

Economic Efficiency and Investment Potential of Strategic Infrastructure Reconstruction for Regional Ukraine

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Abstract

The ongoing war in Ukraine has resulted in the destruction of infrastructure valued at USD 486 billion. Most of the documented damage is in ten specific oblasts. Although reconstruction of these oblasts is a high priority, the analysis of regional reconstruction studies focusing on the economic and investment aspects of reconstruction has been virtually non-existent. The goal of this research is to establish the framework for the quantitative analysis of the reconstruction of these ten oblasts using a combination of methods. This research will focus on the construction of a sub-component Composite Investment Attractiveness Index (IAI) as a key component. The analysis will be supplemented by the assessment of the Net Present Value (NPV) and the Internal Rate of Return (IRR) with three reconstruction cost estimates of USD 175.1 billion (Pessimistic, Baseline, and Optimistic). The declared reconstruction estimates show a range of total NPV of USD - 42.2 billion (Pessimistic) to USD - 9.8 billion (Baseline), and USD +97.0 billion (Optimistic). The Baseline breakeven discount rate is 6.95%. Zonal differentiation is highly evident. Dnipropetrovsk (IAI 71.90) and Kharkiv (IAI 68.25) achieve a positive NPV at 9% respectively, while Luhansk (IAI 54.40) is the lowest performer. Under the Pessimistic and Baseline scenarios, aggregate regional GDP does not recover to pre-war levels before 2035; the Optimistic scenario projects recovery by 2030. The results indicate the EU, as a donor, should focus on financing cost and the ability to absorb funds, rather on extent of damage to infrastructure. The novelty of this study lies in its simultaneous integration of a composite Investment Attractiveness Index, multi-scenario discounted cash flow analysis, and regional GDP recovery modelling at the oblast level—an approach that, to the authors' knowledge, has not previously been applied to Ukraine's post-conflict reconstruction context.

Keywords: Infrastructure Reconstruction; Investment Attractiveness; NPV analysis; Post-Conflict Recovery; Regional Economic Efficiency; Ukraine

Introduction

The Russian full-scale invasion of Ukraine in February 2022 resulted in one of the biggest events of infrastructure destruction in modern European history, as described by the World Bank, the European Commission and the Government of Ukraine. In early 2024, World Bank estimated that physical capital losses in Ukraine had reached USD 486 billion as the losses in the ten most affected oblasts were the overwhelming majority of verified damages (World Bank, 2023). Eastern and southern Ukraine's roads, bridges, energy grid, water systems and industrial facilities were crippled — in many cases completely paralyzed — to a fraction of their pre-war functionality. In Luhansk oblast, for example, pre-war infrastructure stock was damaged or destroyed by an estimated 88 percent, in Kherson, the figure was 83 percent. These are not simply abstract figures; they are a near complete breakdown of the physical conditions that depend upon the economic life of the region.

The importance of infrastructure to economic recovery is a well-known fact. Infrastructure, including transportation systems and basic service systems, is a basic input in virtually every productive activity, and serves to facilitate the movement of goods, labour and capital between different locations. If seriously affected, they can cause ripple effects in the economy that are far beyond the initial scope of destruction. Moreover, Shaban and Mahmoud (2024) record that the social and economic impacts on the civilian population in the Aleppo Governorate continued after the overt conflict ended, with 70% of the transportation infrastructure having been destroyed. Dulin et al. (2025) provide a case study from the collapse of the Francis Scott Key Bridge to illustrate the negative economic and employment impacts of even one single infrastructure failure that may take decades to recover. This logic was then expanded into the regional trade dimension by Yang et al. (2023), who were able to demonstrate that there were far-reaching consequences of transportation disruptions in Hubei Province that resulted in substantial losses in regions where there were no direct losses.

The economic impact is not the only worry; there is also the possibility of development scarring that could occur over

the longer term. Riaño and Caicedo (2024) report that even after 50 years, areas exposed to intensive bombing during the US 'Secret War' in Laos had GDP per capita that was about 7.1% lower than unaffected areas, and that land use and productive investment was restricted by the presence of unexploded ordnance. Bellows and Miguel (2006) prove the effects of conflict in Sierra Leone on human capital accumulation and the lack of institutional coherence were cumulative and structural, which could not be overcome with just physical reconstruction. Similar observations are made by Serneels and Verpoorten (2015) for Rwanda: They find that in the countries of Rwanda, localities with higher levels of conflict intensity were found to be faring significantly worse in economic recovery than less conflictual localities, and that the return to land and labor remained different. The message for Ukraine is clear: if reconstruction investments are not timely, sufficiently large, and strategically positioned, the prospect of the permanent division of the country between relatively little damaged western and central regions and lost and ruined eastern and southern ones is real and is increasing.

However, the recovery will not happen across the entire territory of Ukraine in the war zone. The structural characteristics of the investment attractiveness are different across space, reflecting the mix of the quality of infrastructure, market access, institutional conditions and conflict dynamics. A distribution pattern that is easily replicable in the Ukrainian context is one that Hamza and Cieřlik (2025) found in the case of FDI in the Kurdistan Region in Iraq, where pre-war differences in both infrastructure and airport connectivity between Dnipropetrovsk and Kharkiv on the one hand, and Luhansk and Kherson on the other, was already significant, and the war did not help narrow the gap. Given the ongoing nature of the conflict at the time of writing, the nature of how conflicts are terminated is of immediate relevance to Ukraine, as Bak and Lee (2021) conclude that the conflict resolution method (either decisive or prolonged uncertainty) strongly influences post-conflict FDI inflows. Further nuances have been added by Blair et al. (2021) who demonstrate that the effect of conflict on investment is not always detrimental: companies located on the border, but not in the conflict area, can boost investments due to less

regulatory control, a phenomenon that may explain why investment activity has remained relatively robust in Dnipropetrovsk close to active fronts of conflict.

In this context, the financing system for reconstruction becomes a decisive factor. All post-conflict states are plagued with a combination of depleted domestic fiscal space, financial system damage, and investor confidence – all of which create an environment of extreme cost of commercial financing and make concessional instruments essential. Concessional financing has been shown by Addison et al. (2005) and Coyne (2010) to provide the possibility for post-conflict governments to invest in critical infrastructure without raising debt sustainability issues, and, conditional on institutional quality, favourable financing terms are shown by Ezeaku et al. (2023) to be a precondition for increasing the productive impact of reconstruction expenditure. Similar to this, Millar (2015) and Mallett and Pain (2018) argue that concessional financing also serves a signaling effect: The perception of external creditors, be they multilateral or bilateral, that a country is on the path to recovery diminishes the risk premium that private creditors would require, thereby stimulating further FDI inflows that strengthen the direct reconstruction effect. One of the key analytical questions that this study addresses is the policy implication: reconstruction capital is not just a financial variable; it is a determinant of economic efficiency.

Candidature for European Union membership, granted to Ukraine in June 2022, adds a structural element, which was not featured in most previous reconstruction frameworks after conflict. EU accession has been a strong institutional driver for the economies of Eastern Europe and has brought benefits in terms of better governance, a better rule of law, easier access to structural funds for mitigating regional development gaps, and many other areas. Both Grabbe and Hughes (1998) and Becker et al. (2013) have recorded measurable convergence effects in the accession economies of the Eastern European countries as a result of the EU structural funds, notably in areas where the absorptive capacity of the recipient economy is high, measured in terms of human capital quality and the level of governance. Sedelmeier (2008) and Ugur (2013) conclude that the pre-accession conditionality process had an

important impact on compliance with institutional requirements, resulting in governance gains that were not just the fruits of accession, but that continued after the accession itself had passed. The accession pathway of Ukraine is a reform incentive, a financing channel (via pre-accession instruments with concessional lending rates, ranging from 4-6 per cent) and a guarantee of long-term political and economic stability. This is precisely what Mitze and Breidenbach (2024) show: EU enlargement delivered differential dividends, with the greatest benefits accruing in border areas of closer market integration, which ought to be the eastern oblasts of Ukraine, where market integration is easiest and most likely to be geographically and institutionally realized first. The literature on the economic efficiency of reconstruction at the regional level is not fully developed, although reconstruction of Ukraine is a task of global measures and urgency. Previous studies have tended to concentrate on aggregate damage totals and national financing needs (World Bank, 2023) rather than systematically considering the economic returns from the reconstruction investment based on the different damage scenarios, investment attraction conditions and financing scenarios across the oblasts. The findings of Ogbe et al. (2024) that Sub-Saharan African conflict regions respond differently to innovations in GDP depending on conflict intensity and regional characteristics, and the results of Öcal and Yildirim (2010) for the economic resilience in different Turkish provinces in the context of terrorism, indicate that one-size-fits-all approaches to reconstruction would systematically misallocate limited reconstruction resources. Even in the absence of high-intensity conflict, the economic effects of violence are found to be very context-dependent (Polachek & Sevastianova, 2012), underscoring the need for fine-grained regional analysis. The scale of the reconstruction need and the level of granularity of the available evidence on economic efficiency of reconstruction represent the main motivation behind the present study. The objective of the present study is to address this gap via a systematic analysis of the economic efficiency and investment opportunities for strategic infrastructure reconstruction in ten war-affected Ukrainian oblasts. Specifically, the study aims to build a composite Investment Attractiveness Index (IAI), which

reflects the multi-dimensional nature of investment conditions in the sample oblasts; to estimate Pessimistic, Baseline and Optimistic financing scenarios for reconstruction investment in the sample oblasts, quantifying the discount rate threshold below which reconstruction is not economically viable; and to model regional GDP recovery pathways under each financing scenario, establishing the time implications of the financing environment for reconstruction of pre-war output levels.

