INTEGRATING LEAN MANAGEMENT INTO PPP PROJECTS: A PATHWAY TO SUSTAINABLE INFRASTRUCTURE RECOVERY IN POST-CONFLICT UKRAINE

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ABSTRACT

This article examines how Lean principles can be integrated into public-private partnership (PPP) projects to promote effective reconstruction and sustainable infrastructure development in postwar Ukraine. Driven by the urgent need to rebuild, Ukraine faces the challenge of not only rehabilitating its infrastructure assets, but also ensuring compliance with European Union standards and global sustainable development goals. The study explores the theoretical underpinnings of Lean manufacturing and its applicability to infrastructure PPP projects. A mixed method approach, including document and literature review, case studies, expert opinion and SWOT analysis, was used to identify opportunities for improving project implementation and resource allocation. The results show that the Lean concept can save costs, promote multi-stakeholder collaboration, and optimise procedures at each stage of the PPP infrastructure project lifecycle. Overcoming regulatory hurdles, attracting private investment and reducing political and economic uncertainty, are necessary ingredients for the successful implementation of Lean-based infrastructure PPP projects.

KEY WORDS: *public-private partnership, Lean management principles, infrastructure development, reconstruction, sustainability*.

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Introduction

The urgent need for effective post-conflict recovery in Ukraine arises today because of the extensive damage caused by Russian military aggression since February 2022, which has required both national and international responses to revitalise the economy and restore basic services. Published in February 2024 by the World Bank and its partners, RDNA3 (Rapid Damage and Needs Assessment) estimated the cost of re-building Ukraine over the next decade at $486 billion. As of April 2024, the total direct documented damage to Ukraine's infrastructure as a result of the full-scale Russian invasion was more than $157 billion. At the same time, the damage to infrastructure reached $36.8 billion (Report on damage, 2024; Government of Ukraine, 2022). This amount is constantly growing.

One of the important tasks of the postwar reconstruction of Ukraine is not only the physical reconstruction of the destroyed infrastructure, but also its modernisation, as well as the transition to European standards (Herbst et al., 2024; Integrated Approaches, 2021).

Integration into the EU zone and further full membership mean bringing Ukraine's infrastructure facilities into compliance with EU standard requirements. This means full integration into ENTSO-E (The European

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Energy Network) and the single transport network TEN-T (Trans-European Transport Network), and the development of public infrastructure standards. Therefore, its total infrastructure rehabilitation needs may well exceed current estimates and require significant investment in relatively short time-frames. Meanwhile, the total costs reflected in the recovery and reconstruction figure, $486 billion, include measures needed to rebuild for a modern, low-carbon, inclusive and climate-resilient future (Updated Ukraine Recovery, 2024; Integrated Approaches, 2021). The postwar reconstruction plan presented by the government in Lugano last year envisaged that $250 billion would come from private investors.

However, Ukraine needs to create transparent and understandable mechanisms to attract businesses to the area. One of the options is the public-private partnership (PPP). In turn, the application of Lean principles in PPP projects can significantly improve the quality and reliability of infrastructure facilities, contributing to the achievement of the global sustainable development goals, and create the necessary prerequisites for compliance with EU standards (Herbst et al., 2024; Casady et al., 2024). It is expected that the application of Lean construction principles will be important to improve the performance of PPP projects as Ukraine recovers from the postwar reconstruction. The urgent need to build and renovate infrastructure with minimal environmental impact is in line with Lean construction's emphasis on sustainability and environmental responsibility. The SWOT analysis of integrating Lean principles into PPP projects, along with the examination of other conceptual aspects of Ukraine's postwar infrastructure development, revealed that such a comprehensive approach can effectively leverage the synergy of long-term incentives, integrated teams, advanced technologies, and risk-sharing mechanisms. This ensures not only the reconstruction but also the development of a resilient and optimised infrastructure in the future.

The purpose of the research is to analyse and evaluate how Lean principles can influence the rehabilitation and sustainable development of infrastructure in long-term public-private partnership (PPP) projects in postwar Ukraine, particularly in meeting the global sustainable development goals and local needs.

The object of the study is the infrastructure reconstruction process in postwar Ukraine, particularly focusing on the implementation of PPPs as a mechanism for sustainable development.

The research questions are:

- How can Lean principles be applied to improve the preparation and implementation of PPP (public-private partnership) projects aimed at infrastructure rehabilitation in Ukraine?
- What specific Lean tools and techniques can be used to optimise PPP project workflows in these contexts?
- How does Lean methodology promote innovation and sustainable infrastructure development in long-term and high-budget PPP projects?
- What are the main regulatory, institutional and cultural barriers to the implementation of Lean principles in PPPs in Ukraine?

Methods of the research. Given the interdisciplinary nature of this study, which combines aspects of management, public administration, social and economic sciences, a mixed approach was chosen: a document and literature review, to study existing scientific publications, reports and regulatory documents related to the principles of PPP mechanisms and their application in infrastructure projects; and case study, to identify the key factors of effective PPP implementation in infrastructure projects. Thematic comparative analysis helped to systematically compare recurring themes in different contexts, identifying patterns and critical success factors for effective Lean implementation. Factor analysis provided the basis for identifying and assessing the underlying variables (latent factors) that influence outcomes in Lean-based PPP projects.

