On the Right Track? Valuing the ESG Effect of a Railway Infrastructure Upgrade on the Budapest-Zamárdi Line

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Submitted: 4. November 2025
Published: 27. November 2025
Volume: 12
Issue: 5

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Languages: English
Keywords: EU Funding; Railway infrastructure; ESG; Green Finance; Cost of Capital; Cost-Benefit Analysis
Categories: Humanities, Social Sciences and Law, Demetrios Project
DOI: 10.17160/josha.12.5.1107

Abstract:

This thesis evaluates the economic, social, as well as environmental impact of a railway infrastructure upgrade on the Budapest–Zamárdi line in Hungary. Through implementing a comprehensive cost-benefit (CBA) analysis framework, the study focuses on both the financial viability and the broader socio-economic benefits of the investment. The research investigates the potential of using green finance instruments and EU grants to support the project, analysing their role in sustainability and financial feasibility. Results indicate that while the project is not financially profitable on its own, it generates significant positive externalities. Sensitivity analyses highlight the importance of investment costs, and volume of EU funding in determining viability of the project. The findings underscore the necessity of integrating financial, social, and environmental considerations in large-scale infrastructure planning and support the use of hybrid financing models to achieve sustainable development goals.

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On the Right Track?

Valuing the ESG effect of a Railway Infrastructure Upgrade on the Budapest-Zamárdi Line

Kiss Csanád Sándor

Master's in Finance Programme

Corporate Finance specialisation

2025

Thesis Supervisor: Péter Juhász, PhD, CFA

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1. Introduction

Sustainable infrastructure is a cornerstone of long-term economic, social, and environmental development. Among all forms of infrastructure, transport infrastructure, and in particular railways, have been widely recognised as useful instruments for supporting regional development, enhancing mobility, and increasing productivity. Due to its diminished environmental footprint and high passenger capacity, modern rail travel is increasingly viewed as a cornerstone of sustainable economic strategy at the national and European Union levels. As urbanisation and economic development increase, rail modernisation and expansion have become a strategic necessity for governments.

Following these trends, this thesis seeks to evaluate the proposed modernisation of the rail connection between Budapest, the capital city of Hungary, and the town of Zamárdi near Lake Balaton. The overall aim of the thesis is to determine whether this specific infrastructure investment, intended to reduce travel time to approximately one hour, and thus incorporate the region into the Budapest metropolitan network, can be justified relying on purely financial grounds, but also on the broader ground of socio-economic viability. The general research question answered is "Does the suggested railway investment along the Budapest-Zamárdi line yield a positive net value in financial return, public utility, and local development impact?"

Building on this trend, this thesis examines the potential of a sustainable financing strategy for a proposed railway modernisation project between Budapest, the capital of Hungary, and Zamárdi, a town near Lake Balaton. The railway line is nowadays a dual-function route. On the one hand, it is obviously a commuter route for residents employed or studying in Budapest. More importantly, on the other hand, it plays a very significant role during the peak tourist seasons, when thousands of Hungarian and international tourists travel to the Balaton area. Despite its underlying potential, the current railway service along this line lags behind EU standards in terms of frequency and speed. Travel between the two cities takes approximately 90 to 120 minutes depending on train type, time of day, and service level setting back the integration of Zamárdi into the Budapest economic sphere and limiting the region's potential.

The primary objective of the project is to reduce travel time between the two locations to approximately one hour, effectively integrating the region into the Budapest metropolitan network. This study aims to evaluate the project not only from a traditional financial perspective but also through an ESG lens, assessing the broader socio-economic and environmental impacts of the investment. Specifically, the research will address the following question: “Can the proposed railway modernisation be financed through green funding sources and EU grants?”

The proposed rail development project revolves around two key upgrades. First, the acquisition and introduction of new Stadler FLIRT passenger trains for the whole line of service, and secondly, the introduction of European Rail Traffic Management System (ERTMS Level 2, an essential pre-requisite for high-speed rail travel) to enhance operational efficiency, safety, and harmonisation within the EU's Trans-European Transport Network. Apart from changes in the assumed commuting patterns, the thesis also envisages an improved tourism in Zamárdi. Furthermore, in line with Hungary's commitment to reach EU transport standards and environmental sustainability, the research also determined an assumed shift from road to rail, leading to numerous positive externalities for the environment.

To provide a complex answer to the underlying research question, the thesis uses a cost-benefit analysis, a widely used tool for public infrastructure analysis, especially within the EU, where the funding of projects is often a function of strong socio-economic justification. During the analysis, the thesis will first consider the monetary and financial returns from the perspective of the state and secondly, add the presumed economic value created by the investment, including social externalities such as travel time savings, reduction in environmental degradation, accident reduction rates, and the regional economic multipliers. Additionally, the study will evaluate the potential for green funding to cover not only the direct costs of the project but also the investment in sustainable practices that align with the EU’s green transition policies. In evaluating the potential for green financing, the thesis will investigate several funding options available under the EU’s green transition frameworks. These include EU grants dedicated to sustainable transport projects, as well as green bonds and loans that prioritise projects with clear environmental benefits

Since the core idea of project planning and forecasting inherently entails the necessity of making economic assumptions, it poses a significant risk, as many variables, such as ridership growth, energy prices, and future demand elasticity, are hard to measure, and their movement over time is even harder to predict. For this reason, a sensitivity analysis will be conducted as part of the analysis, allowing for testing the robustness of the outcomes over the project lifetime. Thus, the thesis does not present decision-makers with one single outcome, but rather with a list of possible results, increasing transparency.

The relevance of the research is underscored by the overall environment in the EU and in Hungary as well. Hungary's rail network, while being historically dense, has been subject to decades of underinvestment, ageing technology, and little to no innovation. Many lines still operate with diesel locomotives and lack advanced signalling technology. While electrification and capacity enhancement have been sought over the last several years, the lack of significant development in recent years has caused strong reliance on road transport, which has resulted in greater congestion, higher emissions, and higher maintenance costs. Thus, the Budapest–Zamárdi line offers a case study of how a strategic investment could serve as a catalyst for broader economic transformation and environmental sustainability. It demonstrates how green financial tools, such as EU grants and green bonds, can be used to drive forward a sustainable infrastructure project that not only meets modern transportation needs but also contributes to the EU's sustainability targets.

The thesis has seven chapters. Following the introduction, the second chapter provides a theoretical overview of the case of investing in infrastructure, with a focus on transport's role at the state level as well as regional development. It covers key literature on cost-benefit analysis and rail project funding alternatives. Chapter 3 presents the methodology, explaining assumptions made, data sources used, and analytical techniques employed for analysis. Chapter 4 presents the main financial and economic analysis of the project, including net present value calculations, costs and revenues estimated, and the estimated monetised positive externalities of the project from a socio-economic perspective. Chapter 5 includes the financing structure of the project, and a sensitivity test is also carried out to see how certain inputs assumed in the thesis would alter the final outcomes. Chapter 6 interprets the findings and elaborates on the limitations of the analysis and gives recommendations for decision makers and infrastructure planners for further research on the matter. Lastly, Chapter 7 concludes the project analysis with a recap of the thesis.

