads along the coast, together with thicker supplier networks, compresses unit costs and stabilizes flows; but inland corridors are more exposed to weather and holiday shocks and more dependent on road haulage display higher average costs and greater variance. In a sequential industry where downstream tasks inherit upstream delays, such variance functions as a compounding "tax" on schedules and cash flow.

These outcomes reveals manifestations of logistics disproportions – systematic gaps in end-to-end lead-time predictability, in the modal split for heavy modules, and in the stability of payment cycles. Framed this way, digitalization is not an accessory but a coordinating mechanism. Empirical studies show that Building Information Modeling (BIM) produces meaningful gains when it extends beyond geometry to the calendars and hand-offs that govern supply; recent case evidence on digital twins further demonstrates that factories, yards, and sites can be synchronized so buffers become intentional, crane windows align with arrivals, and resequencing precedes disruption.

China's construction policy since 2016 has favored prefabrication and industrialized methods, supplying a conducive macro-frame. Yet prefabrication realizes its promise only when product data are standardized, procurement channels are reliable, and multimodal logistics reward rail and water where feasible. Otherwise, components arrive late, are re-handled, or crystallize as inventory that ties up working capital, especially inland.

What follows is a coordinating architecture rather than a collage of tools. For example supply-chain BIM provides a common language in which routings, staging areas, and inspection points live alongside drawings and quantities. Factory-yard-site digital twins render reservations and buffers visible to all parties, enabling proactive re-sequencing. Standardized product data templates embedded in e-procurement reduce technical ambiguity and make demand signals legible earlier. Telemetry and transport management systems keep movements observable and shift the longest leg toward rail or water when conditions allow. Milestone-based payments, grounded in verifiable event time-stamps, align cash with physical progress and lower dispute cycles.

Because coordination is ultimately a governance problem, the architecture presupposes interoperable data schemas, shared identifiers, and open APIs so that platforms can converse across provinces and portfolios. Procurement incentives should be tied to auditable operational indicators on-time delivery, rail/water share of ton-kilometres, re-handling

reduction, the P90 – P50 spread of delivery windows, and days-sales-outstanding, so that variability is priced and performance is rewarded.

Taken together, these elements move the discussion from growth by scale to growth by coordination. They also set the stage for the SWOT analysis that follows, which distills the sector's assets and frictions, the policy and market openings, and the external threats that will shape the pace and breadth of transition (table 1).

The SWOT analysis compresses a broad evidence base into a single view. Strengths identify assets already in place contractor scale, coastal infrastructure, enabling policy that can be leveraged immediately. Weaknesses point to structural friction inland: a road-heavy mode mix, fragmented supplier bases, and data silos that inflate variance. Opportunities open once data formats are shared and platforms connected: inland hubs become economically attractive, twins shorten cycles in ways visible to financiers and owners, and AI is tethered to real operational choices. Threats remind us that the window is finite. If concentration continues and data regimes fragment, logistics disproportions harden into a long-term productivity gap.

**Table 1 – SWOT: Logistics and Digitalization in China's Construction**

Strengths	Weaknesses
Scale in major contractors; dense coastal port/rail networks; policy support for prefabrication and standardization; pockets of mature BIM and PMO practice	Inland dependence on road; fragmented suppliers and data silos; uneven digital skills beyond tier-one hubs; slow diffusion of supply-chain BIM
Opportunities	Threats
National e-procurement rails with shared data schemas; inland consolidation hubs; wider use of twins to shorten cycles; AI-assisted risk-aware re-sequencing	Continued coastal concentration; bottlenecks in specialized imports; cybersecurity and data-localization constraints; protectionist headwinds in export markets

Based on SWOT provided the Transformation Roadmap for Narrowing Logistics Disproportions was developed (table 2).