This study also uses SWOT analysis to systematically evaluate the potential application of Lean principles in infrastructural PPPs. This tool has provided a common understanding of both the positive and negative impacts of Lean implementation in PPP contexts, as it takes into account both internal factors (those directly under the PPP's control, e.g. resource allocation, organisational capacity, and existing Lean practices), and external factors (those outside direct control, e.g. policy changes, market forces and stakeholder relations).

The conceptual Mind Map tool (from Whimsical) was used to create a visual representation of the implementation process of the PPP project 'New Multidisciplinary Hospital in Zhytomyr', incorporating Lean principles.

1. Literature review and theoretical foundations

The public-private partnership (PPP) has long been recognised as an effective mechanism for financing and implementing infrastructure projects. These strategic partnerships leverage the strengths of both the public and private sectors to deliver services and develop infrastructure more efficiently than if each sector acted independently (Yun, 2024; Transparency International Ukraine, 2023; Kruhlov et al., 2024). Increasingly, research has highlighted the importance of PPPs in providing critical infrastructure, particularly in situations where institutional capacity is strained and rapid reconstruction is required (Jermenchuk, Paljchyk, 2019; Havrysh et al., 2024; Kruhlov et al., 2024; Shevchenko, 2024).

In the article by Mentukh (2024), the legal nature of PPPs in the construction and operation of transport routes in Ukraine is explored, with an analysis of theoretical foundations and proposed improvements to enhance infrastructure development through effective collaboration between the public and private sectors. In the context of Ukraine's postwar recovery, scholars emphasise that PPPs can mobilise private capital and expertise, while distributing risks and costs between the public and private sectors (Havrysh et al., 2024; Nahorna et al., 2024). For example, Shevchenko (2024) investigates the theoretical foundations of PPPs as a tool for Ukraine's postwar economic recovery. The author provides a thorough analysis of the genesis and evolution of strategic PPP partnerships in both global and Ukrainian contexts, identifying the role of PPPs in the administrative-legal framework and their potential to stimulate economic development and infrastructure rehabilitation.

The article 'Revitalizing Ukrainian Cities: The Role of Public-Private Partnerships in Smart Urban Development' examines how PPPs can support the restoration and modernisation of the urban infrastructure in Ukraine, particularly through the Smart City framework. It emphasises the need for effective mechanisms for urban area recovery, especially considering the destruction caused by the Russian military aggression (Kruhlov et al., 2024). While this work does not specifically address Lean principles, its insights into PPPs and smart urban development offer valuable information on strategies for integrating Lean methodologies into infrastructure restoration projects in postwar Ukraine. Combining these approaches could enhance the efficiency and sustainability of recovery efforts. However, the effectiveness of such partnerships depends on political will, transparent regulations, and a favourable institutional environment (Malin, 2019; Khazhyraieva et al., 2020; Zabashtanskyi, Sidor, 2023; Kruhlov et al., 2024).

Lean management, rooted in the manufacturing sector, is increasingly applied in public administration to optimise processes and enhance value delivery. In the context of the post-conflict challenges in Ukraine, integrating Lean principles with PPP models can facilitate rapid and efficient infrastructure recovery. This approach leverages the collaborative and resource-sharing nature of PPPs with Lean's focus on efficiency and waste reduction. A conceptual framework for implementing Lean construction in infrastructure recovery projects emphasises the need for organisational resilience and contractor efficiency (Habibi Rad et al., 2022). This framework addresses the need for performance evaluation tools tailored to PPPs, filling a gap in existing research.

Studies also indicate the positive potential of integrating Lean into PPP initiatives to align with the sustainable development goals. For instance, Woetzel and Pohl (2014) emphasise that incorporating Lean principles into PPPs can improve efficiency by reducing redundant processes, thereby enhancing resource utilisation in infrastructure projects. Lean methodologies in PPPs act as catalysts for achieving long-term sustainability, particularly in the construction and infrastructure sectors. This approach aligns with the framework introduced by Ceranic et al (2018) for incorporating sustainability as a guiding criterion in PPPs. Wright et al. (2018) also highlight the critical importance of this approach for sustainable infrastructure investment. The effective implementation of Lean principles in PPPs requires flexible stakeholder collaboration, as noted by Eweje et al. (2021), and a multifaceted Lean PPP approach significantly enhances the ability to achieve the sustainable development goals (Evadje et al., 2021). Additionally, research shows that Lean can optimise procurement processes, often a critical bottleneck in PPP projects (Chou, Pramudawardhani, 2015; Soecipto, Verhoest, 2018).

Thus, the theoretical foundation for our research is provided by fundamental theories of Lean production and PPPs, connected to sustainable infrastructure development. However, despite a significant body of scholarly work on the potential synergy between Lean principles and PPP frameworks, particularly in infrastructure development (Ceranic et al., 2018; Yun, 2024), there is a lack of empirical studies evaluating how these concepts function in the complex conditions of post-conflict environments. This gap is particularly evident in the context of Ukraine, characterised by urgent recovery needs, limited funding, and evolving regulations.