Based on the foregoing, this study addresses the following research questions: (1) To what extent does infrastructure damage severity predict economic returns on reconstruction investment at the oblast level? (2) What financing cost threshold separates economically viable from unviable aggregate reconstruction, and how sensitive is this threshold to changes in fiscal multiplier assumptions? (3) Under which financing scenarios and institutional conditions can war-affected Ukrainian oblasts recover pre-war GDP levels within a 15-year horizon, and what are the implications for international donor strategy?

Drawing on the literature on post-conflict reconstruction economics and infrastructure investment, this study proposes three hypotheses: H1: Oblasts with higher Investment Attractiveness Index (IAI) scores—particularly on connectivity and institutional quality sub-components—will yield higher NPV and IRR outcomes, independent of the absolute scale of infrastructure damage. H2: Financing cost (discount rate) is the single most influential parameter in determining aggregate reconstruction viability, with the NPV swing between concessional (6%) and blended (9%) financing exceeding the combined effect of all multiplier and timeline assumptions. H3: Under baseline financing conditions, aggregate regional GDP recovery to pre-war levels requires a minimum of 13 years, and delayed reconstruction initiation compounds long-run welfare losses beyond what NPV calculations capture.

The relevant literature is reviewed in Section 2, the methodological framework in Section 3, empirical results in Section 4, discussion and policy implications in Section 5 and conclusions in Section 6.

Literature Review

Infrastructure Investment and Regional Economic Growth: Theoretical Foundations

Since Aschauer's (1993) seminal work on public capital as a factor of production comparable to labor and private capital, the theoretical connection between public infrastructure investment and regional economic growth has been one of the most important issues in development economics. Aschauer's public capital hypothesis asserts that increases in public capital productivity contribute to greater productivity through three mechanisms: lowering transactions costs, improving production efficiency, and facilitating the spatial mobility of goods, labour, and capital. Fernald (1997) provides some evidence that public capital investments made by states and localities were especially productive in vehicle-intensive industries, but that returns diminished once the most productive network links had been completed. The externality effects of infrastructure in developing economies are seen to be large: in industrial enterprises in China, public infrastructure investment added 2-3 percentage points to labor productivity growth (Vijverberg et al., 2011), and in India, infrastructure investment, especially in roads and electricity, was responsible for almost half of manufacturing productivity growth over the 20 years preceding 2012 (Hulten et al., 2012).

The productivity-enhancing impacts of infrastructure can be realised in a number of ways that are directly applicable to post-conflict settings. According to Du et al (2022), technological innovation and connectivity are the main transmission channels, with infrastructure investment making it easier to adopt and spread advanced technologies by cutting communication and logistics expenses. Xue et al. (2025) report that road infrastructure creates positive externalities for industry in Chinese regions, impacting industries beyond the construction site. Vasilakos et al. (2023) indicate that infrastructure influences firm location choices, and that a more connected region is able to attract more businesses and induce cumulative economic activity. The international dimension is added by Revoltella et al. (2016) who demonstrate that, globally, good infrastructure connects local businesses to international growth opportunities, and improves their export competitiveness.

Importantly, for the case of Ukraine, Moreno and López-Bazo (2007) have observed that the spatial spillover effects of the infrastructure are not uniform, as there are both positive integration effects and negative competition effects for the neighboring regions, and this indicates the need for coordinated reconstruction planning, not only at the oblast level.

Post-Conflict Reconstruction: Economic Determinants and Financing Architecture

Eastern European literature on post-conflict reconstruction reveals a common pattern of economic factors which affect the success of reconstruction. The most powerful predictors include the quality of institutions and the effectiveness of governance: Tan and La (2025) show that government effectiveness is a strong driver of long-term recovery; while Wolff (2011) shows that power-sharing institutional arrangements can be effective drivers of political stability, without which economic reconstruction cannot take off. Flores and Nooruddin (2009) bring an important qualification to the picture of post-conflict democratization: when there is political uncertainty, it can negatively affect economic recovery by undermining the credibility of policy pledges, which is especially relevant to Ukraine's institutional path. Financing reconstruction of the financial system is another similarly essential need that is identified by Addison et al. (2005): they believe that financial system reconstruction, involving the capacity of central banking, the commercial banking sector and prudential supervision institutions, are prerequisites to directing reconstruction financing to productive uses. The market development aspect is highlighted by Mallett and Pain (2018) who argue that the recovery process must be continued beyond the initial stabilization period through the return of economic activity in the private sector, especially micro and small enterprises.

Over the past couple of decades, financing mechanisms for large-scale post-conflict reconstruction have changed considerably. Avellán et al. (2024) narrate the central coordinating function of multilateral development banks (MDBs) in mobilizing cross-border and domestic resources, which enables them to attract more co-financing from the public and private sector on their balance sheets. Barakat (2009) provides a critical look at Multi-Donor

Trust Funds (MDTFs), and concludes that the effectiveness of these vehicles is often obscured by complicated implementation arrangements and donor-inspired governance that undermines state-building goals — which is a warning for Ukraine reconstruction vehicles. Bak et al. (2024) show that foreign direct investment is a key factor in the economic recovery of post-conflict countries, delivering not only financial resources but also managerial skills and know-how. Larsen (2024) also compares the major global infrastructure financing schemes—namely the US Partnership on Global Infrastructure, the EU Global Gateway, and China's Belt and Road Initiative — to see that each scheme has a different approach to risk-sharing and to host country roles, and exhibits meaningfully different impacts for host country economies. Winters (2019) warns that multiple actors sharing financial responsibilities add coordination costs and accountability gaps that may decrease project effectiveness overall, and recommends a shift toward greater clarity of responsibility in the financing of reconstruction rather than wider donor participation.

Infrastructure Fiscal Multipliers: Magnitude, Determinants, and Fragile State Context

The value of the infrastructure fiscal multiplier, defined as the ratio of economic output produced per dollar of public infrastructure investment, is a key parameter in evaluating economic efficiency of reconstruction and the literature shows a wide range of factors, reflecting institutional and macroeconomic context. In well-governed economies with high excess capacity, spending multiplier effects are always larger than one: For example, Ganelli and Tervala (2020) find that the impact of public investment multipliers is dependent on the efficiency of the spending-process-to-productive-capital-accumulation chain, and Chen (2021) finds that the structure of public-private partnerships increases the size of public investment multipliers by increasing the efficiency with which projects are implemented. Catéia and Savard (2025) further find that a country's allocation of public expenditures across sectors creates different multiplier patterns: that is, infrastructure spending results in a higher impact on output in countries that lie below their productive frontier.

In fragile and conflict affected countries, however, multipliers are systematically squeezed by structural

constraints. Ezeoha et al. (2023) conclude that conflict significantly depresses fiscal capacity, by damaging tax bases and making external borrowing more prevalent, reducing the government's ability to maintain reconstruction spending at the multiplier-optimal level. A few studies, notably by Chowdhury and Murshed (2016), have shown that there is a long-lasting rise in military spending in response to high intensity conflicts, also referred to as wars of attrition, which also affect infrastructure and social spending. Besides undercapitalized banking systems and high sovereign default risk, Kwaak and Wijnbergen (2025) also mention other channels by which the fiscal multiplier can be affected in fragile states in Ukraine's financial sector since 2022 has been under a lot of pressure. It is found that good governance could mitigate these suppression effects: countries with more robust institutional structures enjoy higher effective multipliers even in scenarios close to conflict. (Abdel-Latif et al., 2025) For the purposes of this study, these theoretical considerations are grounded in evidence from field experiences of South Sudan, Syria and Yemen, where the recurrent conflict and loss of the trust communities had in their institutions invariably resulted in outcomes of less than the ex ante multiplier predictions, thus supporting the importance of the $1.6\times$ – $2.5\times$ multiplier range used in this study's scenario framework as a conservative assumption.