2. Theoretical Background

Infrastructure development is regarded as a critical driver of economic progress, offering opportunities to enhance productivity and foster regional growth. However, the decision whether to invest in certain projects requires a detailed and careful assessment of financial, economic, and social considerations. Understanding the complexity of the subject, in this chapter of the thesis, the key literature on the relationship between economic development and infrastructure investment will be introduced. Once this relationship is being understood, the chapter will first elaborate on the main methods and tools of analysis and then, the potential financing structures and sources will be explored.

2.1 The Role of Infrastructure in Economic Development

Infrastructure development is usually recognized as a cornerstone of economic progress by playing a vital role in the growth of states and regions through fostering economic interactions and enhancing productivity. However, this relationship between infrastructure and economic development is rather complex, and it is influenced by a large variety of factors. This chapter is intended to explore this relationship, emphasizing the potential underlying the investment in infrastructure projects.

Aschauer (1989) and World Bank experts (Timilsina & Stern & Das, 2021) have explored the importance of infrastructure, concluding that there is a significant relationship between infrastructure and economic development. Aschauer also made this assumption, declaring that differences in public infrastructure systems are a decisive factor behind differences in national productivity and economic output.

Other scholars also drew attention towards the positive effects of strong infrastructure on economic development. For example, Kessides stated that infrastructure could be considered to create an ‘amenity value’, contributing to increased welfare and generating positive environmental externalities (Kessides 1993). This idea was strengthened by Crescenzi and Rodríguez-Pose, who argued that apart from these ‘values’, infrastructure investments may also create multiplier effects in the investment flows, referring to a rippling effect they have on the broader economy (Crescenzi & Rodríguez-Pose, 2012). Biel noted that investments can harness productivity and decrease the costs of labour, allowing businesses to be more competitive (Biehl, 1991).

Holtz-Eakin (1993) found that such investments may boost the economic output of the region, which often exceeds the region's average GDP level due to spillover effects such as increased market accessibility and agglomeration development. Others examined the long-term impacts, showing that these investments, apart from intermediate effects, also tend to have compounding benefits over time, which fuels further economic growth (Glomm & Ravi, Kumar, 2014).

Importantly, Ramey stated that infrastructure investments, especially when centred around state-level strategic goals, can play a pivotal role in the development of the economy's productive capacity as well as in the increase of productivity on a long-term horizon (Ramey, 2020). This is especially true for investments that target areas where infrastructure lags behind the population's and economy's needs. By introducing development initiatives in such circumstances, infrastructure upgrades can create additional benefits, enabling businesses to operate more efficiently, fostering trade and innovation, and giving better accessibility for those using the transport line (Glomm and Ravi-Kumar 1994).

Ramey (2020) found three pillars of valuation through which the success of the investments can be analysed. The first one is the productivity of public capital, which assesses whether the infrastructure investment aligns with the economic demands. The second revolves around the question of whether the investment, apart from an economic point of view, is in line with the broad needs of society. These may include a decrease in inequality, environmental considerations, long-term growth or elimination of development gaps between regions.

Last but not least, an essential criterion of whether a project can be accepted is the means of financing the investment project. Using different sources of financing may have different effects on the project's overall profitability, both from a financial and economic perspective (Ramey, 2020). For instance, using debt instruments as primary sources may have positive effects, such as speeding up the implementation, but may also put a heavy burden on the state's financial stability, where the interest payouts might put a heavy burden on subsequent years' budgets.

2.1.1 Means of Transport, Railway

While infrastructure development is a cornerstone of economic progress, its evaluation often oversimplifies the complexities of different transport modes. Railways stand out for their unique potential to boost trade, enhance connectivity, and support sustainable development.

As Wessel (2019) stated, if we take a look at the economic advantages of the railway infrastructure, it is argued that they support cost-effective logistics, facilitate efficient regional and international trade and drive economic integration. From an environmental sustainability perspective, as one of the most energy-efficient transport modes, railways produce significantly lower greenhouse gas emissions, reducing pollution and mitigating climate change. Furthermore, railways contribute less to noise pollution and air contamination, fostering better public health and environmental quality (Galushko et al., 2024). However, from a social perspective, railway infrastructure, through enhancing connectivity, enables better access to core services such as healthcare, education, and cultural activities (Pauer, Molemaker, 2014).

Parallelly, railway transport also helps to decrease road congestion, decrease delays and associated costs while also promoting safe travelling conditions. For this reason, it is widely accepted that railway infrastructure is an indispensable investment for sustainable development in a state's life. The environmental, economic, and social advantages which are attributed to this form of travel underpin the underlying potential they have in fostering growth, combating inequality and contributing to environmental sustainability. Building on the understanding of the advantages of railway systems over other modes of transport, this thesis will focus solely on railway infrastructure.

2.1.2 Railway Improvements' Effect on Local Economic Development

As discussed in the first chapter, a strong relationship between economic prosperity and the development of infrastructure has become widely accepted in academic literature. In addition to the general positive effects of infrastructure investments, some experts highlight the importance of such investments on regional and local development as well, drawing attention to the positive benefits arising from the realisation of such projects on a local and regional scale (Blanquart, Koning, 2017). Examples of these benefits include the fostering of economic interaction, raising productivity, shaping the level of private investment in a positive direction and the impacts on the labour market, and increasing the active workforce of the region (Venables, 2015).

If one looks at the classical economic theory of transport investment, the anticipated high returns of such projects can be explained. Such investments, leading to better accessibility, enable public decision-makers to facilitate trade by lowering transportation costs (Pol, 2003), and harnessing the movement of the human workforce, all aiding different regions to maximise competitive advantage (Crescenzi, Rodríguez-Pose, 2012). By establishing new transportation systems, both companies and individuals can have better access to other regions, where the maximum travel and trade distance can be increased and travel times can be decreased (Seitz and Licht, 1995). This, based on economic theory, increases public utility as well as the profitability of firms, contributing to the rise of market potential of different regions, consequently leading to better wages (Niebuhr 2006).

In real terms, however, decision makers must incorporate many other factors and effects as well in order to get a proper glimpse of the real influences of railway investments. Importantly, one can divide the effects of these investments into two categories. First, the ones that are incurred during the construction phase and the ones which are visible after the railway service is already in operation. Regarding the first one, it must be highlighted that the observable effects, such as higher wages or increased demand for specific goods in the region, are merely temporally visible. Whereas, as soon as the construction is finished and the new service is in operation, the economic characteristics of the region are permanently altered (RUS et al., 2009). As a result, this thesis is intended to focus on the second group of effects, as in the author's opinion, the decision whether to make a large-scale investment or not is based on long-term prospects.

To assess the proper effects of investment in infrastructure, experts must take into account all factors that shape the relationship between infrastructure projects and long-term regional economic effects (Holl, 2006). Although these factors are dependent upon many factors such as the size of cities or the level of industrialisation of the region, as soon as the project is in operation, railway developments immediately start to influence several areas. Among the most important ones, business productivity, labour markets and tourism could be mentioned (Vickerman, 2007). The new railway lines, by reducing travel times, allow better accessibility to urban centres, which eventually increases productivity and contributes to the expansion of labour markets. In addition, service-oriented businesses can benefit from enhanced connectivity, which results in broader market access and increased efficiency (Bazin et al., 2011). Recent examples also show that efficient railway lines contribute to a better competitive edge in tourism as well (Chen & Haynes, 2012).