The research problem is to identify the potential of applying Lean principles to optimise the implementation of PPP projects in the context of restoring and developing Ukraine's infrastructure in the postwar period, as well as to identify the immediate prospects and obstacles to organising synergies between PPPs and the Lean concept in this area.

2. Infrastructure and public-private partnerships in Ukraine

PPPs in infrastructure development usually involve long-term contractual relationships between public entities and private companies, where both parties share the responsibility and risks associated with project financing, ownership and revenue generation, allowing for efficient design, construction, operation and maintenance of infrastructure projects (Schanzenbach et al., 2017; Stella, Menassa, 2020).

International experience shows that the most frequent projects are roads, bridges, airports, pipelines and stadiums. These are the facilities that have been damaged in Ukraine and need to be restored as a priority. But there are many more social infrastructure facilities (kindergartens, hospitals, schools) that also need rehabilitation and sometimes even construction.

Ukraine's critical infrastructure has long faced enormous challenges, which have only worsened since the Russian invasion of Ukraine. Until February 2022, Ukraine was implementing a reform programme focused on private sector participation in infrastructure. In 2018 and 2019, the Public-Private Infrastructure Advisory Facility (PPIAF) provided initial support to the country to help establish the PPP Agency and develop a pipeline of potential projects.

In 2020, the first concession agreements were signed for the Olvia and Kherson port concession projects. PPIAF assisted the Ministry of Infrastructure of Ukraine and the PPP Agency in building the institutional capacity of concessionaires and developing a monitoring system to oversee the concessions during the first critical years of operation (PPIAF, 2023).

In general, it is possible to highlight advantages that can be associated with the use of PPP mechanisms in the context of the rehabilitation and reconstruction of Ukrainian infrastructure:

1. PPPs can attract significant private investment, which is especially important for large projects, the independent implementation of which may be financially unaffordable for public authorities (Schanzenbach et al., 2017).
2. PPP promotes progress and innovation. Modern solutions that increase sustainability and efficiency can be beneficial to such projects (Berglöf, Rashkovan, 2023).
3. The flexibility inherent in PPPs can help reach consensus on complex strategic and policy issues related to infrastructure investment. This makes PPPs a strategically important tool for achieving national and sustainable development goals (Stella, Menassa, 2020; Schanzenbach et al., 2017).

Today, it can be said that Ukraine has significantly developed its legal and regulatory framework for the implementation of PPP projects in order to attract private investment and improve the quality of infrastructure. We have reviewed the key components of this framework, including primary legislation, some additional rules, institutional support and international assessments (Appendix 1).

Ukraine's current efforts are aimed at improving this structure to better meet international standards and effectively attract private investment for sustainable infrastructure development.

For example, PPP bureaucratic procedures currently take about two years. This significantly affects the willingness of private partners to participate in project implementation. The National Recovery Council of

Ukraine proposes to reform the legislation. In particular, it proposes to speed up the approval of projects worth up to $5.3 million through the use of an electronic procurement system. This will guarantee transparency and allow the community to monitor project implementation.

Ongoing legislative amendments and efforts to harmonise with international standards demonstrate Ukraine's commitment to improving the mechanism of PPPs in infrastructure development. Nevertheless, there remain shortcomings in the legal and regulatory framework that require close attention and appropriate responses.

Table 1. Problems and gaps in the legal and regulatory framework for PPP regulation in Ukraine

Legal and regulatory challenges	Issue	Impact on the decision of potential investors
1. Complex and Fragmented Legislation	Overlapping laws and regulations can create confusion	Potential investors face legal uncertainty, deterring investment
2. Inadequate Risk Allocation Mechanisms	Lack of clear guidelines on risk sharing	Increases the financial exposure of private investors
3. Judicial and Enforcement Challenges	Weaknesses in the judicial system affect enforcement	Investors may perceive higher risk, making dispute resolution difficult
4. Limited Institutional Capacity	Public authorities lack PPP project management expertise	Inefficiencies and delays in project implementation
5. Corruption and Lack of Transparency	Corruption undermines fair competition	Reduced investor confidence and unsatisfactory project performance

Source: the authors

Moreover, the successful integration of PPPs into Ukraine's reconstruction efforts requires strong domestic support, as well as ownership, underscoring the importance of inclusive consultation with local stakeholders to ensure the legitimacy and effectiveness of investment decisions (Berglöf, Rashkovan, 2023).

Today, the Ukrainian government is actively working in this direction. For example, the involvement of the private sector (including through PPPs) and the application of digital tools to urban renewal planning in Ukraine are being discussed. A draft National Framework Programme for Integrated Rehabilitation of Human Settlements has been developed, piloting initial efforts in the cities of Kharkiv and Mykolaiv, in cooperation with UNECE and other stakeholders. The implementation of pilot projects at the city level emphasises the importance of involving the private sector in reconstruction planning and the use of innovative tools (UN4UkrainianCities, 2023; Kruhlov et al., 2024).