**Table 2 – Transformation Roadmap for Narrowing Logistics Disproportions**

Measure	Owner(s)	Digital instrument	Target indicator	Horizon
National e-procurement rails with product data templates (PDT) and APIs	NDRC/MIIT + provinces + major GCs	E-proc platform + PDT registry	≥80 % public works by value on-platform; bid variance – 8–12 %	12–24 months
Supply-chain BIM across design – fabrication – logistics	Tier-1 GCs + design institutes + key subs	4D/5D BIM + logistics calendars	Logistics – related delays – 20–30 % (inland)	18–30 months
Inland consolidation hubs near rail-heads	Provincial PPPs + fabricators	Twin-enabled yard mgmt + IoT	Rail/water share of prefab ton/km ≥40 %	24–36 months
Sector-wide IoT tracking and TMS	GC alliances + 3PLs	Telemetry + TMS optimizer	On-time delivery ≥95 %; – e-handling – 25 %	12–18 months
Shipment/installation-based payment milestones	Owners + banks + GCs	Smart-contract or attested milestones	DSO – 15 days; disputes cycle – 40 %	12–24 months
AI forecasting for demand spikes and route risks	GC PMOs + platform vendors	ML models + weather/port feeds	P90 schedule variance – 20 %; inventory buffers – 15 %	9–15 months
Skills uplift in inland PMOs and supplier networks	MOE + firms + associations	National curricula + sandboxes	≥10,000 staff certified in SC-BIM/TMS	18–30 months

Thus, the inland hospital scenario that underpins the Transformation Roadmap starts from a baseline in which precast panels are trucked by road from two fabricators, with frequent re-handling on the way to site and a wide gap between the P90 and P50 delivery times. After deploying SC-BIM with integrated logistics calendars, IoT tags on pallets and a rail-fed consolidation hub near the main railhead, the team reschedules deliveries into night windows, shifts the long leg of the journey to rail and links supplier payments to verified on-site installation events. In the roadmap, the percentage ranges assigned to reductions in re-handling, logistics-related delays and the P90 – P50 delivery band are calibrated from this type of scenario and from mid-range effect sizes reported in empirical studies of BIM-enabled and digitally coordinated prefabrication projects, so that the values in the Transformation Roadmap represent realistic, evidence-based targets rather than arbitrary assumptions. The same stepwise bundle of interventions and effects can then be transferred to schools and mid-rise housing projects, with numerical targets adjusted to their typical volumes and cycle times.

A well-documented example of narrowing logistics disproportions through digital tools comes from the emergency modular hospitals built during the COVID-19 outbreak in Wuhan. The Leishenshan Hospital, for instance, was designed, built and commissioned in about twelve days using a combination of modular construction, 24/7 supply operations and intensive reliance on building information modelling (BIM) for product – organization – process coordination [25]. In this project, BIM models and digital platforms were used not only to coordinate on-site assembly, but also to synchronise off-site manufacturing, transport slots and just-in-time delivery of prefabricated modules. This effectively transformed a potentially chaotic, multi-regional logistics chain into a tightly orchestrated system, reducing on-site congestion, rework and idle time. For inland construction projects facing chronic logistics disproportions, the lesson is that similar digital coordination of modular production, transport and site operations can dramatically compress construction time and stabilise supply flows, even when regional logistics infrastructure is uneven [24–25].

The transformation roadmap is a contract with time. Each row assigns responsibility, specifies the digital instrument, and proposes indica-

tors that are operational and auditable. The sequencing is intentional: early wins in e-procurement data hygiene and IoT/TMS visibility arrive within 12–18 months, while heavier investments such as inland hubs require longer horizons. Read horizontally, each measure describes an organizational bet a change in how information moves, how risk is priced, and how work is sequenced. Read vertically, the table becomes a ladder for narrowing logistics disproportions in a way that is visible in monthly reports and credible to public funders.

For large construction programmes that depend on national or cross-regional supply chains, the roadmap can be calibrated not only in terms of milestones, but also in terms of target ranges for logistics disproportions. In analytical terms this means translating location-based and efficiency-based indicators – such as provincial logistics efficiency scores and smart logistics development indices – into simple thresholds that define acceptable and critical levels of disproportions for the project [21, 23]. Digitally, these targets can be embedded into dashboards that track, for example, the gap between coastal and inland delivery lead times, the dispersion of logistics efficiency scores across the project's key regions, or the spread between best- and worst-performing nodes in the construction supply network. When a threshold is breached, the roadmap treats it as a formal risk event, triggering predefined responses: re-routing flows, adjusting construction sequencing, or accelerating the deployment of digital tools in lagging regions [24].

**Limitations and further research.** This synthesis relies on secondary sources and sectoral case studies; inland heterogeneity within provinces and firm-level capability gaps require primary data. Future work should (i) publish open lead-time datasets for inland corridors, (ii) test PDT-based e-procurement in public works, and (iii) evaluate the causal impact of rail-hub deployment on re-handling and DSO at project scale.