On the other hand, it should be noted that there are also several studies where the causal relationship between railway improvements and regional development was not explicitly determined. They called for a lack of empirical findings and no clearly definable wealth increase in several cases. Interestingly, as Cheng et al described, high-speed railway improvements tend to have a positive impact on regions which are located relatively close geographically to huge urban centres (Cheng et al., 2015). Nevertheless, even in these areas that are close to the metropolitan centres, decision-makers must face a "brain drain" phenomenon where, as the original isolation of the periphery is broken, these railway developments reinforce the dominance of major urban centres due to easier labour movement (Puga, 2002). As a result, several experts are calling for a more comprehensive approach to regional development (Blanquart & Koning, 2017).

While sufficient transport infrastructure is essential for enabling mobility, its capacity to foster innovation, knowledge exchange, and economic efficiency ultimately depends on the interplay of local socio-cultural factors. This would mean that parallel to railway development, complementary investments should be carried out as well in urban planning, local infrastructure, and workforce development to maximise the benefits of and mitigate potential downsides (Ollivier, 2014).

All things considered, these projects should be viewed as part of a broader strategy for regional growth, rather than as standalone solutions (Blanquart & Koning, 2017). For this reason, more and more scholars state that it is important to rethink the role of transport infrastructure in development schemes used for investment. Future public investments may have a more inclusive approach, involving side investments, and innovative solutions to have a sustainably higher return of the allocated public spending on regional development (Crescenzi & Rodríguez-Pose, 2012).

2.1.3 Role of Railway in Sustainable Development and reaching ESG targets

Environmental, Social, and Governance (ESG) principles have become a fundamental framework for assessing the sustainability and ethical impact of infrastructure projects, including railway development (Özcan, 2023). ESG offers an approach that ensures that railway projects not only deliver economic benefits but also contribute to environmental protection, social responsibility, and strong governance practices.

First, regarding the environmental aspect of ESG in railway development, it revolves around minimising carbon emissions and reducing energy consumption. Az Özcan (2023) highlights, specific measures may include electrification of railway lines to reduce fossil fuel dependence, use of renewable energy for railway operations such as solar, wind, or hydrogen, design of energy-efficient trains and infrastructure, sustainable construction practices such as recycling materials and minimising waste, and implementation of noise reduction technologies in sensitive areas (Özcan, 2023).

Secondly, the social dimension addresses the project's impact on communities and society in general, which means ensuring passenger safety and accessibility for all, including people with disabilities. Lastly, regarding the governance aspects, it refers to the ethical management and oversight of the railway project. This includes transparent procurement processes free from corruption, compliance with international standards and local regulations, and regular ESG performance reporting to stakeholders (Baranova & Efimovskii, 2023). Integrating such principles into railway development is essential as ESG-aligned projects are more likely to secure green financing, such as green bonds or green loans, and can enhance the reputation of the project developer and result in lower rates. As the demand for sustainable infrastructure continues to grow, ESG will remain a critical factor in successful project planning and execution.

2.2 Cost-Benefit Analysis

Motives for state-level investments in infrastructure projects can be numerous, ranging from improving public safety to promoting environmental consciousness. However, more and more attention has been paid to how such investments contribute to the overall economic development of the economy. Thus, countries have started investing in transport and, more concretely, railway infrastructure developments to harness their economic efficiency and increase their output. But how do they decide which project they should realise?

On the area of transport infrastructure, the analysis is often deone through a cost-benefit analysis (CBA), an analytic tool to evaluate the economic pros and cons of investment decisions based on costs and benefits. Importantly, as Funk et al. (2019) assert, the method allows governments to measure the contribution of the investment to economic welfare over a long-time horizon. This is a key attribute of the method since the evaluation period of railway infrastructure investment is 30 years, including both the realisation and the operation of the investment (Funk et al., 2019). As the method, due to its simplicity and rationality, is regarded as one of the most important essential tools of project evaluation, it is widely accepted, even required by many institutions across the globe, when it comes to infrastructure investments. These analyses are especially crucial in the public sector, where, due to the size of the calculated investment, the state has a higher opportunity cost of capital arising from higher capital commitment, higher risk and longer time horizons (Jones et al., 2014). In these circumstances, having a clear and transparent monetised evaluation method of deciding if the net benefits outweigh the costs is useful for determining whether to continue with an investment or not (Nickel, Ross & Rhodes, 2009).

As the World Bank study emphasises, the CBA directly states certain economic assumptions, such as externalities or environmental considerations, which help prevent analysts from overlooking these factors (World Bank, 2004). Another advantage of the method is that it also incorporates the effect of time on values. Using the discounting of cash flows of both costs and benefits, it is able to give a profound numeric expectation of the project's potential return, aiding government decision-making (Nickel, Ross & Rhodes, 2009). Needless to say, the CBA method also carries certain risks that must be carefully assessed during analyses. These risks arise from the mere characteristics of the method, namely that since the model is heavily built on assumptions, the correctness of these approaches determines the final reliability of the results (Jones et al., 2014). Carefully analysing the accuracy of putting monetised value behind holistic factors is extremely important to take into consideration, as the final results can lead to incorrect biases.

The main evaluation indicator in cost-benefit analysis is the NPV, where the total discounted expected cash flows are subtracted from the project costs (Venezia, 2023). Importantly, a huge challenge is to determine the correct discount rate, as in the case of CBA analysis, it is not merely enough to take into consideration the financial aspects of the results, but also the social ones are needed. Thus, solely the capital's rate of return that would be used in normal scenarios may not be adequate to serve as the basis for the discounting (Broughel, 2020). Another issue with the discount rates is that these project investments tend to last for a long period of time, roughly 30 years in the case of railway projects. There is serious uncertainty within the project. Yet, international Institutions such as the European Union, one of the main financing bodies of environmentally sustainable infrastructure investments, still urge the use of an approximate 4% discount rate.

2.2.1 Evaluation Methods

A possible way of structuring the evaluation is dividing the analysis into three parts: the financial, the economic and the sensitivity analysis. The financial analysis from the infrastructure investor is conducted, followed by an economic analysis covering the economic benefits of the whole society. Finally, a sensitivity analysis is carried out, including the identification of the risks, the sensitivity analyses and some quantitative and qualitative analyses as well (Funk et al., 2019). By taking into account more aspects of the investments, the chance of ending up with a positive NPV project is significantly higher (Venezia, 2023). The reason for this is that, despite having an initially negative NPV and/or a low financial rate of return resulting from a solely financial perspective, the investing entity may still consider the project as a viable investment due to the long-term economic benefits, justifying the continuation of the investment. Decision makers from the public entities thus can end up with results showing that while the financial profitability might be limited since the public value is significant (regional development, accessibility or environmental consciousness), the project might be continued. It should not be taken that this does not mean a mitigation of financial aspects; a harmonised, balanced view of financial and economic value creation should be applied to correctly estimate the project's effects on the given region's development (Venezia, 2023).