The war required a dynamic adaptation of the PPP structure in Ukraine, with an emphasis on international cooperation, governance reforms for effective reconstruction and development of sustainable infrastructure. The strategic role of PPPs in reconstruction is actively increasing, and PPP projects will be an integral part of mobilising private investment for reconstruction efforts (Transparency International Ukraine, 2023). Both international support and investment play a significant role in catalysing PPP arrangements during this difficult period for Ukraine. Global organisations have already committed significant resources to help Ukraine's recovery. The EU has committed up to $39 billion to rebuild Ukraine's economy and energy system, to decentralise the energy infrastructure to increase resilience to attacks (Cook, 2024). Also, the European Bank for Reconstruction and Development (EBRD) and the International Finance Corporation (IFC) have allocated $435 million to support the merger of Ukrainian telecommunications companies, improving digital connectivity and infrastructure resilience (Harmash, 2024).

However, reconstruction efforts are still hampered by problems of corruption and poor governance, resulting in delays in critical infrastructure projects. Addressing these issues is critical to ensuring effective reconstruction and rehabilitation, and meeting international standards of transparency and accountability

(The Times, 2024). It is also critical that the costs and benefits of PPPs are realistically assessed, as the financial obligations will ultimately be borne by taxpayers or consumers.

3. The application of Lean principles in the context of PPP

In turn, embedding Lean principles into infrastructure and construction projects through partnerships appears to be a driving force for achieving long-term sustainability (Ceranic et al., 2018). In addition to enhancing efficiency, this strategy helps align private-sector incentives with public infrastructure requirements, ensuring that projects meet relevant socio-economic goals and sustainability objectives in the areas of economy, society and the environment. Lean thinking directly supports the SDGs by focusing on the efficient use of human, financial and environmental resources.

In Ukraine, where systemic inefficiency, corruption and wasteful resource use have historically hindered progress, the theoretical link between Lean production concepts and public-private partnerships (PPPs) facilitates the adoption of this approach for infrastructure reconstruction and recovery (OECD, 2021). An integrated Lean-PPP approach can ensure that Ukraine's recovery efforts are sustainable, inclusive and transparent, providing an effective pathway to address urgent postwar needs, while simultaneously laying the groundwork for long-term development, regional resilience, and alignment with global sustainability standards (European Commission, 2022; Yun, 2024; Berglöf, Rashkovan, 2023).

This approach aims to both attract significant investment and spur innovation, and (crucially) ensure that reconstruction projects are aligned with the needs of local communities (Fig. 1).

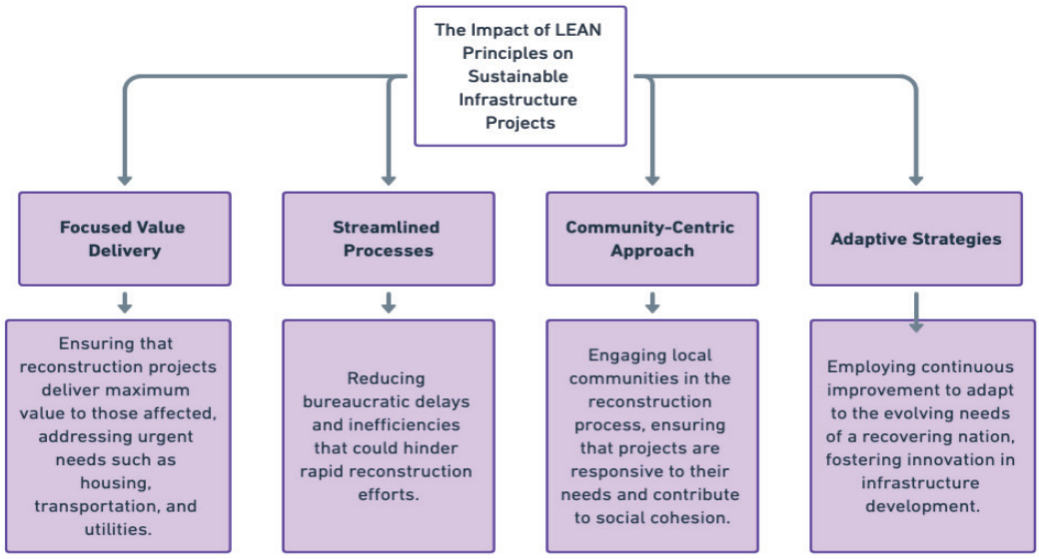

Figure 1. The impact of Lean principles on the implementation of infrastructure projects in the context of sustainable development

Source: the authors, based on Wright et al., 2018; Cruz Villazón et al., 2020; United Nations, 2021; https://whimsical.com/impact-of-lean-principles-on-sustainable-infrastructure-BUqY6zw7H2C8gdKVutGA4K

Although Lean principles are actively applied in construction and manufacturing for infrastructure development, the structure of PPPs in the postwar period suggests special conditions for their holistic and sustainable implementation, especially when an efficient, sustainable and resilient infrastructure is crucial. In traditional infrastructure projects, due to fragmented contracts and short-term priorities in traditional infrastructure projects, the implementation of Lean can be difficult. In contrast, PPPs inherently support the collaborative, life-cycle-oriented and value-based approach that the Lean methodology promotes. Postwar

reconstruction with urgent demands and resource constraints emphasises these differences. Lean in PPPs aims to synergise long-term incentives, integrated teams, risk sharing, and advanced technologies to ensure not only urgent recovery, but also optimised, durable infrastructure for future generations (Appendix 2)

By integrating, for example, Lean methods such as *VSM (Value Stream Mapping)*, *Standard Work, Just-In-Time*, and so on, stakeholders can optimise each step of the process PPP. This approach not only accelerates recovery efforts, but also ensures that the recovered infrastructure maximises benefits.

