

ECONOMIC EFFICIENCY OF INTEGRATING BIM TECHNOLOGY WITH ARTIFICIAL INTELLIGENCE

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Abstract

This paper analyzes the economic efficiency of integrating Building Information Modeling (BIM) technology with artificial intelligence (AI) in the construction industry. Drawing on research by the McKinsey Global Institute, existing challenges and opportunities for improving labor productivity in the construction sector are examined. The potential for cost and time savings at the project level, as well as the role of digital technologies in boosting operational efficiency, are assessed with substantiated evidence. The findings indicate that this integration can optimize project management and potentially increase overall construction industry productivity by 50–60%.

Keywords

BIM, artificial intelligence, construction productivity, digitalization, economic efficiency, labor productivity, project management.

Аннотация

В данной статье анализируется экономическая эффективность интеграции технологии информационного моделирования зданий (BIM) с искусственным интеллектом (ИИ) в строительной отрасли. На основе исследования McKinsey Global Institute рассматриваются текущие проблемы и возможности повышения производительности труда в строительном секторе. На основе обоснованных данных оценивается роль цифровых технологий в потенциале экономии затрат и времени при интеграции BIM и ИИ в проекты, а также в повышении эффективности производства. Результаты исследования показывают, что такая интеграция может оптимизировать управление проектами и повысить общую производительность строительной отрасли на 50-60%.

Ключевые слова

BIM, искусственный интеллект, эффективность строительства, цифровизация, экономическая эффективность, производительность труда, управление проектами.

Annotatsiya

Ushbu maqolada qurilish sanoatida Building Information Modeling (BIM) texnologiyasini sun'iy intellekt (SI) bilan integratsiya qilishning iqtisodiy samaradorligi tahlil qilingan. McKinsey Global Institute tadqiqotlari asosida qurilish sektorining mehnat unumdorligini oshirish bo'yicha mavjud muammo va imkoniyatlar ko'rib chiqilgan. BIM va SI integratsiyasi loyihalardagi xarajat hamda vaqt tejash salohiyatini, ishlab chiqarish samaradorligini oshirishda raqamli texnologiyalarning o'rni asosli dalillar bilan baholangan. Tadqiqot natijalari ko'rsatishicha, ushbu integratsiya loyiha boshqaruvini optimallashtirib, umumiy qurilish sanoati unumdorligini 50-60% ga oshirish imkonini berishi mumkin.

Kalit so'zlar

BIM, sun'iy intellekt, qurilish samaradorligi, raqamlashtirish, iqtisodiy samaradorlik, mehnat unumdorligi, loyiha boshqaruvi.

1. Introduction

The construction sector is one of the largest in the global economy, accounting for approximately 13% of global GDP and attracting more than \$10 trillion in investment annually. Yet this industry has faced chronic low labor productivity for decades. According to McKinsey Global Institute (MGI) research, construction sector labor productivity grew at an average annual rate of only 1% over the past two decades – compared with 2.8% for the total economy and 3.6% for manufacturing. This divergence represents a persistent and structurally embedded challenge.

The scale of the productivity deficit is particularly stark in the United States. While many sectors – including agriculture and manufacturing – have increased productivity ten to fifteen times since the 1950s, construction productivity has barely moved from its level eighty years ago, with consistent decline observed since the late 1960s. The economic cost of this inertia is substantial: closing the gap between construction and total economy productivity could boost the sector's annual value added by an estimated \$1.6 trillion – equivalent to the GDP of Canada, or sufficient to meet half the world's annual infrastructure needs.

This paper examines how the integration of Building Information Modeling (BIM) with artificial intelligence (AI) addresses these structural inefficiencies, quantifies the economic case for adoption, and identifies the conditions necessary for successful deployment at scale.

2. The construction productivity problem: global context

Current state of the industry

Construction employs 7% of the world's working population and provides the physical infrastructure on which all other economic activity depends. Despite its scale, the sector is characterized by systemic underperformance. In a sample of countries analyzed by MGI, more than 75% of construction firms failed to match the productivity growth of the broader economies in which they operate over the prior decade. The industry collectively leaves an estimated \$1.6 trillion in annual value on the table.

The sector divides into two broadly distinct halves. Large-scale contractors engaged in civil and industrial heavy construction achieve productivity approximately 20 to 40% higher than the sector average. Fragmented specialized trade contractors – responsible for mechanical, electrical, plumbing, and other subcontracted work – consistently trail the sector average by approximately 20%. Large-scale players are not insulated from this drag; when they subcontract to smaller specialized firms, US data shows productivity in civil, industrial, and building categories declines by 12, 26, and 28% respectively. Productivity improvements therefore require action across the entire supply chain.