2.2.1.1 Financial Analysis

The first part of the evaluation is the financial analysis. Any financial analysis is inherently built around the simplified equation of revenues minus costs equals income. Thus, it is not surprising that this mindset is required in the case of financial analysis aiding infrastructure project evaluation.

First, revenues assumed to be collected following the realization of the project are calculated. This, among other income sources, may include passenger ticket revenues, freight transportation fee, capacity sales, government subsidies or advertising revenues within trains and stations. What is crucial to underline is that, as Funk et al. (2019) call attention to, these incomes may be influenced by many factors, such as transport performance or government pricing policies; they are independent of the valuation methodology. Other revenues, such as from new commercial areas, also bear this characteristic; they are also being assessed separately, remaining unaffected by the methodology used (Funk et al., 2019). Secondly, investment costs are assessed, which means the costs directly attributable to the feasibility of the investment. These cover preparation costs, such as administrative expenses, as well as costs such as land acquisition, construction, technical support, marketing, or supervision. The calculation of reserve funds is also advised (Funk et al., 2019).

In valuing a project investment, it is important to assess the term of residual value in financial analysis. As the literature on infrastructure investments has a consensus of having a lifespan of 30 years, the residual value calculation involves the period following the period's expected cash flows. Importantly, experts intend to determine the economic life of the project based on measuring the individual costs of project components (Funk et al., 2019).

2.2.1.2 Economic Analysis

The economic analysis broadens the project's evaluation beyond traditional financial metrics by incorporating social welfare and environmental impact considerations. Based on the guidelines given by the European Commission (2015), unlike financial analysis, which intends to capture the returns to the stakeholders, economic analysis focuses on how the project contributes to society's overall benefit by factoring in externalities. The involvement of the broader scope ensures that public resources invested in the project generate widespread benefits for the community (European Commission, 2015).

Consequently, in the economic analysis, the project-related externalities shall be included since these effects could be regarded as "savings" in an economic mindset. (Funk et al., 2019). Railway developments often contribute to the achievement of environmental and sustainability goals of the state. These externalities tend to be regarded as positive since the project draws such consequences as noise reduction, air pollution reduction or the reduction of the number of accidents. Not to mention the benefits resulting from travel time savings from passengers and goods as well as the decrease in the cost of road and highway operation, since due to railway investment, a certain amount of passengers or goods are transferred to the railway form of travel (Funk et al., 2019).

Environmental externalities are particularly valuable in economic analysis, as they capture the societal costs of pollution and traffic accidents that would otherwise burden taxpayers. The analysis assigns a monetary value to these benefits, creating a comprehensive view of the project's contributions to public welfare. Even if the project was less profitable purely financially, these societal benefits justify public investment. Overall, the economic analysis reinforces the project's role as a long-term social and environmental sustainability contributor, aligning with policy goals and enhancing regional quality of life (Canning, Bennathan, 2000). What is essential to highlight is that in the case of such investments, one can observe certain indirect social benefits that are not included in the economic analysis because they are not easily quantifiable but shall be regarded as benefits resulting from the project realisation.

For this thesis, one of the most important benefits is regional economic development. For one part, through realising the project, the involvement of the local labour force as well as supply industries further boosts the benefits. In addition, the realisation of the project can entail economic development of the region. By involving local labour and supply industries, the project gives further benefits to the region. Furthermore, enhanced rail infrastructure provides better access to economic centres, fostering economic interconnectedness. Consequently, decision-makers can count on an increase in various positive externalities and consequences of the investment, ranging from population increase to real estate value increases. (Venezia, 2023). Note should be taken that these side effects are well interconnected, and a causal relationship can be observed between them.

2.2.1.3 Potential Methods Addressing the Challenges of CBA Analysis

Regardless of the preparedness and expertise of any railway or investment analyst, many assumptions that serve as the backbone of the CBA analysis, can change before and during the realisation of the project. As the final result must be shown in one single number, not taking into consideration any variations that may tremendously influence the outcome, this is regarded as one of the key disadvantages of analyses revolving around future estimations. For this reason, experts call for supplementary analyses to get a better understanding of the possible solutions.

To get a glimpse into how the change of certain variables affects the results, we could use a sensitivity analysis. As Juhász (2020) highlights, this method is useful to observe how a change in a certain input parameter of the model affects the result, helping to see the risks caused by estimation errors in the input parameters. Thus, a range of possible values should be created, and the minimum and maximum values for the given parameter of this range should be substituted into the model. Then, the potential changes in the final result should be assessed based on the "most extreme, but still probable" input values. This way, the consequences of potential miscalculations can be understood. (Juhász, 2020)

Testing processes are essential to assess potential results, especially in case of long-term projects. By constantly changing certain factors such as traffic volume, price of tickets or initial investment costs, decision-makers can understand which areas are the most crucial to dedicate the most attention to, and which are the ones that hide additional risks requiring further planning. (Venezia, 2023).

Such processes are especially important in connection with environmental considerations from two aspects. First, as experts of the Swedish Defence Research Agency highlight, due to railway systems being critically vulnerable to climate risk, proactive measures must be taken to mitigate the potential negative effects of these environmental challenges. During calculation and planning, the potential climate-related risks must also be carefully addressed (Lindgren, Jonsson, Carlsson-Kanyama, 2009). Secondly, train engines can be fuelled by various forms of power. Using electrified, renewable-based means instead of diesel or coal-based power plants can significantly alter the economic costs and benefits of the project (Lindgren, Jonsson, Carlsson-Kanyama, 2009).

2.2.2 EU Guidance CBA Analysis

As the European Commission is a key promoter of CBA analyses for sustainability projects, it developed guidelines for performing a cost-benefit analysis it became mandatory in 2014. Since the focus of this thesis is observing a railway investment in Hungary, it is essential to take a look at the European legislation as well. Thankfully, the European Union has already introduced certain guidelines for CBA analysis in 2008 (Venezia, 2023), which became compulsory from 2014 onwards (European Commission, 2015). It is important to mention, that these guidelines are only applicable for those investments that are investment projects requiring "a series of works, activities or services intended to accomplish an indivisible task of a precise economic and technical nature which has clearly identified goals and for which the total eligible cost exceeds EUR 50 million" (European Commission, 2015).