Lean principles in the implementation stages of PPP infrastructure projects (Alghamdi et al., 2022; Bigwanto et al., 2024; Casady et al., 2024; Solaimani et al., 2019):

Stage 1. Initiating a partnership and submitting a proposal. Applying the 'just-in-time' approach to concept note and feasibility study preparation, ensuring that the required information is provided in an optimal timeframe. Use of visual management (e.g. mapping) to transparently track all stages of proposal preparation.

Stage 2. Analysing the effectiveness of PPPs. Applying the Value stream principle to identify and eliminate inefficient processes in analysis, ensuring the accuracy and timeliness of findings. Utilising the Kaizen method to continuously improve the analysis process.

Stage 3. Making a decision on PPP and holding a tender. Applying process standardisation to the development of tender documents, which reduces the possibility of errors and speeds up the process. Use of the *'5S' (Sort, Straighten, Shine, Standardise, Sustain)* to organise the tender process

Stage 4. Organisation of the competition. Applying Lean manufacturing to minimise wasted time and resources in setting up the panel, developing documentation, publishing advertisements, receiving and evaluating proposals. Utilising the *'Just-in-Time' (JIT)* method to manage and evaluate incoming proposals in a timely manner.

*Stage 5. Approval of the results and conclusion of the contract with the private partne*r. Using the Visual management and Kanban system to clearly track approval and contracting milestones for transparency and efficiency. Using the 'Poka-Yoke' (error prevention method) to minimise errors in contracting.

Applying Lean principles throughout the life cycle of a PPP project will increase efficiency, reduce waste, and accelerate the rehabilitation of Ukraine's infrastructure.

4. The SWOT analysis of Lean principles in PPP models

To assess the potential application of Lean principles in PPPs in this study, we used SWOT analysis. SWOT was chosen because it allows for a holistic assessment of both internal and external factors that may affect the success of Lean in PPP projects. Authors (Helms, Nixon, 2010; Marilyn et al. 2021; Taherdoost, Madanchian, 2021) have demonstrated the effectiveness of SWOT in evaluating strategic management initiatives in complex organisational contexts. It serves as a tried-and-tested tool to weigh the benefits of Lean implementation against the challenges and risks that may arise due to different public and private partner interests, resource constraints, or macro-environmental factors. In our view, in this respect, SWOT offers an accessible and widely understood format that stakeholders from different sectors can easily interact with, thereby facilitating joint decision-making and clarifying which elements of Lean are most beneficial or most risky in the context of infrastructure PPP projects. This analysis can also serve as a starting point for more in-depth studies, such as cost-benefit analysis and stakeholder mapping. Once strategic issues have been identified through SWOT, it is possible to delve deeper into specific topics that require more focused research or targeted interventions.

For example, PESTEL analysis complements tools such as SWOT by focusing on the macro-environmental forces that shape the broader contexts (in which organisations or projects such as PPP or Lean initiatives operate).

Thus, the SWOT matrix in our study was developed using a combination of literature review, analysis of industry reports and PPP regulations, and articles and secondary data on existing infrastructure PPP models and the integration of Lean principles into infrastructure and construction projects.

SWOT analysis has shown that the use of Lean principles in PPP models can significantly improve infrastructure development by increasing efficiency, risk sharing and innovation. However, there are challenges and limitations (Table 4).

Table 2. SWOT analysis of the application of Lean principles in the context of PPP infrastructure projects in Ukraine in the postwar recovery period

Strengths	Weaknesses
1) Professionalism and efficiency: Lean principles contribute to process optimisation. This allows for the faster implementation of infrastructure projects and lower costs. 2) Risk sharing: PPPs share risks between private and public partners, making projects more resilient to economic and operational changes. 3) The application of Lean principles encourages innovation and new management methods, which improves the overall efficiency and quality of projects. 4) Synergies between public and private expertise. Where governments may lack specialised know-how (in advanced project management or Lean methodology), private partners can fill this gap 5) Well-structured PPPs often include performance-based contracts and KPIs. This aligns well with Lean principles of continuous improvement, which can improve the standard of project delivery and accountability. 6) Lean plus PPP can accelerate the adoption of digital project management tools that further reduce waste and inefficiencies	1) Complex regulatory frameworks can make it difficult to implement PPP projects based on Lean principles. 2) Uneven distribution of resources. The attractiveness of more profitable projects can leave less profitable but vital projects without the necessary attention and funding. 3) Internal organisational or structural issues (e.g. limited internal capacity, lack of Lean expertise in the public sector). 4) The introduction of new approaches and technologies can face resistance from state and local authorities that are accustomed to traditional ways of working. 5) In a postwar environment, local workforce or government entities may lack experience of Lean This internal shortfall can slow implementation. 6) PPP agreements can be extremely lengthy and technically detailed. Misalignment with Lean's need for agile, iterative processes can be a weakness if legal frameworks are overly rigid or bureaucratic
Opportunities	**Threats**
1) Wider adoption of technologies such as building information modelling, IoT sensors and advanced analytics, can enhance the impact of Lean on PPP project delivery, reducing costs and environmental impacts. 2) Coordination and partnerships with institutions (e.g. the World Bank, EBRD, private foundations, etc) can provide access to low-interest financing and technical assistance for PPPs that implement Lean. 3) The use of innovative technologies and approaches can make infrastructure more efficient and sustainable. 4) Green initiatives. Opportunities to integrate environmentally friendly technologies and solutions into PPP infrastructure projects will contribute to the sustainable development of the country	1) Economic and social instability, possible fluctuations in international financial markets may affect the attraction and retention of investment. 2) Macro-level volatility (economic, political changes) can derail projects. 3) Corruption and lack of transparency in processes may reduce investor confidence, and, as a result, reduce the effectiveness of projects. 4) Supply chain disruption risk: postwar disruptions to transport infrastructure or logistics could delay project delivery and increase costs. 5) Uneven distribution of financial and other resources, as well as possible inconvenience for the population (for example, toll roads) may cause social tension and protests