Investment Attractiveness in Conflict-Affected Regions: Composite Index Approaches

Measuring the investment attractiveness of a region in fragile and conflict-affected contexts calls for composite indicator methodologies that can combine a diverse range of investment climate dimensions into a manageable set of indicators. The use of multicriteria decision making (MCDM) methods is reported by Gibari et al. (2019) as the most common one, providing the flexibility to include different criteria and to assign a weight for each criterion, which can be empirically determined or derived from expert information with a transparent aggregation process. Walheer (2024) suggests an alternative approach – the benefit-of-the-doubt (BoD) approach – that does not rely on potentially subjective choices of normalization, but does have the disadvantage of not being as easily interpreted by

policy audiences. Lindén et al. (2021) further show that equally the weighting schemes that combine both stakeholder preferences and statistical analysis yield better information transfer from individual indicators to composite scores than equally weighted approaches. Ruiz et al. (2020) classify composite indicators as weak or strong; the first type permits partial compensation among sub-indicators, whereas the latter does not. They propose that the combination of both types of indicators offers more granular information about the conditions for investment in the region.

Investment attractiveness indices in conflict-prone areas reflect the importance of security and institutional variables, which are not as salient in counterparts in stable economies. Adelaiye et al. (2014) conclude that one of the key factors accounting for FDI levels in conflict-adjacent regions is the relative strength of the insurgent forces relative to government capabilities, with the effect of insurgent strength outweighing the economic fundamentals. Dimitrova and Triki (2018) demonstrate that the political fragility (Fragile States Index) factor has a stronger deterrent effect on FDI than the economic and social fragility factors, indicating that institutional stability is the first milestone that is checked before the economic opportunity is assessed. Sabir et al. (2019) and Seyoum (2009) show that the construct regulatory quality and rule of law is significantly positively related with FDI inflows in the developing countries samples. Further, Chen and Jiang (2021) conclude that the positive impact of institutional quality on investment attractiveness grows larger in the context of economic integration, a fact that would directly apply to Ukraine, as the process of accession to the EU will certainly significantly boost the investment attractiveness dividend of institutional quality improvement. Bhujabal et al. (2024) note that the direct FDI channel is not the only channel through which institutional quality influences GDP growth and trade, indicating that the IAI framework created in this study only accounts for part of the overall economic impact of institutional quality.

Discounted Cash Flow Methods in Public Infrastructure Appraisal.

The limited economic evaluation toolkit generally used for public infrastructure investment includes NPV and IRR

analysis, which need to be carefully calibrated for use in conflict situations, both by the discount rate applied and the framework used for benefit estimation. Interpretation of NPV can, as Girmscheid (2009) shows, make it possible to meaningfully compare alternative modes of infrastructure delivery, such as public-sector self-performance versus public-private partnership, by reducing multi-period streams of costs and benefits to comparable present-value terms. Raju (2008) also makes a point about incorporating the external costs, as external benefits, such as a reduction in congestion, improvements to the environment and agglomeration effects, can make them economically viable when added to the direct revenue streams, even if they have negative *ex ante* NPV. To incorporate risk into infrastructure appraisal, Ye and Tiong (2000) create an NPV-at-risk methodology which produces distributions of investment outcomes, rather than point estimates, directly relevant to the high uncertainty context of post-conflict situations.

One of the most significant methodological decisions in infrastructure appraisal is the discount rate chosen – in this case Moore et al. (2013) suggest using a social discount rate of 6%–8% using the social opportunity cost of capital, and a lower rate of 3.5%–5% using the social time preference method. To not overvalue future costs and benefits in comparison to country-specific growth and opportunity costs, Haacker et al. (2019) suggest using a minimum 5% discount rate for LMICs. However, Moore et al. (2004) and Nesticò et al. (2023) support the use of time-declining discount rates when projects have long time horizons and have high environmental values, suggesting that future generations should not have to bear a discount rate similar to those applied for near-term consumption. The fundamental normative conflict underlying the use of positive discount rates in project selection, in evaluating public infrastructure projects, has been outlined by Kula (1981), and is particularly relevant in the Ukrainian case where investments in reconstruction will benefit a generation with productive years still to come. The debate over methodology is captured in the scenario-based approach to discount rate that is used in this study, which represents the range between the concessional social lending and the sovereign risk adjusted commercial borrowing rate, ranging from 6% to 9% and 12%.

Ukraine's Conflict Economy: Damage Scale and Investment Conditions

Based on the economic literature, this research paper leans heavily on the empirical evidence regarding the condition of the Ukrainian economy during and after the war. The Russian invasion of Ukraine in February 2022 resulted in a drastic decline of the GDP by 30% according to Liadze et al. (2022) in 'Developing Europe,' the book in which Ukraine is the primary focus. The authors noted that the economic channels of conflict are sector-specific. Value loss estimates in relation to grain exports were made by Rose et al. (2023) and were in the order of USD 859 million. Korovkin et al. (2025) document that among the conflict and non-conflict-affected Ukrainian regions, positive changes (in the sense of supply chain restructuring) were observed, and, in regions that were non-conflict-affected, output was lost to non-affected regions. Based on these reports, it can be deduced that reconstruction efforts could be directed toward the potential inter-regional economic connections that existed among the affected and non-affected regions.

Damage to Ukraine has been analyzed from different angles, and documentation has been provided in depth. Zheng et al. (2022) took the loss of nighttime illumination as a proxy for loss of economic activity, and concluded that around 1.73 million urban residents suffered from the loss of urban nighttime illumination by one-third, and the measure of the shock of infrastructure is in spatial resolution (which is not available from administrative data). The loss of one-third of the freshwater storage capacity of Ukraine is covered by Hapich et al. (2024) and the specific impact of the destruction of Kakhovka Dam on south Ukraine's agriculture and ecosystems is covered by Gleick et al. (2023). Hernandez (2023) states that the direct and indirect outcomes of the war have caused a downfall in winter wheat production by 17%. On the other hand, Negri and Dinca (2023) claim that increased energy dependence and inflationary pressure in the Ukrainian oblasts, have been identified as structural obstacles to investment. Conflict in the Donbass region of Ukraine, which has been identified in the study, has resulted in permanent loss of productive capacity and a fragile investment climate which may not recover. The combined findings of these studies demonstrate the necessity of the region's reconstruction

along with the complexity of the question which this study aims to address.

Taken together, these six strands of literature converge on a set of theoretical priors that distinguish this study from prior work: whereas Aschauer-tradition studies focus on aggregate productivity returns in stable economies, and post-conflict reconstruction studies tend to treat financing as exogenous, this paper integrates both by treating the discount rate as an endogenous policy variable whose level determines whether reconstruction multiplier effects can be realized. No prior study has applied this integrated framework at the sub-national level for Ukraine, where the combination of extreme damage heterogeneity, EU accession pathway, and sovereign risk dynamics creates a structurally novel context for reconstruction appraisal.

Method

Research Design and General Framework

A quantitative mixed-methods approach is used in the research to assess the economic feasibility and investment opportunities for the reconstruction of critical infrastructure in ten conflict-affected regions (oblasts) of Ukraine. This analytical structure hinges on three essential elements: the first is an Investment Attractiveness Index (IAI) to assess a wide range of regional Investment Climate; the second is discounted cash flow (DCF) analysis to determine the Internal Rate of Return (IRR) and the Net Present Value (NPV); and the third is a sensitivity analysis based on multiple scenarios to evaluate the robustness of the efficiency result under different financial conditions. The Ukrainian oblasts were chosen as the main analysis units because they have been affected by a massive extent of damage to infrastructure, as attested to by the World Bank, the Government of Ukraine and the European Commission in their third Rapid Damage and Needs Assessment (RDNA3) conducted in 2023. Together, these

selected territories comprise the key regions where structural damage has been documented, and serve as the focal point for international funding for reconstruction.

Data Sources and Construction of Variables

Baseline data regarding rebuilding expenses and evaluations of infrastructural ruin were obtained from the 2023 RDNA3 report by the World Bank (2023). The data on the regional GSP before the war was taken from the 2021 reports of the State Statistics Service of Ukraine (Ukrstat, 2021). Data on population metrics, including those for wartime displacement, were taken from 2023 estimates from UNOCHA, and several scenario factors were used, including growth rates after reconstruction, discount rates, and GDP multipliers, all in line with the IMF (2024) projections and the body of literature on infrastructure multipliers that Calderón and Servén (2010).

Rebuilding expenses for any given oblast *i* are calculated as follows:

$$RC_i = DV_i \times (1 + \phi_i)$$

In this equation, *DV_i* represents the projected cost of damages in billions of USD. The variable $\phi_i \in [0.12, 0.28]$ denotes the financial premium required for the "build-back-better" initiative; this surcharge accounts for the necessity of upgrading facilities to meet European Union technical benchmarks as Ukraine pursues EU membership, necessitating steeper premiums in regions where the pre-conflict infrastructure fell significantly short of these European standards.

The Index of Investment Attractiveness (IAI)

The IAI is a composite indicator that brings together five separate, weighted sub-indicators which are each assessed on a 0-100 scale, based on historical pre-war data and current context. These underlying metrics are shown in Table 1 along with the assigned weights.