These rules carefully define the methodology of the cost-benefit analysis specified for every type of industry. Since following these rules within the given framework is compulsory for the proper implementation of the investment, a detailed introduction of this framework will be provided in the analysis part. Of course, setting the main guidelines for such analyses is a crucial step towards interstate EU investments. However, as the commissioner of sustainable transport, Apostolos Tzitzikostas, stated (CINEA, 2022), the EU is firmly devoted to the constant development of railway networks (International Railway Journal, 2024). This means that through the forthcoming 2021-2027 period, the EU is determined to finance increasing railway projects through various projects (European Commission, 2022). The tools for financing these projects are the Connecting Europe Facility (CEF), the European Regional Development Fund (ERDF), and the Cohesion Fund for the 2021-2027 period. (European Commission 2021)

2.3 Efficient Financing Structures of Railway Projects

At this point, the thesis has arrived at another crucial aspect of infrastructure investments, which is the question of financing structure, which obviously has a huge impact on the potential incurred costs as well as the viability of the projects. For decision-makers, it is essential to take into account the potential sources that could be involved in the realisation (High-Speed Rail Group, 2024). Obviously, in Hungary, the easiest funding source to use is a mixture of state and EU funds, where, by using a combined national financing, the government could levy the burden of the invested amount off the state budget as well as strengthen the financial stability of the projects. (Venezia, 2023). Needless to say, such investments more often than not consume incredible amounts of money from the side of the government. Thus, from the state perspective, it may be a reasonable idea to involve other sources of funding as well to finance such projects. (World Bank, 2014)

2.3.1 Role of Green Finance

Green finance refers to investments aimed at achieving environmental sustainability and combating climate change. This has significant implications for infrastructure sectors, particularly in railways, which are a crucial part of transportation systems worldwide.

Railway infrastructure projects, often capital-intensive and long-term, can significantly benefit from green finance initiatives. Over the past decade, there have been notable trends in the green finance sector. The emergence of green bonds, green loans, and other sustainable investment instruments has allowed governments and financial institutions to fund projects that require substantial funding and comply with the ESG targets of the financing body. According to the International Finance Corporation (IFC, 2020), green bonds are one of the most widely used tools, which direct capital to projects focused on reducing greenhouse gas emissions and improving energy efficiency. Using green finance instruments, railway companies can access the capital needed to electrify their networks and reduce their reliance on fossil fuels.

Another growing trend is the integration of ESG factors into investment decisions. This approach not only prioritises financial returns but also considers the broader social and environmental impacts of investments (Scholtens, 2020). Railway projects financed with ESG principles can lead to better long-term sustainability.

2.3.2 Private Investment

One efficient way is to involve private investment in financing these projects. In recent years, more and more attention has been directed towards the possible advantages of this idea. First and foremost, there is a logical assumption that avoiding overdependence on one or two sources could establish a more robust financial resilience (High Speed Rail Group, 2024). Secondly, as the World Bank researchers argued, the involvement of private capital in projects may accelerate the pace of network development and increase efficiency in asset development, management or operations due to the private sector’s stronger commercial focus and innovation (World Bank, 2014).

One of the most widely used collaboration methods is the 'Public Private Partnership' (PPP) strategy, which means that the state and the private sector join to construct a railway line (ESCAP, 2011). According to Zhang, the PPP method has the potential to increase the economic value of infrastructure projects (Zhang, 2005) and can facilitate the effectiveness of the development of infrastructure (ESCAP, 2011). As the World Bank's experts stated: "Successful PPPs are structured so that the private sector makes money by accomplishing the objectives of the public sector" (World Bank, 2014), which very well highlights the financial and economic aspects of such an investment.

However, the actual form and extent of collaboration may vary from project to project. The reason for this is that PPPs are always project-specific. Thus, they depend on many factors that are specific to the given investment. In most cases, a Special Project Vehicle (SPV) is established by the government, a legal entity responsible for the realisation of the project. (ESCAP, 2011). These entities are then financed through debt (loans by financial institutions or issued bonds) and equity by sponsors and shareholders (Davis, 2008). Significantly, the separate entity due to legal obligations cannot get involved in any other business apart from the project realisation. This method protects the interests of debt and equity holders (ESCAP, 2011).

2.3.3 Loan Structures

Although the involvement of private investment in the form of equity is a vital financing source, according to studies, the role of equity in infrastructure projects usually accounts for 15 – 30% of the total cost of investment (Songer, Pecsok, Diekmann, 1997). Thus, the loan involvement financing of the project realisation should also be briefly discussed. Crucially, debt instruments are involved in project financing as (if the proper kind of loans with carefully arranged terms) they provide liquidity to the government throughout the financing process (Finnerty 1996).

Given that these projects require significant capital volume invested, these financing forms often happen in syndicated structures or partnership with multilateral financial institutions. These entities may include the European Investment Bank (EIB), the World Bank or state-level regional banks. (OECD, 2024) Importantly, these banks usually offer tailored terms more suitable for government funding, with longer loan tenors or reduced interest rates (Brzozowska, 2023).

These financing structures may vary from project to project (Donkor, 2013), but generally, the best idea is to mix different loan types to get the lowest possible cost and risk. An excellent example of this is mezzanine financing, which provides an intermediate layer of capital, enabling the government to leverage extra funds without relying too much on debt (Bull and Lethbridge, 1996).

However, according to Brzozowska, for government projects, it may be a logical approach to use lower-cost EIB loans to finance the core project and apply commercial syndicate funding for the add-on, supplementary funding (Brzozowska, 2023). Needless to say, the European Union applies specific criteria for providing such loans with lower interest rates, regulated by the Union's taxonomies for sustainable finance that play a key role in defining and promoting ESG principles in railway transport (NRC Group, 2024). Structuring the financing this way, a balanced model could be created where the EIB loan provides stable and cost-effective funding for core investments. In contrast, the other financing methods could provide extra flexibility, minimising financial constraints.

2.3.4 European Union subsidizing scheme

The European Union assists in the development of sustainable and high-quality transport infrastructure using various different financing tools in the 2021-2027 cycle, one of which is the Trans-European Transport Network (European Commission 2024). This network, intended to improve connectivity and offer interoperability within the EU by 2040, has the most important requirement that passenger railway lines on core and extended core networks must be capable of running trains with a speed of at least 160 km/h.

In addition, as the European Commission declares, the use of the European Rail Traffic Management System (ERTMS) will be made mandatory for the whole Union, with the intention of forcing out national signalling systems. Projects with the aim to achieve these objectives must satisfy crucial environmental standards posed by the union, and the EU-level funding is tied to the achievement of these objectives. To finance these goals, the European Union has various financing instruments, among which the Connecting Europe Facility (CEF) is the main instrument (European Commission, 2025). Apart from this, the Cohesion Fund and the European Regional Development Fund (ERDF) can also provide financing in EU member states with less developed economies. As the thesis revolves around a transport infrastructure which is in alignment with the sustainable and integrative goals of the EU, grants received from the institution could be seen as an important financial tool for the realisation of the project.

2.3.5 Green Bonds

Green bonds are a type of debt security issued to finance projects that generate positive environmental outcomes. These projects can encompass a wide range of sustainable initiatives, including renewable energy, energy efficiency, sustainable transport, water management, and climate adaptation measures. Funds raised through green bonds are exclusively allocated to environmentally friendly projects, ensuring that the capital directly contributes to sustainability objectives. These projects are typically verified against recognized international standards, such as those established by the International Capital Market Association (ICMA, 2021).

Green bonds offer several advantages to governments and other issuers. They enable governments to tap into a growing pool of environmentally conscious investors who prioritize sustainability in their investment decisions. Due to high demand from investors with a preference for sustainable finance, green bonds may offer lower interest rates compared to conventional bonds (Bace & Singh, 2023). OF course, issuers are required to report on the use of the capital and the environmental impact they create, which helps to promote transparency.