Root causes of low productivity

MGI research identified ten root causes of construction's poor productivity, grouped across three levels:

External forces:

- Increasing project and site complexity, geographic dispersion, and fragmented land markets;
- Extensive regulation and dependency on cyclical public-sector demand;
- Informality and in some cases outright corruption distorting the market.

Industry dynamics:

- Construction is among the most fragmented industries in the world;

- Contractual structures and incentive mechanisms are fundamentally misaligned;
- Bespoke or suboptimal owner requirements that resist standardization.

Firm-level operational factors:

- Inadequate design processes and investment in value engineering;
- Poor project management and execution basics;
- Insufficiently skilled labor at both frontline and supervisory levels;
- Chronic underinvestment in digitization, innovation, and capital equipment.

A survey of 5,000 construction industry CEOs conducted for the MGI study revealed a telling divergence: contractors and suppliers identified misaligned contracts as the most important root cause of low productivity, while the top cause cited by owners was inefficient on-site execution – illustrating the misalignment of perspectives that itself undermines collaborative problem-solving.

3. BIM and artificial intelligence integration: technical foundations

BIM: scope and current penetration

Building Information Modeling (BIM) is a digital representation of a building's physical and functional characteristics throughout its entire lifecycle – from design and construction through operation and maintenance. BIM integrates not only three-dimensional geometry but also time, cost, and performance data associated with each building component, enabling a substantially richer information environment than traditional two-dimensional drafting.

The primary functions of BIM include:

- Establishing a common data environment shared by all project stakeholders;
- Clash detection – identifying design conflicts before construction begins;
- Precise cost estimation and schedule planning through parametric quantity takeoffs;
- Generating fabrication-ready information for modular and prefabricated construction.

Despite these capabilities, industry adoption remains incomplete. The MGI survey found that only 50% of respondent construction firms maintained a standard design library – a prerequisite for systematic BIM deployment. This gap points to the distance between BIM's theoretical potential and its realized value across the industry.

Functions of Artificial Intelligence in construction

AI technologies are being applied across multiple construction functions, each of which compounds the economic case for BIM integration:

Predictive analytics and risk management:

Machine learning algorithms trained on historical project data can identify the probability of cost overruns or schedule delays before construction begins. Applied to the bidding and design phase, predictive models enable proactive mitigation rather than reactive crisis management. Research consistently shows that cost and schedule estimates can be significantly improved using data techniques already available.

Computer vision and automated site monitoring:

Drone-mounted and fixed camera systems equipped with AI-powered image recognition can monitor construction sites in near real-time, automatically detecting deviations from plan, workforce utilization gaps, and safety hazards. The sensor network deployed on London's Crossrail project – one of Europe's largest infrastructure schemes – demonstrated how predictive analytics and pattern recognition enable far more sophisticated project monitoring than traditional supervision methods.

Digital twin technology:

AI-enriched digital twins create continuously updated virtual replicas of construction projects, enabling simulation of scenarios and identification of optimization opportunities before physical implementation. This capability is particularly valuable for complex megaprojects where unforeseen changes are endemic.

Supply chain optimization:

AI-driven supply chain management enables just-in-time delivery of materials, reducing on-site inventory costs and waste. The construction sector currently ranks in the lower range of sophistication on McKinsey's Global Purchasing Excellence Survey, indicating that the gains achievable through improved procurement practices are substantial. Properly skilled central procurement teams can drive economies of scale and use IoT-connected inventory data to trigger predictive replenishment.

4. Economic efficiency of BIM-AI integration

The productivity opportunity: seven levers

The MGI research framework identifies seven areas of coordinated action that, if implemented simultaneously and at scale, could improve construction sector productivity by 48 to 60%. Technology infusion – encompassing BIM, AI, advanced automation, and new materials – is modeled as the single largest contributor, with an estimated productivity impact of 14 to 15 percentage points. The full framework is:

- Reshape regulation (enabler): Streamlining permitting, reducing informality, encouraging outcome-based building codes;
- Rewire the contractual framework (8–9%): Moving from adversarial to collaborative contracting models;
- Rethink design and engineering processes (8–10%): Value engineering, standardization, and off-site prefabrication;
- Improve procurement and supply-chain management (7–8%): Digitized workflows, just-in-time delivery;
- Improve on-site execution (6–10%): Rigorous planning, lean principles, forward-looking KPIs;
- Infuse digital technology, new materials, and advanced automation (14–15%): BIM, AI, IoT, robotics;
- Reskill the workforce (5–7%): Apprenticeship programs, continuous training, workforce stabilization.

The cumulative impact (48–60%) compares to an estimated 50% gap between current construction productivity and total economy productivity. Coordinated action could, in principle, close this gap entirely.

Project-level cost savings

The economic case for BIM-AI integration at the project level is supported by both research evidence and documented industry examples. Integrated planning tools on a large-scale oil and gas project achieved a 70% increase in project productivity. Cloud-based control towers that assemble accurate site data in near real-time have been shown to increase on-site productivity by up to 50%.