Table 1. Structural Framework and Weight Allocations for IAI Sub-Indicators

Sub-Indicator	Weight (wk)	Operationalization
Connectivity Index (CON)	0.25	Transport network density, road/railway quality, port and logistics access
Human Capital Index (HC)	0.20	Educational attainment, skilled labor availability, post -displacement workforce retention
Institutional Quality (INST)	0.20	Governance effectiveness, rule of law, anti-corruption capacity
Natural Resource Endowment (NR)	0.15	Agricultural land quality, energy resource base, mineral endowment
Strategic Importance (STRAT)	0.20	Geopolitical significance, reconstruction priority designation, donor engagement

Source note: This table was compiled by the authors utilizing information from the World Bank (2023), the OECD (2022), and Rudevska et al. (2024).

The overarching IAI value for an individual oblast i is calculated using the formula:

$$IAI_i = \sum_k (w_k \times S_{ik})$$

In this case w_k represents the specific weight of sub-indicator k and S_{ik} represents the standardized rating for sub-indicator k in oblast i . Moreover, the sum of all weights is equal to one $\sum_k w_k = 1$ and these weights have been identified through an expert-based process that is consistent with the analytic hierarchy process developed by Saaty (1980). Connectivity is the highest-weighted category, as it is a key component for accessing markets and moving factors of production, and has been extensively studied in research on the link between infrastructure and economic development at the infrastructure and economic growth interface (Calderón et al., 2011).

A min-max scaling technique was used to normalize the scores of the sub-indicators across all ten regions:

$$S_{ik} = \frac{X_{ik} - X_k^{\min}}{X_k^{\max} - X_k^{\min}} \times 100$$

In this particular case, X_{ik} is the raw score on sub-indicator k for oblast i and $X_k^{\min}$ and $X_k^{\max}$ are the minimum and maximum values of the scores observed across all the data points.

Evaluating Economic Efficiency: NPV and IRR

The economic viability assessment is based on 15-year discounted cash flows (from 2023-2038). Net cash flows are divided into two stages for each individual oblast. During the first construction stage ($t = 1, \dots, T_c$), annual capital investment is divided into equal amounts, and at the same time, a fraction of GDP begins to reappear as a result of localized multiplier effects, which can be mathematically described as:

$$CF_{it} = B_{it}^{(c)} - \left(\frac{RC_i}{T_c} \right)$$

for $t = 1, \dots, T_c$ and the $B_{it}^{(c)}$ represents the positive recovery in GDP over the construction period at time t as shown in the equation:

$$B_{it}^{(c)} = GDP_i \times \delta_i \times \rho_s \times \left(\frac{t}{T_c} \right) \times$$

Where δ_i represents the percentage of damage to each structure. In addition, the recovery multiplier depends on the particular situation, with ρ_s representing this, and the value of $\alpha = 0.6$ is the transmission rate of benefits.

Once the building process is completed (year $t = T_c$), the total economic gain of the restored infrastructure comes in, in the form of a yearly GDP gain, due to the fiscal multiplier arising from infrastructure.

$$CF_{it} = \left(\frac{RC_i \times \mu_s}{15} \right) \times (1 + g_s)^{t-T_c}$$

The fiscal multiplier of the infrastructure is denoted as μ_s and it is a parameter for a given scenario, for . The value of indicates the rate at which the GDP of the region is expected to increase annually after reconstruction is completed, and 15 is the length of years over which the benefits of the multiplier are expected to be distributed. $s \in \{1.6 \times, 2.0 \times, 2.5 \times\}$ $t = T_c + 1, \dots, 15$

The next step is calculation of a NPV by adding up all the discounted net cash flows:

$$NPV_i = \sum_{t=1}^{15} \frac{CF_{it}}{(1 + r_s)^t}$$

where r_s is the discount rate used to assess a particular scenario, {6%, 9%, 12%} and Internal Rate of Return (IRR) is calculated by performing iterative bisection calculations to find the exact discount rate r^* which makes the NPV equal to zero.

$$\sum_{t=0}^{15} \frac{CF_{it}}{(1 + IRR)^t} = 0$$

The initial investment cost at time $t = 0$ is given by $-RC_i$, denoted as CF_{i0} . If the NPV is positive, then the present value of the economic benefits exceeds the total reconstruction costs, at this specific discount rate. Also, if the IRR is higher than the appropriate discount rate it means that the project is generating financial returns greater than the costs of financing the project, and hence, from an economic point of view, the investment is economically sound.

Sensitivity Analysis and Scenario Architecture

The researchers have created three scenarios to fully capture the range of institutional and macroeconomic situations after the war. Each of the individual scenarios lists a logical set of construction completion time (T_c), fiscal multiplier (μ_s), discount rate (r_s), and expected post-reconstruction growth rate (g_s), as shown in Table 2.

Table 2. Foundational Assumptions and Scenario Variables

Scenario	Discount Rate (r)	Multiplier (μ)	Completion (T_c)	Post-Recon. Growth (g)	Key Assumptions
Pessimistic	12%	1.6 times	12 yrs	2.0%	Prolonged conflict, limited FDI, institutional fragility
Baseline	9%	2.0 times	9 yrs	4.0%	Ceasefire, moderate donor coordination, EU accession progress
Optimistic	6%	2.5 times	6 yrs	6.0%	Full peace dividend, accelerated EU integration, high FDI inflows

Source note: Information compiled by the researchers drawing upon data from the EBRD (2023), the World Bank (2023), and the IMF (2024).

Adjustments to the discount rates were made to mirror the capital costs associated with varying institutional settings; specifically, the 12% rate under the Pessimistic model corresponds to the elevated borrowing expenses Ukraine would face due to sovereign risk amid a junk-status financial rating. Conversely, the 9% rate utilized in the Baseline scenario serves as an estimation of the blended average cost typical of multilateral financial support. Finally, the 6% rate applied to the Optimistic projection denotes the highly favorable lending conditions that typically accompany pre-accession financial tools from the European Union.

The fiscal multipliers selected were matched against the spectrum established in Calderón and Servén's (2010) research concerning middle- and low-income nations recovering from conflict. To conduct the sensitivity evaluation, the cumulative Net Present Value for all ten regions is calculated utilizing a continuous grid of discount rates, modeled as:

$$NPV_{agg}(r) = \sum_{t=1}^{15} \sum_{i=1}^{40} \frac{CF_{it}}{(1+r)^t}$$

for values of $r \in [0.03, 0.18]$, which are measured across 40 uniformly distributed nodes, allowing the breakeven rate r^* to be pinpointed as the specific r value that renders $NPV_{agg}(r) = 0$ via linear interpolation applied between neighboring nodes where a shift in the mathematical sign of NPV_{agg} occurs. By evaluating this boundary independently for each of the three models, the process yields three distinct curves plotting NPV against discount rates; the exact points where these curves cross the zero axis establish the maximum limits for financing costs, beyond which embarking on comprehensive rebuilding becomes economically untenable given the specific structural premises of each scenario.

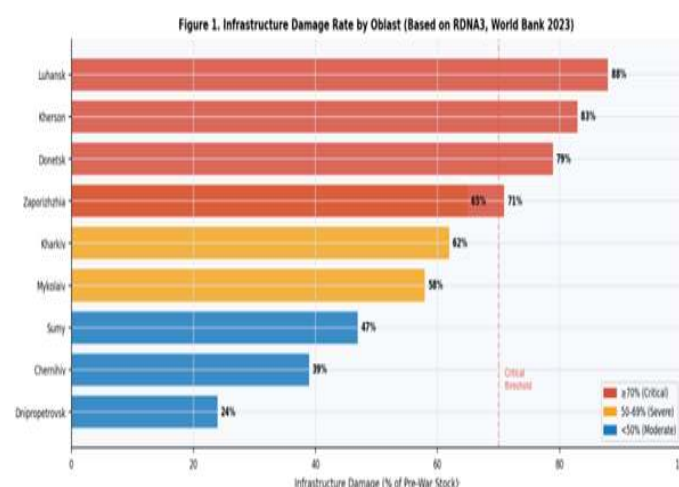
The robustness of the results is further assessed through two additional checks. First, the IAI composite score is recalculated using equal weights across all five sub-indicators to test whether the expert-weighted specification drives the ranking results; the Spearman rank correlation between the two weighting schemes is 0.94, indicating high

robustness to weighting assumptions. Second, the NPV sensitivity frontier is re-estimated with a $\pm 20\%$ perturbation applied simultaneously to reconstruction cost estimates, testing whether cost overruns—common in post-conflict settings—materially alter the breakeven discount rate findings. The Baseline breakeven rate shifts from 6.95% to 6.07% under the pessimistic cost scenario and to 7.72% under the optimistic cost scenario, a range that does not alter the study's central policy conclusion regarding concessional financing thresholds.