Source: the authors, based on Solaimani et al., 2019; Cruz Villazón et al., 2021; Alghamdi et al., 2022; Bigwanto et al., 2024; Casady et al., 2024; Kolosky, 2024; Havrysh et al., 2024; Nahorna et al., 2024; Shevchenko, 2024; Berglöf, Rashkovan, 2023; PPIAF, 2023; UN4UkrainianCities, 2023.

While the integration of Lean into PPP infrastructure projects looks promising, there are significant challenges that need to be addressed comprehensively. The success of PPP programmes depends on the quality of the country environment and the ability to overcome challenges in developing effective models.

Potential risks such as regulatory hurdles, political instability and lack of experience with PPPs and Lean can adversely affect the realisation of important infrastructure projects.

It is also worth noting that adopting Lean principles requires a cultural shift towards continuous improvement and stakeholder collaboration. This requires training, capacity building, and commitment to change management, among all parties involved. Early involvement of contractors and suppliers is seen as a key differentiating factor for best construction practices, emphasising the need for integrated project delivery

methods. Another problematic aspect that was not included in the SWOT matrix is determined by the complexities associated with the reconstruction of Ukraine (e.g. disputes over land ownership, security issues, urgent humanitarian needs overshadowing long-term planning).

The SWOT analysis shows a tendency that the combined PPP-Lean approach can improve efficiency, innovation and risk sharing. However, obstacles such as political and economic instability, corruption and lack of transparency, supply chain disruptions in the postwar environment, and social tensions may hinder progress.

5. The 'New Multidisciplinary Hospital in Zhytomyr' PPP project

General information about the project: On 9 July 2024 in Vienna in Austria, an agreement was signed between the International Finance Corporation (IFC), a member of the World Bank Group, and the Zhytomyr City Council, to engage consultants and provide advisory services for further preparation of the project 'New Multidisciplinary Hospital in Zhytomyr'. The results of the preliminary appraisal confirmed the suitability (compliance with the attributes and criteria) and potential of the project for PPP implementation, and a Concept Note for implementation has been prepared (PPP Agency, 2024). A brief description of the project is presented in the table below.

Table 3. The PPP project 'New Multidisciplinary Hospital in Zhytomyr' (Zhytomyr, Ukraine)

	Description
1. Goal	To unite Zhytomyr's outdated city hospitals into a single, modern, multidisciplinary centre providing comprehensive medical care
2. Problems to be Solved	Ageing infrastructure limits opportunities for modernisation and increases maintenance costs. Longer waiting times and inefficiencies are caused by fragmented care and duplication of services. Poorly organised clinical workflows and high operating costs affect the responsiveness and quality of care. Unequal access to high-quality health care is reduced by limited availability, especially for low-income individuals
3. Conditions	TA private partner will design, build, finance and operate the new hospital, ensuring affordable infrastructure while maintaining clinical services that are controlled by the city municipality
4. Partners	The International Finance Corporation (IFC), Zhytomyr City Council, the PPP Agency, and several private companies are supporting the project using the PPP model
5. Scope	The 400-bed hospital will be designed to accommodate up to 400,000 patients and will meet modern service requirements, optimise patient flows, and provide round-the-clock treatment
6. Outcomes	The objectives of this PPP project are to increase patient satisfaction, reduce operational inefficiencies, improve access to medical care, and provide the region with long-term, high-quality medical services

Source: the authors, based on PPP Agency, 2024.

This strategic project aims to modernise and improve the health-care infrastructure of the city of Zhytomyr in Ukraine. The initiative aims to promote more efficient, reliable and patient-centered health-care services through public-private partnerships (PPPs), against the backdrop of the ongoing challenges caused by the war. Zhytomyr City Council plans to optimise service delivery, reduce operating costs, and significantly improve clinical outcomes, by consolidating several outdated, high-cost hospital facilities into one modern facility. We envision that integrating Lean principles into the Zhytomyr hospital PPP project will ensure a systematic approach throughout the project life cycle, helping to improve the efficiency and effectiveness of both the construction and operational phases. By focusing on waste elimination, process optimisation and effective stakeholder engagement, such an integrated approach is in line with the project's goal of delivering high-quality health-care infrastructure in a post-conflict context. Our vision for the implementation of this PPP project using the Lean methodology is presented below (Fig. 2, Appendix).