Additionally, governments that issue green bonds can enhance their reputation as leaders in sustainability. Governments typically use green bonds to finance a wide array of sustainable infrastructure projects, including renewable energy facilities such as solar, wind, and hydroelectric power plants, as well as sustainable public transport systems like electric buses, rail networks, and other low-emission transportation options.

3. Methodology

In this section of the thesis, the applied methodology will be explained. Through the analysis, relying on this framework proposed by industry standards, the thesis divides the analysis into three parts, which were already introduced in the theoretical chapter. First, a financial analysis is carried out to assess the viability of the project from a solely financial perspective. Secondly, an economic analysis is conducted where the societal benefit of the project is assessed. Finally, a sensitivity analysis is conducted, identifying the potential risks underlying the project. Not surprisingly, if one wishes to give an estimation of the financial and economic implications and effects of an investment, a lot depends on the underlying assumptions used for calculations. In this segment of the thesis, a detailed list of these basic figures and assumptions will be introduced to familiarise the reader with the metrics used later in the analysis.

In conducting this thesis, a diverse range of data sources was utilised to ensure both analytical depth and empirical relevance. The research draws heavily on governmental and institutional reports, including Hungarian national railway development plans, statistical publications from the Hungarian Central Statistical Office (KSH), and policy documents related to EU-funded infrastructure programs such as the Connecting Europe Facility (CEF) and TEN-T corridor guidelines. These were essential in establishing baseline infrastructure conditions, project eligibility criteria, and financial feasibility benchmarks.

Additionally, transportation statistics and usage data were incorporated, particularly through MÁV Group operational reports and industry repositories, to model passenger trends, commuting patterns, and service performance. Academic literature, primarily in transport economics, cost-benefit analysis, and regional development, was integrated to provide theoretical grounding and support the interpretation of economic impacts. Lastly, online materials, including benchmarking data from international railway procurement cases, consultancy reports, and European Commission publications, were used to supplement the financial modelling and cross-country comparisons. This multidimensional sourcing approach ensures the robustness of the cost-benefit and financial analysis presented in the thesis.

The investment projects are evaluated using discount rates that reflect financial and socio-economic conditions. The financial discount rate is set at 4 percent whereas economic discount rate is set at 5 percent, based on international standards and EU guidelines for cost-benefit analysis (European Commission, 2014). As one of the main financing bodies of infrastructure investments in the EU, the thesis throughout the CBA is going to apply this rate for calculation purposes. However, through the analysis of the financing of the project, the thesis will calculate a separate discount rate, which will be compared with the original version. The reason for this is that by applying such a rate, the model is forced to make severe generalisations, supposing that the same economic conditions and risk atmosphere exist in all member states of the Union. Not to mention that this rate is currency-independent, which can pose significant challenges in accurately assessing reality since it implies that the rates do not account for potential fluctuations in exchange rates, which can substantially impact the cash flows and costs associated with a project. Thus, in the relevant chapters of the analysis, the thesis conducts an estimation of the realistic discount rate that the project should apply. The total lifecycle of the project is estimated to span 30 years, where the investment period spans six years, encompassing both planning and construction phases.

The study focuses on the railway line between Budapest and Zamárdi, with the estimated distance calculated based on existing railway mapping. Following the development, the average speed on the line is expected to reach 160 km/h, thereby significantly reducing travel time and enhancing passenger demand. To reach this expected speed, specific types of trains, the Stadler FLIRT, have been considered. These trains operate at a maximum speed of 160 km/h, and their passenger capacity has been estimated based on existing fleet operations in Hungary, reaching approximately 280 individuals per train (Stadler, 2025).

Planned section of development on railway line 30, 30A

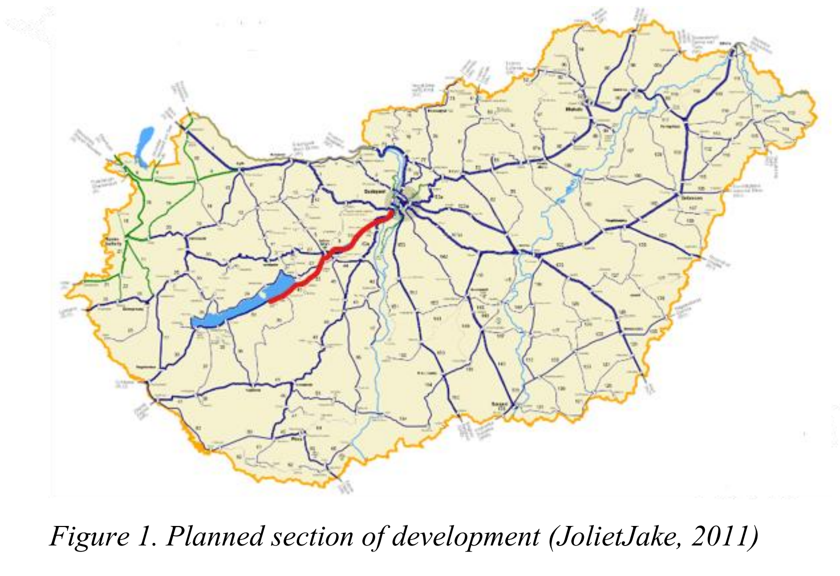

Figure 1. Planned section of development (JolietJake, 2011)

In terms of the current usage rates of the lines 30 and 30A as well as the estimated commuters by road, the thesis, in the absence of available disclosed data, set up an assumption scheme, crucial for the economic models of the analysis. It is presumed that during the off-season period, Zamárdi maintains a relatively small population of about 2700 permanent residents (KSH, 2025). Based on typical demographic distributions, approximately 60% of this population is of working age, resulting in 1800 individuals who could potentially commute. Given the 124 km distance to Budapest, daily commuting is believable but not realistic for most residents.

Interestingly, according to a statistical study carried out by the Eurofund (2009), it is seen that 60.3% of Hungarians work in the administrative borders of their settlement. In addition, it is also stated in the statistics that 28.5% of the people commute 60 minutes daily and merely 8% commute more than 90 minutes (Balogh, 2009). Although the data gathered can be regarded as outdated information, since there is no related statistical study, it is considered relatively realistic information. Needless to say, these values may be even lower since the high technological advancement of the COVID 19 pandemic and the appearance of the home office opportunity as a consequence. Assuming that only a fraction of the working-age population commutes in the direction of Budapest regularly by car and by including additional traffic such as occasional trips for services, shopping, or business, it is reasonable to assume a total of about 150 car trips per day during the off-season.

However, during the summer season, Zamárdi experiences a dramatic population increase due to tourism, with temporary residents and visitors, including not only tourists but also seasonal workers and event staff. Using the average number of visitors per day (see chapter 4.3.5) the thesis assumes that on average roughly 1,500 car trips per day occur during the high season, considering an estimated 120 high-season days (covering summer months and peak weekends). Combining both off-season and peak-season estimates gives a total of approximately 302,500 car trips between Zamárdi and Budapest per year. Due to the fact that these assumptions are rather hard to justify, a separate section is dedicated to sensitivity analysis, concentrating on the re-examination of these figures.