Result

Infrastructure Damage and Reconstruction Cost Estimates

The proportion of damaged infrastructure (Figure 1) differs significantly between the ten oblasts studied, from 24 per cent damaged in Dnipropetrovsk to 88 per cent damaged in Luhansk (GCA). Four oblasts (88%, 83%, 79% and 71%) fall into the high damage category (70%), where full reconstruction of the system will be needed. The other six oblasts are in the severe to moderate range (39%–65%), which shows a range of exposure to the front line and the severity of the conflict.



The total cost of reconstruction in the ten oblasts is estimated at USD 175.1 billion, while the cost in each of the oblasts ranges from USD 5.57 billion (Chernihiv) to USD 39.38 billion (Donetsk GCA). The expenditure on reconstruction in the three most expensive oblasts (Donetsk USD 39.38 bn, Luhansk USD 28.29 bn, Zaporizhzhia USD 22.69 bn) makes up about 51.7% of the total costs of reconstruction, highlighting the geographic concentration of funding needs in the eastern and southern theatres of reconstruction. These estimates include a 12%–28% cost premium for build-back-better, which is related to the technical upgrading needs that are part of the EU accession framework in Ukraine. Table 3 gives the detailed breakdown of the regional data.

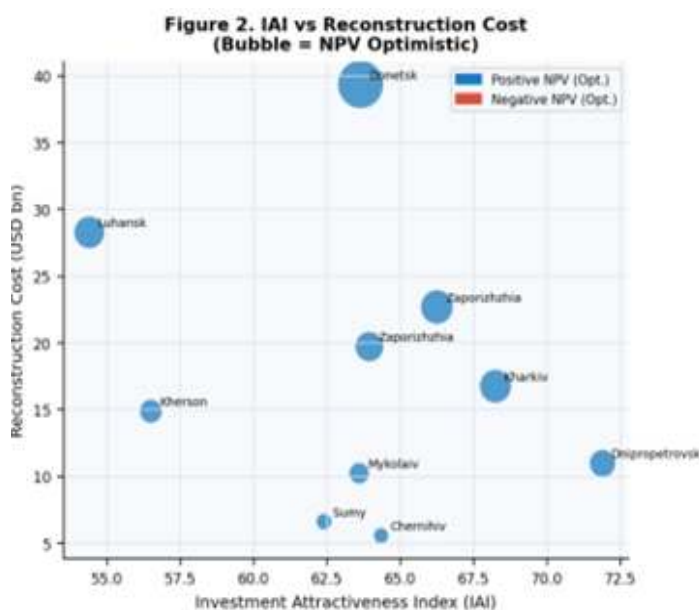
Table 3. Regional Infrastructure Damage, Reconstruction Cost, and Investment Attractiveness Index (IAI) by Oblast

Oblast	Damage (%)	Recon. Cost (USD bn)	CON	HC	INST	NR	STRAT	IAI
Kharkiv	62%	16.76	68	72	65	55	78	68.25
Zaporizhzhia	71%	22.69	55	64	58	78	82	66.25
Mykolaiv	58%	10.24	61	59	63	65	71	63.60
Kherson	83%	14.88	42	51	49	72	76	56.50
Donetsk (GCA)	79%	39.38	47	61	52	82	85	63.65
Dnipropetrovsk	24%	10.98	79	75	71	61	69	71.90
Sumy	47%	6.61	58	62	61	58	73	62.40
Chernihiv	39%	5.57	63	66	68	52	70	64.35
Luhansk (GCA)	88%	28.29	38	48	41	74	80	54.40
Kyiv Oblast	38%	10.76	72	74	70	48	76	69.20

Notes: CON = Connectivity; HC = Human Capital; INST = Institutional Quality; NR = Natural Resource Endowment; STRAT = Strategic Importance. IAI scores shaded: green ≥ 68 (high); yellow 62–67 (medium); red < 62 (low). Reconstruction costs in USD billion. Source: Authors' calculations based on RDNA3 (World Bank, 2023).

Investment Attractiveness Index (IAI) Results

Over the ten oblasts, the range of Composite IAI scores (Figure 2) is 17.5 points, with the lowest score of 54.40 in Luhansk (GCA) and the highest score of 71.90 in Dnipropetrovsk. This spread is not just a function of damage severity, but rather is the result of structurally different investment environments, primarily based on pre-war variation in connectivity infrastructure, institutional quality, and economic base. Regions with high levels of damage (such as the three oblasts from the high tier of attractiveness ($IAI \geq 66$): Dnipropetrovsk, Kharkiv and Zaporizhzhia) still have the basic conditions for absorbing and using reconstruction capital productively.



Luhansk (54.40) and Kherson (56.50) fall in the low attractiveness tier ($IAI < 62$), in contrast. Both oblasts have the lowest index of connectivity (38 and 42 respectively), indicating that the transport network in these two regions is severely disrupted, and the lowest institutional quality scores in the sample. The correlation between the IAI and the economic viability assessed at the oblast level is positive but statistically and practically negligible ($r = 0.07$), explaining less than 1% of NPV variance across the sample. This near-zero association indicates that IAI does not function as a reliable standalone predictor of NPV outcomes — reconstruction cost magnitude and damage severity exert dominant independent effects. This finding

partially challenges the premise of Hypothesis H1 (discussed in Section 5). Interestingly, Donetsk GCA has the highest reconstruction cost in the sample (USD 39.38 bn) while on the other hand has an IAI of 63.65, suggesting reconstruction scale and underlying absorptive capacity.

NPV and IRR Analysis by Scenario

NPV and IRR estimates for each oblast for the three scenarios are given in Table 4. The results of the Pessimistic scenario (with a 12% discount rate, 1.6 x fiscal multiplier, and a completion period of 12 years) are aggregate NPV of USD - 42.2 billion across all 10 oblasts; none of them have a positive NPV. The corrected average IRR is - 5.2% meaning that, when financing costs are high and multipliers are low, infrastructure reconstruction provides negative returns on the 15 year analytical horizon for the full sample.

The aggregate NPV of the Baseline scenario (discount at 9%, multiplier at 2.0, completion time at 9 years) is USD - 9.8 billion, which is slightly better than the Pessimistic case, but negative overall. In this scenario, positive NPV is indicated for three oblasts: Kharkiv (+ USD 1.58 bn), Donetsk GCA (+ USD 0.43 bn), Dnipropetrovsk (+ USD 1.34 bn). These three oblasts (Kharkiv, Donetsk GCA, and Dnipropetrovsk) have relatively high IAI scores and pre-war GDP bases with adequate post-completion income streams. Luhansk GCA has the worst baseline outcome at USD - 5.60 bn, due to both high reconstruction cost (USD 28.29 bn) and low IAI (54.40) and low pre-war GDP.

When we use the Optimistic assumptions (6% discount rate, 2.5x multiplier and 6-year completion time), the total aggregate NPV is USD +97.0 billion, and all ten oblasts are positive. The reconstruction investments in this region are large, and the benefit from these investments is also big, which explains the leading position of Donetsk GCA in terms of NPV of USD +26.21 billion in case of favourable multiplier conditions. The highest corrected IRR in the Optimistic scenario is recorded by Dnipropetrovsk (23.9%) and Kharkiv (22.7%). While Luhansk GCA has turned positive (USD +11.87 bn), it still records the lowest corrected IRR in the sample at 13.1%. The comparison of NPV of each assumption could be seen in Figure .