Thus, the use of the *Integrated Project Delivery (IPD)* method for the PPP project in Zhytomyr hospital can ensure that all stakeholders (government agencies, private partners, designers, contractors) will effectively collaborate to build a modern hospital on budget and on time, integrating Lean and sustainable methods to minimise waste and environmental impact, encouraging innovation and adaptability, ensuring that the institution will meet long-term health needs. By implementing IPD, the project team will be able to optimise processes, align interests and deliver results that will meet the needs of the local community.

To ensure continuous progress at all stages of this project without unnecessary delays, *just-in-time (JIT)* principles can be applied to synchronise activities in the supply chain of materials and equipment. And using *Takt time planning*, it is possible to balance the workload and maintain stable rhythms of construction and operation.

Gemba Walks is a powerful method for monitoring progress within the framework of Lean management. By physically visiting the site where work is being done, interacting with employees, and observing processes in action, managers can gain an invaluable insight into operational performance. And when combined with tools such as *A3 reports* and the *PDCA cycle* (Bigwanto, 2024; Kolosky, 2024), *Gemba Walks* promotes a holistic approach to continuous improvement, ensuring that not only changes are implemented, but processes are maintained and improved over time.

To implement continuous improvement to adapt and improve processes throughout the project life cycle, it is also worth creating a feedback loop with all project stakeholders for iterative improvements, and regular *Lean audits* and *Kaizen* events for verification.

Thus, by systematically applying Lean principles at every stage of the PPP project, the new multidisciplinary hospital has a chance to achieve the planned goals on time and within budget (Figure 3).

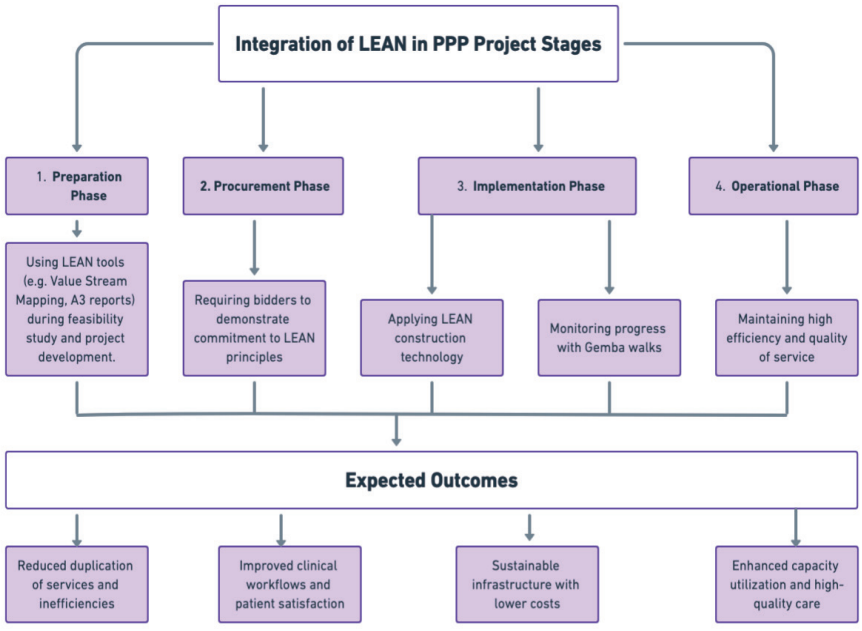

Figure 3. General scheme of Lean implementation in the stages of the PPP project based on the example of the Zhytomyr hospital

Source: the authors, https://whimsical.com/integration-of-lean-in-ppp-project-stages-B73nQSfRou54Nqt92CZHBL@3QU9HnCUztRKKukDTapo5oBboXAqGkDPo3WcD3U

In order for the PPP project for the construction of the Zhytomyr hospital to be in line with the *Sustainable Development Goals (SDGs)* and provide long-term social and environmental benefits, it is necessary to include SDG-aligned objectives. For example, the project plans for the hospital to serve not only Zhytomyr,

but also neighbouring areas, increasing the region's resilience and equity in health care. This is in line with *SDG 11: Sustainable Cities and Communities.* The network must provide for the positioning of the hospital as a central hub for regional health care, reducing the need for numerous inefficient institutions, and also take care of increasing accessibility through integrated transport solutions for the urban and suburban population.

Of course, despite the potential of Lean for PPP in this project, there are many difficulties in this respect. For example, resistance to change, risk sharing, funding gaps, etc. The problems are also exacerbated by the ongoing military action in Ukraine.

Conclusions

Contemporary concepts and initiatives highlight the ongoing global focus on sustainable, efficient and resilient infrastructure development. When properly combined with Lean manufacturing principles and PPP models, they can address pressing issues such as post-conflict reconstruction, digital transformation and environmental sustainability. By aligning with international frameworks and implementing modern technologies, these approaches increase the potential for the effective implementation of Ukrainian infrastructure projects in military and post-military contexts.