In addition, the current number of train riders was estimated. To estimate the number of trains operating on the Budapest–Zamárdi railway corridor, this thesis, in the lack of publicly disclosed estimates about the available trains on the route, is forced to set up a logical estimation scheme to assess how many locomotives operate on the line. Line 30A connects Budapest and Székesfehérvár and operates 2 trains per hour, and Line 30 to Zamárdi usually operates one train per hour, especially during the rest of the year. There are thus around 60–70 round trips per day between Budapest and Székesfehérvár, and around 8–12 trains per direction to Zamárdi.

During the summer months, additional trains travel to the Lake Balaton area because of tourist traffic. It is a round trip from Budapest to Zamárdi and back that lasts approximately 3 to 4 hours, including waiting times and turnaround. For this reason, there is room for only a few trips per day from one train; roughly 45 trains are needed to cover the current schedule efficiently. In order to meet the condition of the project, trains are expected to run every half hour between Budapest and Zamárdi, and then the number of trains must be increased. As it is known that the locomotives currently operate at 100-120 km/h, the increased speed of 160 km/h would require approximately 60 trains to conform to the requirement. As this assumption is based on logical assumptions, not on accessible data, the sensitivity analysis on the thesis will assess the effect of the change in the number of trains to be purchased on the project returns.

To accommodate an anticipated increase in demand, train frequency has been adjusted accordingly. The anticipated rise in railway efficiency is expected to result in increased ridership, which is analysed using the concept of time elasticity of demand (Ozbay, Yanmaz-Tuzel, Holguín-Veras, 2006) as well as through real-life examples derived from recent examples. Elasticity is calculated using the standard economic formula, where elasticity is derived as the percentage change in quantity divided by the percentage change in travel time. Transport economics studies suggest that travel time elasticity values typically range between -0.3 and -0.7 (Victoria Transport Policy Institute, 2023).

In this analysis, a conservative estimate has been applied, projecting a 21 percent increase in passenger numbers as a direct consequence of reduced travel times. On the other hand, empirical evidence from previous railway development projects substantiates the correlation between travel time reductions and increased ridership. Janic (2016) found that HSR rail lines operating in Europe tend to yield a double-digit increase in passenger use of rail transport, while Couto and Graham, in their research in 2008, stated that this number is merely around 8-10% overall. On the other hand, Ren et al. (2019) found that in the case of China, on the route between Chengdu and Chongqing, the calculated increase reached approximately a 25 to 30% increase overall.

It is important to note that as the train route is already in use for many decades with high utilisation rates, especially during the summer seasons, it is safe to assume that the traffic intensity of the route is likely to reach it is full forecasted passenger flow potential within the first 5 years of investment. In addition, the seasonal and economic considerations further reinforce the anticipated increase in railway demand. During peak tourist seasons, a significant rise in passenger numbers is expected due to the influx of leisure travellers, while off-season ridership growth is projected to be sustained by regular commuting patterns. The concrete percentages of this increase were calculated during the analysis of the tourism effects of the infrastructure upgrade. Based on those received values (introduced and explained under the relevant chapter of the analysis), the final total increase for the Budapest – Zamárdi line is expected to be around 39.18% for the whole period.

Due to the fact that the volatility of the Hungarian currency has been relatively high in recent years, and due to the current macroeconomic conditions of the country, it would be relatively hard to forecast the forthcoming Euro-Forint exchange rate even under the six-year investment horizon. Consequently, the thesis decided to apply a theoretical assumption that the exchange rate stays stable over the period to evade the possible over- or underestimation of the exchange rate. At the time of the analysis, the rate is around 400 HUF. All Euro-based investments are converted at this rate throughout the thesis.

For the financing of the project's capital expenditure (CAPEX) expenses, it is assumed that all investment costs are eligible for the EU co-funding. Although, the EU guidance on CBA charging principles allows to levy a markup price on the infrastructure users to recollect the initial investment faster (European Union, 2012), the thesis assumes that the current pricing structure of Hungarian railway system does not differentiate based on quality of service provided, thus normal prices will be applied currently in effect. In the financial model, prices are adjusted with long-run inflation on a yearly basis of 3% provided by the long-term economic forecast and inflation target of the Hungarian National Bank (MNB, 2025).

4. Cost-benefit analysis

In this chapter of the thesis, the detailed cost-benefit analysis is carried out, assessing the financial as well as socio-economic effects of the upgrade. In the first chapters, following a general introduction to the Hungarian railway system, the thesis will first, elaborate on the financial investment expenses, anticipated revenues and expenses, as well as on the residual value of the infrastructure at the end of the project lifecycle. Next, the possible economic factors will be observed closely, in particular, how would the effects on the environment, local tourism and other factors contribute to the value of the investment. The next chapter will elaborate on the financing structures of the project, how do the different sources of financing affect the overall value creation. Lastly, a detailed sensitivity analysis of the project is carried out observing how does the change in key variables affect final economic net present value of the investment.

4.1 Introduction to the general state of the Hungarian railway system

So far, this thesis has focused on the basic concepts of Cost-Benefit Analysis, explaining how it works both in theory and in practice, and why it is a crucial tool for evaluating investments in projects that are both socially and economically important. However, conducting any cost-benefit analysis raises a key question: why is this investment necessary in the first place? Is the current system not working well enough? Is it not able to meet the demands of today’s needs? To justify the need for the investment in scope of the thesis, the paper will examine the current state of the Hungarian railway system, in particular the Budapest – Zamárdi railway line.

Hungary’s railway network is one of the oldest in Europe, with its roots dating back to the 19th century. Over the years, the system has become an important part of domestic transportation as well as international connections. The network stretches across about 7,600 km of track (KSH, 2025), which plays a vital role in moving both people and goods. Hungary’s small size and its location in the Carpathian Basin make it a natural transport hub between Western and Eastern Europe. As a result, a modern and efficient railway system is critical for both internal and international trade.

However, in recent years, investment in the railway system has lagged behind that of neighbouring countries and other European Union member states. Of the total 7,606 km of railway tracks, about 3,060 km (or 40%) are electrified (KSH, 2025). Electrification is mostly found along the main corridors connecting Budapest with Vienna, Debrecen, Szeged, and Miskolc. The rest of the network, about 60%, still relies on diesel locomotives, especially in rural and lower-traffic areas where electrification has not been prioritized. Additionally, based on a 2017 report provided by International Union of Railways (2017), the only 1,335 km of track is double tracked, which limits the ability to run trains in both directions without delays (UIC, 2017).

These infrastructure limitations have strong implications on the network performance eventually constraining efficiency. Furthermore, Hungary also lacks a dedicated high-speed rail line. As a result, average train speeds remain relatively low, and long-distance travel is less competitive compared to road or air transport. Outdated infrastructure, congestion, and inconsistent service quality remain significant challenges to the railway system thus it is not surprising that experts continue to stress the need for greater investment in modernization to overcome these issues.