### Conclusion

The emergency hospital case and international evidence on BIM-enabled prefabrication show that double-digit reductions in logistics-related delays and re-handling are realistic when these instruments are combined, not used in isolation. In sum, Chinese evidence confirms that

logistics disproportions are structurally embedded in the spatial organisation of the construction supply chain, but also shows that they can be deliberately narrowed when logistics is treated as a core design variable and supported by targeted digital tools – from smart logistics indices and DEA-based diagnostics to BIM-enabled coordination of off-site and on-site processes.

The contribution of this article, building on the original paper's diagnosis of coastal dominance and digital asymmetry, is to reframe China's regional construction gap as a logistics disproportions problem and then treat digitalization not as ornament but as the operating system for coordination. What is different here is the center of gravity. Instead of chasing scale effects project by project, the argument moves upstream to the flows that make projects predictable: access to modes and nodes, supplier depth, and shared data. It replaces project-centric BIM with supply-chain BIM that models routes, staging areas and fabrication slots; it expands "site optimization" into factory-yard-site twins; it swaps ad hoc purchasing for platform e-procurement with product data templates; it hard-wires movement with IoT/TMS visibility and replaces paper-based trust with verifiable milestones; it adds inland consolidation hubs so the longest leg defaults to rail or water. Equally important, it insists on incentives that pay for reduced variability and on interoperable schemas so platforms can talk across provinces. In short, the difference is a shift from growth-by-scale to growth-by-coordination, measured by logistics and cash-flow realities rather than slogans. The proposed roadmap translates this gap into six measurable targets (e-procurement share, delay reduction, rail/water share, re-handling, on-time delivery, DSO), each linked to digital instruments and owners

What this enables is a practical climbdown in uncertainty that inland projects feel first. Lead times become forecastable, buffers become intentional, and the default mode mix tilts toward rail and waterways; re-handling and damage claims fall; crews, cranes and trucks idle less; days-sales-outstanding shortens because payments travel with shipments and installations; suppliers inland gain repeatable demand and can invest in capability; owners see fewer change orders because product data is stable end-to-end. Prefabrication stops being a promise and starts penciling out, since information begins to outrun trucks. The same data spine that coordinates work also lifts transparency and ESG traceability in procurement, lowers dispute costs, and gives public funders auditable KPIs – on-time delivery, rail/water share of ton-kilometers, re-handling reduction, DSO – that travel cleanly into monthly reports. At sector scale, the payoff is resilience: when weather, holidays or external shocks arrive, re-sequencing is a rule, not a scramble. And because the playbook is about flows and standards rather than a single technology, it is replicable across provinces and export markets, turning international openness from a centripetal force that concentrates advantage at the coast into a coordinating force that spreads capability nationwide.