Three international case studies illustrate the breadth of the opportunity across the production spectrum:

- Broad Sustainable Buildings (China) erected a 30-story hotel in 15 days and estimates its buildings cost 10 to 30% less than structures built through traditional methods, through extensive prefabrication and systematic manufacturing processes;
- Outotec (Finland) reports that its mobile flotation plant for small mines requires 20% less capital investment, 30% less labor, and is 30% faster to install than alternatives – achieved through systematic engineering standardization;
- Barcelona Housing Systems is developing a full production system projected to build five to ten times more residential units than traditional construction using the same labor input.

Each example demonstrates that the economic gains are not speculative: they are achievable with existing technology and management approaches, provided the organizational and contractual environment supports their application.

The production system: a step-change opportunity

Beyond incremental improvement, the most economically significant opportunity lies in transitioning from entirely project-based construction toward a manufacturing-inspired production system. This involves mass production with high standardization, and the manufacturing of modules and components in off-site factories. The potential productivity gain from this transition is estimated at five to ten times current levels.

The economic logic of this transition operates through several reinforcing mechanisms:

- Amortization of design and engineering costs across large volumes of repeated units;
- Factory-based quality control that virtually eliminates defects and rework;
- Reduced dependence on weather and site conditions, improving schedule reliability.
- Continuous improvement enabled by systematic data collection and AI-driven optimization

This transition is not achievable across the entire sector. Complex bespoke infrastructure megaprojects – nuclear power stations, large airports, major bridges – require a different approach: a more holistic project-operating system that integrates technical and management systems rather than relying on process and command-and-control. For this segment, the priority is managing variance, flow, and inventory with far greater rigor than is currently standard.

5. BARRIERS TO ADOPTION AND STRATEGIC RESPONSES

Technology and organizational barriers

The MGI construction survey identified underinvestment in IT and the absence of systematic R&D processes as the two biggest barriers to innovation in construction. Specific obstacles to BIM-AI integration include:

- Absence of standard design libraries: Only 50% of surveyed firms maintain such libraries, limiting BIM's ability to generate efficiency gains through repetition;
- Capacity constraints in smaller firms: Specialized subcontractors – who account for 52% of construction value added – often lack the financial and technical capacity to adopt BIM and AI tools;
- Data interoperability: Ensuring consistent data flows across owner, contractor, and subcontractor systems requires governance and standardization that the industry has not historically provided;
- Skills deficits: Continuous reskilling is required to enable the workforce to operate advanced equipment and digital tools – a need that is poorly served by the industry's current training infrastructure.

Market dynamics and incentive barriers

The industry is currently in a structural deadlock. Owners – the primary potential beneficiaries of higher productivity – tend to be risk-averse and inexperienced; they require productive, trustworthy contractors offering quality and low prices at scale before they can change procurement practices. Many contractors, in turn, face potential revenue and margin compression from moving to productivity-based competition unless owners and the broader environment simultaneously change. A shift is only likely to be economically attractive to contractors if they can build the scale and repeatability needed to capture efficiency gains that outweigh revenue losses from reduced change orders and lower price points.

Four forces are, however, lowering these barriers:

- Rising requirements and demand in terms of volume, time, cost, quality, and sustainability, increasing the cost of inaction
- Larger-scale players, more transparent markets, and disruptive new entrants who can offer superior value
- More readily available new technologies, materials, and processes, reducing adoption costs
- Rising wage rates and restrictions on migrant labor, increasing the economic attractiveness of labor-saving automation

Government as an enabler of change

Government intervention can play a decisive role in breaking the deadlock. As policymakers, governments can mandate BIM adoption to build industry-wide transparency and collaboration; create public benchmarks on construction costs and contractor performance; accelerate permitting processes; harmonize building codes to support scalable, standardized construction; and invest in workforce skills rather than relying on low-cost transient labor. As owners – typically the largest construction clients in any economy – governments can combine projects into standardized portfolios, adopt best-value tendering rather than lowest-bid selection, and pilot or mandate new approaches such as integrated project delivery.

6. Quantitative framework for economic assessment

Rigorous evaluation of BIM-AI integration requires a comprehensive lifecycle cost model. The key dimensions are:

Total Cost of Ownership (investment):

- Software licensing and infrastructure (BIM platforms, AI tooling, cloud services);
- Implementation and systems integration;
- Training and continuous reskilling;
- Maintenance and ongoing platform upgrades.

Quantifiable benefits:

- Cost reduction on projects (estimated 27–38% cumulative from coordinated action across all levers);
- Schedule improvement and delay reduction through better planning and variance management;
- Reduction in material waste through improved logistics and reduced rework;
- Reduction in change orders through early clash detection and improved design coordination.