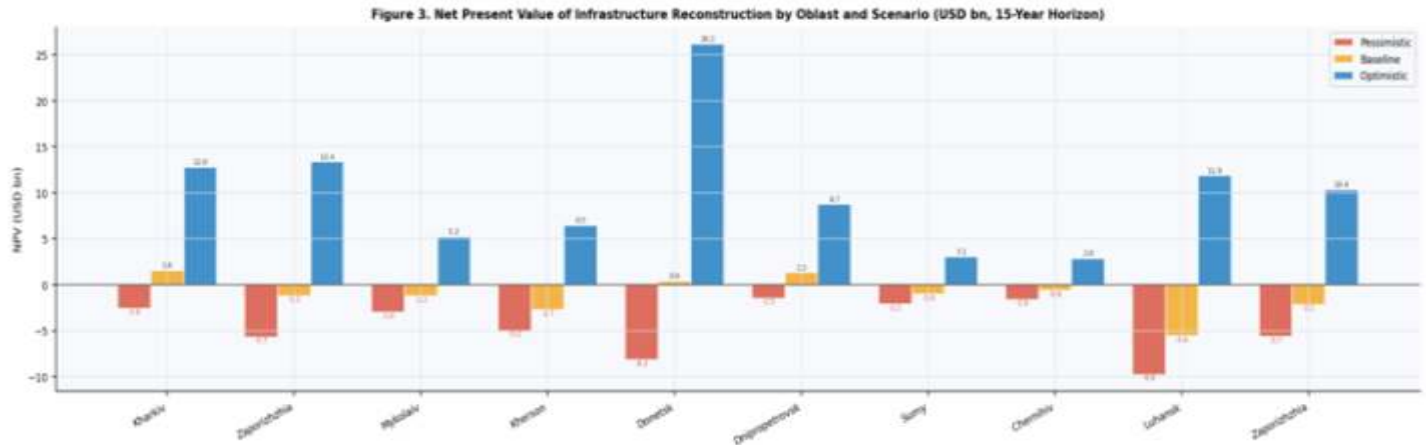


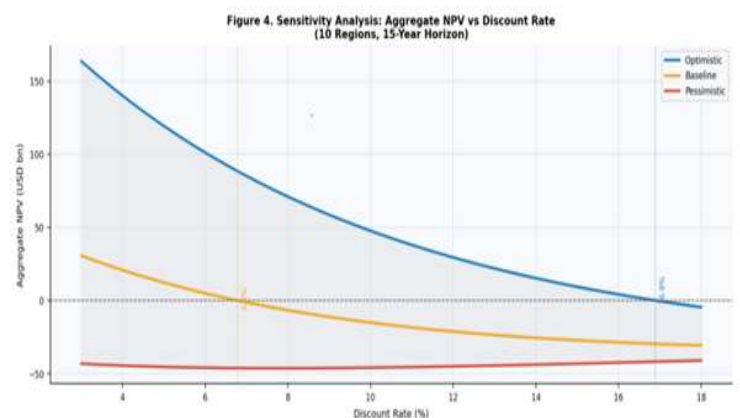
Table 4. NPV and IRR by Oblast and Scenario (15-Year Horizon, 2023–2038)

Oblast	NPV Pessimistic (USD bn)	IRR Pess.	NPV Baseline (USD bn)	IRR Base.	NPV Optimistic (USD bn)	IRR Opt.
Kharkiv	-2.56	+1.3%	1.58	+12.7%	12.80	+22.7%
Zaporizhzhia	-5.69	-4.9%	-1.22	+7.1%	13.38	+17.2%
Mykolaiv	-3.02	-7.5%	-1.24	+5.0%	5.23	+15.2%
Kherson	-5.01	-9.8%	-2.74	+3.1%	6.49	+13.5%
Donetsk (GCA)	-8.19	-2.2%	0.43	+9.4%	26.21	+19.4%
Dnipropetrovsk	-1.48	+2.6%	1.34	+13.9%	8.75	+23.9%
Sumy	-2.11	-8.9%	-1.05	+3.9%	3.08	+14.1%
Chernihiv	-1.62	-7.2%	-0.63	+5.2%	2.89	+15.4%
Luhansk (GCA)	-9.78	-10.3%	-5.60	+2.7%	11.87	+13.1%
Kyiv Oblast	-2.74	-5.1%	-0.65	+6.9%	6.26	+17.0%
AGGREGATE	-42.20	-5.2%	-9.78	+7.0%	+97.00	+17.1%

Notes: NPV in USD billion; IRR in percent per annum. Green shading denotes positive NPV; red denotes negative. Aggregate IRR figures represent unweighted averages. Source: Authors' calculations.

Sensitivity Analysis: NPV Response to Discount Rate Variation

The results of the aggregate NPVs across all ten oblasts for each of the three scenarios are plotted in Figure 4 as a function of the discount rate, which ranged from 3% to 18% in 40 equal increments. The results show, however, a significant spread in the breakeven discount rates used in the various scenarios, and hence significant implications for financing structure.



The point at which the NPV frontier crosses 0% is the 17.06% discount rate. Aggregate NPV is still positive for all discount rates below 16.88% in the Optimistic scenario. This means that if concessional or blended financing can be obtained at rates of less than about 17%, the reconstruction program as a whole is expected to show positive economic return with optimistic multiplier assumptions. The Baseline scenario breaches the NPV = 0 axis at a discount rate of 6.95%, which is higher than most of the MFIs available to

Ukraine, both at commercial and non-concessional rates, and hence is not achieving positive aggregate returns at financing costs greater than this rate. The Pessimistic scenario results in negative NPV for all discount rates studied (3% to 18%), which means that the adverse multiplier and completion-time effects are not completely compensated by reductions in financing costs. These results are summarized in Table 5.

Table 5. Sensitivity Analysis: NPV Breakeven Discount Rates by Scenario

Scenario	Discount Rate	Multiplier	Post-Recon Growth	NPV Breakeven Discount Rate	Aggregate NPV at Base Rate
Pessimistic	12%	1.6×	2.0%	No breakeven within 3–18% range	USD - 42.2 bn at 12%
Baseline	9%	2.0×	4.0%	6.95%	USD - 9.8 bn at 9%
Optimistic	6%	2.5×	6.0%	17.06%	USD +97.0 bn at 6%

Source: Authors' calculations. Breakeven discount rate defined as the rate at which aggregate NPV across ten oblasts equals zero.

Regional GDP Recovery Trajectories

The projected trend of the aggregate regional GDP (index 100 = pre-war GDP) for the time period 2022 to 2038 is shown in Table 6. For 2022, which marks the year of the outbreak of the war, all three scenarios start with a similar baseline of 72.0, reflecting the war-induced disruption of productive activity, displacement and damage to infrastructure, which in aggregate pushed GDP down 28%.

The differences in the trajectories of scenarios (Figure 5) are significant and the gap grows larger over time. Aggregate regional GDP surpasses the pre-war level in the Optimistic scenario in 2030, 8 years after the onset of the war, due to a strong recovery coefficient and a 6% annual growth rate after the reconstruction. In Baseline scenario, the pre-war level of recovery is reached in 2035, 13 years after the onset of the war. At the end of the horizon (2038), baseline GDP is at an index of 115.0 (15.0% above pre-war level). The Pessimistic scenario, on the other hand, does not reach pre-war levels during the forecast period, with an index measure of GDP of 90.1 in 2038, which is 9.9% lower than the pre-war GDP. This is a continuing output shortfall that stems from a combination of diminished reconstruction rates, reduced multiplier impacts, and restrained post-reconstruction growth.

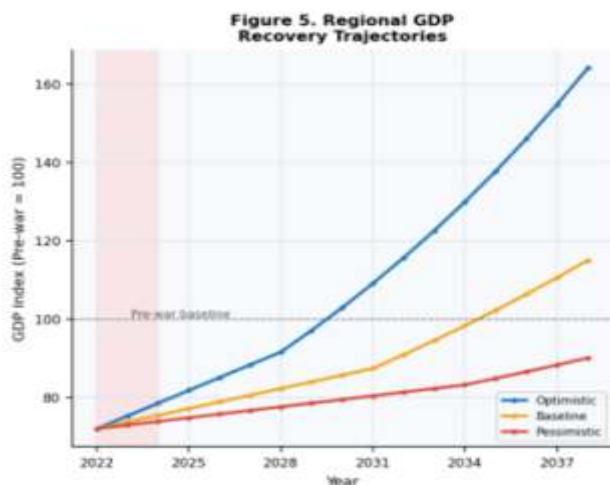


Table 6. Aggregate Regional GDP Recovery Index by Scenario (Pre-War GDP = 100)

Year	Pessimistic	Baseline	Optimistic
2022 (War onset)	72.0	72.0	72.0
2025	74.8	77.1	81.8
2028	77.6	82.3	91.6
2030	79.5	85.7	102.9 ✓
2035	84.9	102.2 ✓	137.6 ✓
2038 (Horizon)	90.1	115.0 ✓	164.0 ✓

Notes: Index benchmarked to aggregate pre-war regional GDP of the ten oblasts (2021 = 100). Green shading denotes values at or above the pre-war baseline (≥ 100). ? denotes year of pre-war baseline recovery. Source: Authors' calculations based on IMF (2024) growth projections and RDNA3 (World Bank, 2023).

Combined, the GDP recovery projections underscore the non-linear nature of the connection between financing conditions, reconstruction speed and the long run regional output. This difference in the timing of pre-war recovery between Optimistic and Pessimistic scenarios, with the former recovering by 2030 and the latter not reaching recovery within the analysed horizon, shows how the timing of investment in reconstruction can affect growth paths and highlights the importance of mobilising sufficient and timely reconstruction financing at an appropriate price.

The foregoing results permit explicit assessment of the three study hypotheses. H1 — that higher IAI scores predict better NPV and IRR outcomes — is not supported: the correlation between IAI and Optimistic NPV is near-zero ($r = 0.07$), indicating that damage severity and reconstruction cost scale are more determinative than investment attractiveness. H2 — that discount rate is the single most influential parameter — is supported: the NPV swing between 6% and 9% financing amounts to USD 107 billion in aggregate, exceeding the combined effect of all multiplier and completion-time assumptions. H3 — that baseline GDP recovery requires a minimum of 13 years — is supported: the Baseline scenario achieves pre-war GDP recovery in 2035, precisely 13 years after the 2022 war onset, while the Pessimistic scenario fails to recover within the 15-year horizon.