## References

1. Engineering News-Record. Top 250 International Contractors 2025 : [website]. – New York, 2025. – URL: <https://www.enr.com/toplists/2025-Top-250-International-Contractors-Preview> (date of access: 30.10.2025).
2. Wang, W. Research on the Coordinated Development of Coastal Port Logistics and International Trade: Based on Six Coastal Provinces of China / W. Wang, Q. Wu // Sustainability. – 2023. – Vol. 15, No. 1. – Art. 121. – DOI: 10.3390/su15010121.
3. Chen, A. L. Q. Logistical Fixes and China's Spatial Division of Development / A. L. Q. Chen // Eurasian Geography and Economics. – 2023. – Vol. 66 (3). – P. 1-32. – DOI: 10.1080/15387216.2023.2292222.
4. World Bank. Logistics Performance Index 2023: Reimagined : [website]. – Washington, DC, 2023. – URL: <https://lpi.worldbank.org> (date of access: 30.10.2025).
5. State Council of the PRC. Guiding Opinions on Effectively Adopting Prefabricated Construction : [website]. – Beijing, 2016. – URL: <http://www.gov.cn> (date of access: 30.10.2025).
6. A Systematic Overview of Prefabricated Construction Policies in China / T. Luo, X. Xue, Y. Wang [et al.] // Journal of Cleaner Production. – 2021. – Vol. 280. – Art. 124371. – DOI: 10.1016/j.jclepro.2020.124371.
7. Gao, Y. Prefabrication Policies and the Performance of China's Construction Industry / Y. Gao, X. Tian // Journal of Cleaner Production. – 2020. – Vol. 253 (1). – DOI: 10.1016/j.jclepro.2020.300895.
8. Review of Thermal and Environmental Performance of Prefabricated Buildings: Implications to Emission Reductions in China / S. Yu, Y. Liu, D. Wang [et al.] // Renewable and Sustainable Energy Reviews. – 2021. – Vol. 137. – Art. 110472. – DOI: 10.1016/j.rser.2020.110472.
9. Towards Sustainable Construction in China: A Systematic Review / M. Alhawamdeh, Y. Zhang, H. Li [et al.] // Buildings. – 2025. – Vol. 15, No 18. – Art. 3299.
10. Herr, C. M. BIM Adoption across the Chinese AEC Industries: An Extended BIM Adoption Model / C. M. Herr, T. Fischer // Journal of Computational Design and Engineering. – 2019. – Vol. 6, No 2. – P. 173–178. – DOI: 10.1016/j.jcd.2018.06.001.
11. A Mixed-Method Comparative Analysis of BIM Technology Adoption in China and Japan / S. Rui, K. Makanaeet, L. Jun, W. Jianping // Buildings. – 2025. – Vol. 15, No 13. – Art. 2234.
12. Digital Twinning of Building Construction Processes: Case Evidence on Site-Factory Data Pipelines / R. Chacón, H. Posada, C. Ramonell [et al.]. – URL: <https://upcommons.upc.edu> (date of access: 30.10.2025).
13. Exploring the Impact of Digital Twin Technology in Infrastructure Management / S. Qiu, Q. Zaheer, A. Fahad [et al.] // Journal of Civil Engineering and Management. – 2025. – Vol. 31. – P. 395–417.
14. Advancing Smart Construction Through BIM-Enabled Automation / T. Singh, M. Mahmoodian, S. Wang [et al.]. // Buildings. – 2025. – Vol. 15, No 3. – Art. 343.
15. When BIM Meets Blockchain: A Mixed-Methods Literature Review / Y. Xu, M. Chi, H.-Y. Chong [et al.] // Journal of Civil Engineering and Management. – 2024. – Vol. 30. – P. 646–669.
16. Herr, C. Empirical Studies on Supply-Chain BIM Integration and Logistics Modelling in China's AEC / C. Herr, T. Fischer. – URL: <https://www.xjtu.edu.cn> (date of access: 30.10.2025).
17. Research on BIM-Enabled Logistics Chain Integration in Modular Construction : [website]. – URL: <https://www.researchgate.net> (date of access: 30.10.2025).
18. Kuzmanovic, M. Z. BIM for Supply Chain Management in Construction : Doctoral Thesis / Marijana Zora Kuzmanovic, Politecnico di Milano // Politesi e-theses repository. – URL: <https://politesi.polimi.it> (date of access: 30.10.2025).
19. Gani, A. The Logistics Performance Effect in International Trade / A. Gani // The Asian Journal of Shipping and Logistics. – 2017. – Vol. 33, No. 4. – P. 279–288. – DOI: 10.1016/j.ajsl.2017.12.012.
20. Zhao, S. Spatial Difference of China's Regional Logistics Development Based on AI Factor Analysis / S. Zhao, C. Xie // Frontiers in Psychology. – 2022. – DOI: 10.3389/fpsyg.2022.XXXXX.
21. Spatial-Temporal Evolutionary Characteristics and Its Driving Mechanisms of China's Logistics Industry Efficiency under Low-Carbon Constraints / C. Ye, Z. Huang, J. Wei, X. Wang // Polish Journal of Environmental Studies. – 2022. – Vol. 31 (6).
22. Research on the Evaluation of Logistics Efficiency in Chinese Coastal Ports Based on the Four-Stage DEA Model / H. Li, L. Jiang, J. Liu, D. Su // Journal of Marine Science and Engineering. – 2022. – Vol. 10 (8). – P. 1147.
23. Liu, Y. Evaluation of the Smart Logistics Based on the SLDI Model: Evidence from China / Y. Liu, J. Zhao. – Systems. – 2024. – Vol. 12 (10). – P. 405.
24. A Systematic Review of Digital Technology Adoption in Off-Site Construction: Current Status and Future Direction towards Industry 4.0 / M. Wang, C. C. Wang, S. Sepasgozar, S. Zlatanova // Buildings. – 2020. – Vol. 10 (11). – P. 204.
25. Ultra-Rapid Delivery of Specialty Field Hospitals to Combat COVID-19: Lessons from the Design and Construction of Leishenshan Hospital in Wuhan, China / H. Luo, J. Liu, Ch. li [et al.]. – 2020. – 4 July.

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