However, successful implementation requires overcoming regulatory and social barriers, and striving to ensure political and economic stability. To mitigate threats such as economic instability, political change, corruption and social tensions, strategies should aim to increase transparency, ensure fair resource allocation, and maintain stable governance.

It is necessary to improve the institutional architecture for supporting, monitoring and tracking the effectiveness of PPP infrastructure projects, introduce a transparent and convenient mechanism for challenging the actions of the state partner (e.g. competition committees at the stage of awarding PPP contracts), and develop the competence of state partners in implementing PPPs.

For Ukraine, where reconstruction will require not only the restoration of physical infrastructure but also increased resilience and regional stability, such an integrated approach offers a roadmap for achieving long-term development goals.

Combining Lean principles with PPP ensures that recovery efforts are not only effective but also sustainable and inclusive, meeting immediate postwar needs while laying the foundations for future prosperity.

Future research will focus on assessing the impact of Lean principles on optimising resource allocation in PPP projects and exploring how to improve this process to ensure efficient and timely project implementation in the context of Ukraine's rehabilitation needs. Additionally, practical recommendations, strategies, and a KPI system for integrating Lean principles into PPP projects will be developed to enhance their contribution to Ukraine's sustainable development and compliance with European infrastructure standards.

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LEAN VALDYMO INTEGRAVIMAS Į VIEŠOJO IR PRIVATAUS SEKTORIAUS PARTNERYSTĖS (PPP) PROJEKTUS: TVARAUS INFRASTRUKTŪROS ATSTATYMO POKARIO UKRAINOJE PERSPEKTYVOS

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Santrauka

Šiame straipsnyje nagrinėjama, kaip LEAN principus galima integruoti į viešojo ir privataus sektoriaus partnerystės (PPP) projektus, siekiant skatinti veiksmingą atstatymą ir tvarią infrastruktūros plėtrą pokario Ukrainoje. Kuo skubiau atstatyti šalį siekiančiai Ukrainai kyla iššūkis ne tik atstatyti infrastruktūros objektus, bet ir užtikrinti jų atitiktį Europos Sąjungos standartams bei pasauliniams tvarios plėtros tikslams. Tyrime analizuojami teoriniai LEAN gamybos pagrindai ir jų pritaikomumas infrastruktūros PPP projektuose. Taikant mišrų metodinį požiūrį, kuris apima dokumentų ir literatūros analizę, atvejų tyrimus, ekspertų vertinimus ir SSGG (silpnybių, stiprybių, grėsmių, galimybių) analizę, aptarta, kaip būtų galima efektyviau įgyvendinti projektus ir paskirstyti išteklius.

Tyrimo rezultatai rodo, kad LEAN koncepcija gali sumažinti sąnaudas, skatinti daugelio suinteresuotųjų šalių bendradarbiavimą ir optimizuoti kiekvieno infrastruktūros PPP projekto gyvavimo ciklo etapo procedūras. Norint sėkmingai įgyvendinti LEAN principais grindžiamus PPP projektus, būtina įveikti reguliavimo kliūtis, pritraukti privačių investicijų ir sumažinti politinį bei ekonominį neapibrėžtumą. Tyrime pabrėžiama, kad tvirtos infrastruktūros PPP sistemos reikia siekiant didinti investuotojų pasitikėjimą ir sutelkti infrastruktūros spartesnio atstatymo pastangas. Būtina tobulinti infrastruktūros projektų rėmimo, stebėsenos ir efektyvumo stebėjimo institucinę architektūrą, diegti skaidrų ir patogų valstybės partnerio veiksmų plano mechanizmą (pvz., sudaryti konkurso komitetai sutarčių sudarymo stadijoje) ir kelti valstybės partnerių projektų įgyvendinimo kompetenciją. Ukrainai, kuriai atstatyti prireiks ne tik atkurti fizinę infrastruktūrą, bet ir didinti šalies atsparumą bei regioninį stabilumą, toks integruotas požiūris yra ilgalaikių plėtros tikslų siekimo gairės.

Suderinus LEAN principus su PPP, užtikrinamos ne tik veiksmingos, bet ir tvarios, įtraukios šalies atstatymo pastangos, tenkinančios neatidėliotinus pokario poreikius, padėjus būsimos gerovės pagrindus. Būsimuose tyrimuose teks įvertinti LEAN principų poveikį optimizuojant išteklių paskirstymą VPP projektuose ir nustatyti šio proceso spartinimo galimybes, užtikrinant efektyvų ir savalaikį projekto įgyvendinimą atsižvelgiant į Ukrainos reabilitacijos poreikius. Be to, bus parengtos praktinės rekomendacijos, strategijos, kaip LEAN principų integravimo į VPP projektus sistema, siekiant didinti indėlį į tvarų Ukrainos vystymąsi ir šalies atitikimą Europos infrastruktūros standartams.

PAGRINDINIAI ŽODŽIAI: viešojo ir privataus sektoriaus partnerystė, LEAN vadybos principai, infrastruktūros plėtra, atstatymas, tvarumas.

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