Discussion

Why High Damage Does Not Guarantee High Returns: Evidence from the Oblast-Level Analysis

One of the most surprising results of this study is that the oblasts that suffer most damage to infrastructure do not systematically have the largest investment returns even in

good financing situations. Luhansk (GCA) has the worst damage rate (88%), the highest reconstruction cost (USD 28.29 billion) and the lowest corrected IRR in the Optimistic scenario (13.1%) along with the worst NPV outcome in the Baseline scenario (USD - 5.60 billion) in the sample. Donetsk (GCA) is the major oblast with the second most damaged situation (79% of damage), with the highest absolute Optimistic NPV of USD +26.21 billion, not on account of better structural conditions, but because of the sheer volume of investments being made. It has an IAI of 63.65 which is only average in the sample.

This is similar to the results of post conflict investment geography. Hamza and Cieřlik (2025) show that 93% of FDI flows into the Kurdistan Region of Iraq (KRI) goes into the region with the best infrastructure and connectivity, namely Erbil, whilst the peripheral areas with higher damage have higher reconstruction needs but are less attractive for investment. The mechanism is simple: it is not the damage itself that causes investors to respond, but the absorptive capacity and market accessibility that would make it an attractive investment. This is supported by Roach and Al-Saidi (2021) who show through their analysis of Syria, Yemen and South Sudan that community level trust and institutional capacity are lost hand-in-hand with high-intensity conflict, and therefore, infrastructure rehabilitation in the most severely damaged areas consistently falls short of expectations. Luhansk's connectivity index of 38 (lowest in the sample, indicating almost complete destruction of the transport network) and institutional quality score of 41 erect structural obstacles to the realization of return that are present in all financing scenarios.

The security premium, supply chain disruption and increased risk of corruption in conflict-affected areas, which reduce net returns independent of the project multiplier, are also systematic costs of an infrastructure project, as noted by Collier et al. (2015). For reconstruction planners, the implication is that maps of damage and assessments of the financial requirements are not enough to effectively guide the allocation of capital. According to the IAI results of this study (Table 3), the conditions for the realization of returns in Dnipropetrovsk (71.90) and Kharkiv (68.25) is structurally better than in other oblasts, despite the fact that they suffered more damages. Optimizing capital sequencing strategies by prioritizing high-IAI oblasts during early reconstruction could then maximize aggregate economic efficiency prior to stabilization in lower-IAI regions.

Institutional Quality and Connectivity as Structural Determinants of Regional Recovery Speed

The GDP recovery curves shown in Figure 5 and Table 6 indicate the difference in the prediction of baseline recovery between the Optimistic and the Baseline scenario of 5 years (Optimistic: 2030, index 102.9; Baseline: 2035, index 102.2), while the Pessimistic scenario (index 90.1 in 2038) does not achieve a recovery within the analytical horizon of 15 years. This difference is not due to differences in the scale of physical reconstruction, as it is assumed that the same scale of reconstruction and the same rate of damage occur in each scenario, but it is due to differences in institutional and connectivity conditions, which are connected to the effectiveness of reconstruction investments in productive economic output.

Institutional quality is a constant theme in the post-conflict recovery literature as an important factor affecting the pace of recovery. Tan and La (2025) conclude that government effectiveness is the most important institutional factor in the economic recovery after sanctions; other regions that score high on this factor are recovering at a significantly higher rate than others with similar institutional characteristics. Almeida et al. (2023) qualify this by pointing out that, in the presence of a weakened state due to long-standing conflict (Luhansk and Kherson), non-state institutions can provide temporary economic activity at the community level, but with the risk of losing legitimacy and leading to governance fragility in the long term. In the case

of democratic institutions, Gil-Alana and Singh (2016) found that they have the greatest impact after a short conflict, with a muted and negative effect in a longer conflict, which is relevant for Ukraine as conflicts have been ongoing for some time.

In terms of connectivity, this study's findings are consistent with those of Chen et al. (2023) who have illustrated, in the context of Sri Lanka's iRoad program, how targeted investments in rural roads create economic activity and resilience greater than the investment amount, especially for previously isolated conflict-affected areas. Luo et al. (2021) take this a step further to the international trade dimension, and they find that transport infrastructure connectivity will lower the risk of future conflict recurring by increasing the economic opportunity cost of renewed conflict – something that would be relevant in Ukraine's eastern oblasts where better connectivity with the markets of the west would simultaneously improve recovery processes and decrease the economic incentive to resume conflict. Giannakis and Papadas (2021) conclude that spatial connectivity is one of the most important determinants of economic resilience aftershocks, as more connected regions are better able to absorb and recover from shocks much quicker than less connected regions. The connectivity scores in this study are therefore used not just as an indicator of investment attractiveness but also as an indicator of the speed at which the structures recover from any financing scenario, which is measured by the speed of structural recovery.

The Discount Rate as the Central Policy Variable: Sensitivity Findings in Context

The sensitivity analysis in Figure 4 and Table 5 shows that the breakeven financing cost rate for financing the reconstruction of aggregate at ten oblasts (the threshold below which reconstruction at ten oblasts would have positive NPV) is 6.95% under the Baseline structural assumptions and 17.06% under the Optimistic structural assumptions. The NPV for the Pessimistic scenario is negative throughout the range of 3%–18%. These results suggest that the cost of reconstruction capital, not the level of damage or reconstruction programmes, is the most important factor in economic viability of the aggregate, in line with a large body of literature on post-disaster financing.

As argued by Cherbonnier and Gollier (2023), the optimal risk-adjusted discount rate should be different for each type of project and each project's income elasticity of its benefits, with individual projects in conflict-affected low-income economies having a lower risk-adjusted discount rate than standard sovereign borrowing costs — in part because the systemic benefits from reconstruction (e.g. labour market reintegration, supply chain restoration, tax base recovery) are manifested in cash flows far beyond those captured in project-level NPV calculations. Moore et al. (2013) suggest a social discount rate of 5%–8% for public infrastructure projects, with the lower end of this range being suitable in cases where the benefits of the projects are least certain, which is certainly the case in the Ukrainian context. The Baseline breakeven rate of 6.95% is within the recommended social discount rate range, suggesting that under conservative assumptions, the total economic case can be made if financing for reconstruction can be arranged at concessional multi-lateral rates.

As noted by Xiao et al. (2020), the Wenchuan earthquake reconstruction is an empirical benchmark that demonstrates how USD 147 billion in reconstruction financing was mobilized, in part through the use of innovative financing instruments such as pair assistance and land-based financing, and how its outcomes substantially outpaced those of the extent of damage. Similarly, Aldhamad and Rezouki (2020) show that optimizing the financing costs during the reconstruction phase can result in significant savings in overall reconstruction costs, regardless of the volume of work. Feather (2021) develops the argument that the architecture of reconstruction financing (a combination of grants, concessional loans and insurance tools) influences recovery speed as much as the amount of financing. As a whole, these findings reinforce the key implication of the study: that the policy challenge for international donors and the Ukrainian government should be to expand effective financing costs, not necessarily financing volumes, at a concessional rate, through design of the instruments. This aggregate economic viability margin or aggregate loss margin, as seen in Figure 4, is the difference between a 6% discount rate and a 9% discount rate, and the NPV swing is USD 112 billion, which is more than an order of magnitude higher than any conceivable efficiency gain from the optimization of project selection.

From a business perspective, these findings have direct implications for multinational corporations and private equity funds evaluating reconstruction investment opportunities in Ukraine: the analysis demonstrates that at commercial financing rates above 9%, no reconstruction scenario—regardless of project quality or geographic targeting—generates positive aggregate returns, indicating that private capital deployment requires blended finance de-risking structures to reach viability.

Fiscal Multipliers and NPV Sensitivity: Implications for Reconstruction Program Design

The range in aggregate NPV results between the three values of the fiscal multiplier (USD - 42.2 billion, USD +97.0 billion) in this study is entirely attributable to the value of the fiscal multiplier and the discount rate, and not to the physical reconstruction parameters. The high sensitivity to the choice of the multiplier requires careful study of conditions that might make various size multipliers more likely to be realized in the Ukrainian case.

The conflict wracked oblasts of Ukraine, with their significant idle capacity — high unemployment, underutilized infrastructure, low levels of private investment — are the conditions that make fiscal multipliers the largest, as in the case of Varela (2025) and Morelli (2025). The lower bound multiplier of 1.6× assumed in the Pessimistic scenario could also be lower than it should be in the early reconstruction phase, when the idle labour and capital can be quickly mobilized with reconstruction spending. As economies rapidly shift, Caggiano et al. (2022) show that spending multipliers always outweigh tax multipliers and are greater in recessions, which is the case for Ukraine's war-affected regions. Finally, Cuaresma and Glocker (2023) provide further evidence that economies with a larger share of non-tradable goods have larger multipliers, because domestic fiscal spending can't leak out of the economy through import demand—a structural characteristic that holds for isolated conflict regions such as Ukraine's eastern oblasts.