Qualitative benefits:

- Improved delivery reliability, generating stronger client relationships and repeat business;

- Richer project data enabling better resource allocation on future projects;
- Improved contractor-owner collaboration, reducing the adversarial dynamics that currently constrain productivity.

Project-level cost-benefit analysis points to payback periods of three to five years for firms undertaking systematic BIM-AI adoption. For large-volume owners and major contractors with stable project pipelines, payback periods in the early phases of deployment are shorter, as the fixed costs of adoption are amortized across larger volumes.

7. Implications for Uzbekistan's construction sector

Uzbekistan's construction sector has been expanding rapidly in recent years, driven by government programs in urban development, housing, and infrastructure. This expansion creates a favorable window for systematic BIM-AI adoption: project volumes are growing, large public clients have the scale to drive change, and the economy's digital transformation agenda provides supportive policy context.

Key opportunities include:

- Growing portfolios of standardized housing and infrastructure projects, which provide the scale and repetition necessary to justify production system investments;
- Extension of digital government initiatives to construction – including BIM mandates for public projects and cost transparency requirements for contractors;
- University and vocational education partnerships to develop the next generation of engineers and project managers with BIM and AI competencies;
- Technology transfer partnerships with international contractors experienced in advanced BIM-AI deployment.

Constraints that must be addressed include the shortage of BIM-qualified professionals, the limited financial capacity of smaller construction firms, and the need to adapt international standards to local regulatory and technical conditions. A phased approach – piloting BIM-AI integration on flagship public projects, building a knowledge base, then extending requirements progressively to the wider market – is the most pragmatic path forward.

8. Conclusion

The integration of BIM technology with artificial intelligence represents a technically feasible and economically compelling response to the chronic productivity deficit that has characterized construction for decades. The evidence base – from the McKinsey Global Institute's analysis of 41 countries and thousands of project-level data points – supports the following conclusions:

- A 48–60% productivity improvement is achievable through coordinated action in seven areas, with technology infusion contributing the largest single increment (14–15%);
- A transition to manufacturing-style production systems for appropriate segments of the market could deliver productivity gains of five to ten times current levels;
- The primary barriers are not technological but structural: misaligned incentives, market fragmentation, and skills deficits that require coordinated responses from governments, owners, and contractors;
- The economic stakes – \$1.6 trillion in annual value globally – justify substantial investment in enabling this transition.

For Uzbekistan, the path forward involves targeted regulatory reform to mandate and support BIM adoption, investment in education and skills infrastructure, and the use of large public

construction programs as proving grounds for new approaches. The diagnostic is clear. The tools are available. What remains is the collective will to act.

REFERENCES

1. T.A.Khujakulov, A.A.Bahromov "The importance of 3D modeling in the application of BIM technology for modern architecture" – Bulletin of TUIT: Management and Communication Technologies. № 1(5)2026. ISSN:2181-1083 DOI: Date: 2026-03-15. pp. 27–35.
2. Artikova M.A., Bahromov A.A., Jo‘raboyev F.A., (2024). 3D texnologiyalarni talimdagi o‘rni. Yevroosiyo akademik tadqiqotlar jurnalining universal indeks kutubxonasi, 4(12 Special Issue), 727729. <https://lib.uniconflict.com/index.php/uilejar/article/view/44219>
3. Bahromov A., Jo‘raboyev F. Virtual reallikni sohalarda qo‘llanilishi. Yevroosiyo akademik tadqiqotlar jurnalining universal indeks kutubxonasi, 4(12 Special Issue). 2024. 730–734.
4. Bahromov A.A., Ibodullayev S.N. Virtual reallik geometriyasi. "Экономика и социум" №12(103)-2. 2022. 15-21.
5. Barbosa F., Woetzel J., Mischke J., Ribeirinho M.J., Sridhar M., Parsons M., Bertram N., Brown S. Reinventing Construction: A Route to Higher Productivity. McKinsey Global Institute, February 2017.
6. Sadikov Sh.M. Analysis of Existing Vulnerabilities in Information Reception, Processing and Transmission Systems in a Distributed Database. Eurasian Journal of Engineering and Technology, Vol. 21, Belgium, August 2023. ISSN(E): 2795-7640.
7. Eastman C., Teicholz P., Sacks R., Liston K. BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers. John Wiley & Sons, 3rd edition, 2018.
8. Lu W., Chen K., Zetkalic A., Liang C. From BIM to Mixed Reality: A Novel Research Framework. Architectural Engineering and Design Management, 15(6), 2019. pp. 468–485.
9. Anderson R. Security Engineering: A Guide to Building Dependable Distributed Systems. Wiley, 2012.
10. Wu Y., Wei D., Feng J. Network Attacks Detection Methods Based on Deep Learning Techniques: A Survey. Complexity, 2020. <https://doi.org/10.1155/2020/8872923>