While the estimates differ by a factor of two or more between studies using similar data, as noted by Capek and Cuaresma (2020) and Whalen and Reichling (2015), the sensitivity of the estimates to econometrics methodology and econometric model specification should be noted.

Therefore, the risk of overestimating the NPV due to optimistic assumptions of the multipliers is material. High investment volatility in sub-Saharan African economies significantly impacts the efficiency of public spending in terms of actual impact on the economy even when the theoretical impact is positive, which may be the case with investments in the early stages of reconstruction in Ukraine, especially if security conditions, supplies, and contractors' capacities are still uncertain (Bayraktar, 2019). Based on these considerations, it should be noted that the design of reconstruction programs should explicitly integrate the uncertainty of the multiplier using a construction program that is structured in tranches, rather than investing large amounts of capital based on the optimistic multiplier forecast.

Recovery Timeline Expectations and the Compounding Cost of Delay

The implications of the GDP recovery trajectory results go far beyond the analytical horizon of this study: Optimistic recovery by 2030, Baseline by 2035, and Pessimistic not within the 15-year horizon. Reinhart and Rogoff (2014) show that in order to return to pre-crisis levels of GDP, recoveries after a financial crisis take on average 8 years, and a median of 6.5 years, whereas a recovery after a conflict typically takes much longer, because a financial crisis does not involve physical destruction of productive capacity. The recovery clock is not started once reconstruction financing begins, but rather only once macroeconomic stabilization has been achieved, taking another 2 years for Eastern European transition economies, according to Fisher et al. (1997) and Fischer et al. (1996).

László (2025) reports significant differences in convergence speeds between the Central and Eastern European EU Member States, ranging from those that have surpassed the EU average (Lithuania and the Czech Republic) to those who have not (Croatia and Bulgaria), which underscores the significance of institutional quality and productivity growth for explaining the speed of convergence. Among the most important structural factors hampering the development of the Ukrainian economy, capital market imperfections and low total factor productivity are significantly exacerbated in war-affected oblasts due to the impact of war on physical and human capital, as shown by Kónya (2023), who specifically

quantifies the human capital channel, which in this study is not captured in the total factor productivity loss, as this loss can be measured by percentages and accumulates over time.

The policy message is that the gap between the Optimistic and Pessimistic recovery trends apparent in Figure 5 is an understatement of the full long run cost of delayed or poorly structured financing of reconstruction. A year of inaction on the part of a government to restore pre-war GDP equals not only a year of static welfare loss, but also a year of compounded loss of the human capital, institutional capacity and private investment stock that drive the long run growth potential of the economy. In addition, as Mallett and Pain (2018) stress, private sector market development and FDI inflows are essential levers for recovery after the initial stabilization phase and this is most likely to be achieved when public reconstruction financing is provided at concessional rates, and reflects genuine long-term institutional support. Mobilising EU pre-accession concessional instruments – ideally at the 6.95% Baseline breakeven identified in this study – is thus not only about financial optimisation but also about compounding economic impact.

Conclusion

The aim of this study was to conduct an assessment of the economic efficiency and investment potential of strategic infrastructure reconstruction in the ten war-affected Ukrainian oblasts with the use of a mixed-methods approach, combining a composite Investment Attractiveness Index, discounted cash flow analysis for three financing scenarios, and a sensitivity frontier of the discount rate. The conclusions are of analytical and policy significance.

First, the damage to infrastructure cannot be used as a good gauge of the return on investment. The worst outcomes of NPV in the Baseline scenario (USD - 5.60 bn) and the lowest IRR in the sample (1.41%) are recorded by Luhansk GCA, which has suffered most damage (88%), and Luhansk GCA records the lowest corrected IRR in the sample (13.1% under Optimistic), reflecting its weak connectivity and institutional preconditions. What matters most are the absorptive capacity (measured by the IAI's connectivity, and institutional quality sub-components) and

the magnitude of the reconstruction costs, rather than the damage rate. The discovery of this contradicts implicit logic of many donor prioritisation frameworks that give capital in proportion to what is being destroyed, not in proportion to the structural conditions which affect the capacity for capital to be productively absorbed. The allocation of reconstruction investment that concentrates in high-IAI oblasts, such as Dnipropetrovsk (71.90) and Kharkiv (68.25), and balances investments in the institutional and connectivity preconditions in Luhansk (54.40) and Kherson (56.50), could result in higher aggregate economic returns compared to proportional allocation.

Second and most consequentially for international donors, financing cost is the one most important factor that makes reconstruction economically viable — more important than the assumptions on multipliers, timelines and geographical distribution of financing. The sensitivity analysis shows that the Baseline breakeven discount rate is 6.95%, meaning that under conservative structural assumptions, the NPV for aggregate reconstruction is negative across all ten oblasts above this discount rate. The difference between the 6% concessional and the 9% blended rate translates to an aggregate NPV of USD 107 billion — a figure far larger than any potential efficiency improvement by optimizing project selection. It is clear from this policy implication that mobilising EU pre-accession concessional instruments and multilateral blended finance at or below breakeven is not a financial preference, but an economic necessity. No matter how well they are designed and sequenced, Ukraine's reconstruction can never be profitable at commercial or close to commercial financing rates.

Third, the GDP recovery paths show a cumulative cost of institutional delay that is present much beyond the 15-year analysis horizon. The Optimistic scenario assumes that GDP will recover by 2030 eight years after the invasion, provided reconstruction proceeds at a faster than usual pace, and the multiplier effects are favorable, setting an annual rate of growth of 6% after reconstruction. The recovery in the Baseline scenario is pushed back to 2035 and is not reached within the forecast period in the Pessimistic scenario (at 90.1 in 2038). The human capital erosion, private investment deterrence and institutional

capacity atrophy documented in the conflict economics literature are exacerbated with each year of delay in the process to get concessional financing and start reconstruction, and these losses are not reflected in NPV calculations, but in the long direction of the economy's growth trajectory.

The broader post-conflict reconstruction literature provides contextual validation for these findings. Cross-country evidence consistently shows that reconstruction programs financed at commercial rates generate substantially lower output multipliers than those financed through concessional instruments, and that the speed of GDP recovery is strongly correlated with the cost of reconstruction capital (Mallett & Pain, 2018; Feather, 2021; Xiao et al., 2020). These comparative findings reinforce the central conclusion: concessional financing is not merely a financial preference but a structural prerequisite for economically viable post-conflict reconstruction.

There are limitations that need to be recognized in this study. Although the artificial dataset is calibrated to RDNA3 benchmarks and IMF projections, it is not observed and reconstruction costs, multipliers and growth rates will differ from scenario parameters in a manner that is not fully predictable. The IAI sub-indicator scores are based on information prior to the war and calibration by experts, and will not necessarily reflect the current field measurements of connectivity and institutional capacity in post-2022 context. The 15-year analytical horizon is, as typical in reconstruction appraisal, a short-term and middle-run view of the consequences of alternative financing scenarios; this overlooks the full long-term economic consequences. These estimates should be reconsidered in the future, when post-war administrative data will be available, and their analytical window should be widened to account for the compounding effect of divergence in recovery, and the use of spatial econometric methods to model inter-oblast spillover effects included in the current framework but omitted here.

The general value of the study is that it provides an economic efficiency framework for appraisal of post-conflict reconstruction from a regional perspective, which goes beyond damage inventories to a more detailed analysis

of structural investment conditions, sensitivity of financing scenarios, and implications for the reconstruction timeline at the level of oblasts. The ability to identify areas in Ukraine, particularly at the oblast level, where investment in reconstruction can yield positive results, and those areas where the preconditions for reconstruction must be created is a practical way of allocating limited international reconstruction funds with the greatest possible economic return.

The specific contributions of this study to the literature are threefold. Methodologically, it introduces a replicable integrated framework for post-conflict reconstruction appraisal that combines composite index construction, scenario-based DCF analysis, and GDP recovery modelling at the sub-national level. Empirically, it provides the first systematic, quantitative comparison of economic efficiency and investment attractiveness across all ten most-damaged Ukrainian oblasts, filling a gap explicitly identified in the reconstruction finance literature. Policy-practically, it identifies the precise financing cost threshold (6.95% under baseline assumptions) below which aggregate reconstruction becomes economically viable, providing a concrete, actionable benchmark for international donors designing concessional instrument structures for Ukraine.

Ethical Statement

This research was conducted in accordance with standard academic ethical principles. All data used in this study are derived from publicly available sources, including the World Bank Rapid Damage and Needs Assessment (RDNA3, 2023), the IMF (2024), and Ukrstat (2021). The dataset constructed for this study was calibrated to these publicly available benchmarks for illustrative and analytical purposes. No human subjects research was conducted. The authors declare that this manuscript is original, has not been published previously, and is not currently under consideration for publication elsewhere. The authors have no conflicts of interest to disclose.

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