Narrowing down the discussion to the state of railway line between Zamárdi and Budapest, it can be stated that it is a crucial part of Hungary's transportation system, especially for travellers heading to Lake Balaton, the country's largest and most popular holiday destination. This line is part of the Budapest–Székesfehérvár–Nagykanizsa railway corridor (MÁV Line 30a and 30) which also serves the southern shore of Lake Balaton. The journey from Zamárdi to Budapest is about 110 km, and the travel time ranges from 1 hour 30 minutes to 2 hours, depending on the type of train service. In recent years, majority of the lines have been upgraded, including improvements to tracks, stations, and electrification allowing improved service quality. Importantly, electrification along the route allows for the use of modern electric trains, which provide a more comfortable and efficient travel opportunities. However, some sections, particularly closer to Zamárdi, still need modernization, in concrete, the line 30 requires the development of the ETRMS level 2 traffic system deployed to allow 160 km/h speed.

The Hungarian State Railways currently operates several types of locomotives in the lines, where the majority of the carriers are still older constructions such as BVH 43 and similar carriers with maximum speed of 100-120 km/h. However, note should be taken that in recent years, the Hungarian state has purchased several Stadler FLIRT electric multiple units that sometimes commute on the lines of our focus, which offer air-conditioned coaches, modern seating, and better accessibility for passengers and most importantly is capable of running at 160 km/h. Yet, the mixture of modern and older trains results in uneven service quality and travel times, highlighting the need for continued upgrades. Given the importance of the Zamárdi–Budapest railway line, further investment is necessary to improve its efficiency, reliability, and overall quality. Continued development would significantly reduce travel times and make the line more convenient for passengers. Moreover, investing in the railway would bring broader benefits to tourism and local economies. Improving the rail link would make it easier for tourists to travel to Lake Balaton and support regional businesses. A better railway connection could also reduce the number of cars on the road, contributing to lower congestion and fewer emissions, which aligns with EU sustainability goals.

This thesis will now move on to a detailed cost-benefit analysis of the proposed investments in the Zamárdi–Budapest railway line, considering the economic benefits, expected outcomes, and broader impacts of the investment. Ultimately, modernizing this key section of the railway system is not just a necessary step for improving transportation, but a strategic investment in Hungary's future economic and environmental growth. In light of these observations, the thesis conducts a cost-benefit analysis to carefully assess the viability of the project. In the forthcoming lines the analysis will immerse into to details of financial as well as economic implications of the proposed investment.

4.2 Financial Analysis of the Railway development

As it has been discussed in Chapter 2 of this thesis, financial analysis part of CBA focuses on evaluating the direct monetary flows associated with a project (Funk et al., 2019), assessing whether it is financially viable from the perspective of the investor or operator. In the first part, the financial CBA this question will be answered, providing the monetary estimates of the savings and revenue increases and of the expenditures of the project. To get the comprehensive financial estimate, the analysis builds up a generic 30-years annual cashflow model of the infrastructure upgrade and management concerning everything that is attributable to the upgrade itself. This approach will allow to assess whether the upgrade can generate a return that justifies the initial investment from a solely financial perspective.

4.2.1 Investment Expenses

Regarding investment related expenses, it is crucial to highlight that the reason for the simplicity of this calculation is due to the fact that the currently used railway lines 30, 30A have already undergone significant developments in recent years. Assets such as noise walls, terminals, or core electrification (25 kv AC) have already been installed in recent years, meaning that the majority of the basic requirements for faster commuting are already done. The whole line of service is operating with double-track lines; the lines are equipped with modern interlocking systems, including electronic and relay-based interlocking. Consequently, the analysis, in alignment with the assumptions previously made focuses on two investments, the purchase of the new fleet of Stadler passenger locomotives and the installation of the European Rail Traffic Management System (ERTSM) level 2 on line 30, the European Union's signalling and train control system used to ensure the safe and efficient operation of trains on high-speed and international railway lines.

First of all, focusing on the purchase of the Stadler fleet, the thesis has developed a financing model drawing on the approaches used in real-life cases, and how recent years' deals were structured in terms of payment arrangements. As the first step of the calculation, the price per train was examined. Due to several publicly disclosed information, the thesis established five different cases, which were proper materials for benchmarking, listed by the number of trains purchased (as the purchase quantity is one of the most decisive factors for train price discounts).

Benchmark Deals	**Country**	**Total deal value [EUR m]**	**Price per train [EUR m]**	**Number of Trains Purchased**	**Contract Sign**
Dallas Rapid Transit	USA	119	14.87	8	2019
VR Group	Finland	250	12.50	20	2022
Slovenske Železnice	Slovenia	150	5.77	26	2019
Koleje Mazowieckie	Poland	750	15.00	50	2024
Dutch State Railways	Netherlands	280	4.83	58	2015

Table 1. Benchmark data for purchase price calculation (Data compiled by the author from: Global Railway review (2015, 2019, 2022), Rail Target (2024), Rail Tech (2019))

As can be seen in the summarised table, examples from all across the world have been collected, indicating significant price fluctuations, which are due to the huge differences in configuration opportunities and, of course, the time of purchase. In light of the research carried out, the thesis has decided to opt for the purchase price paid by the Polish state for various reasons. First, the deal was contracted in 2024 for 50 pieces, giving the best estimation for recent price conditions and more importantly, the investment was made in the Koleje Mazowieckie country of Poland, one surrounding the capital with very similar economic as well as geographic characteristics as line 30A and 30 in Hungary.

By the assumption of the increased number of trains commuting on the route and the estimated price per train, the thesis has arrived to the estimation that in the scenario where all currently commuting trains are being changed to Stadler FLIRT carriers, the presumed value of investment is around 336.16 billion HUF. This entails that the cost per km for the investment is around 2.7 billion forints per km.

It is important to highlight that the realisation of these purchases, due to the volume of investment as well as the high percentage of configurability of these trains, is never to be transferred in one sum, either at contract signing or at the receipt of the last carrier. Instead, these transfer schemes are done through tailor-made structures negotiated by the partners based on factors such as the time needed for planning or the way of receiving the badges. After the payments are tied to the achievement of certain milestones, essentially, this is beneficial for the ordering state as well, since it ensures that costs are spread out over several years, helping manage cash flow and avoid excessive financial strain in any single year. In the case of Stadler deals, such information was not publicly available. Thus, the calculation steps used the industry standard of the US Federal Railroad Administration's program delivery for rail vehicle procurement outline (FRA, 2016) to set up a simplified assumption table, as seen below.

*All data in HUFm

Stadler FLIRT Train PAX Carrier (60pc)	%	2025	2026	2027	2028	2029	2030
Initial deposit	20%	71 703					
Progress Payment (after design completion - 6 months)	10%	35 852					
Progress Payment (after Component completion - 2 years)*	15%			53 777			
Payment upon delivery of the first batch (20pc)	30%				107 555		
Payment upon delivery of the mid batch (20pc)	15%					53 777	
Payment upon delivery of the last batch (20pc)	10%						35 852

Table 2. Stadler FLIRT PAX carriers' payment schedule (Own Calculation)

As it can be seen from the above table, the calculation assumes that the first year will include the payment of the initial deposit as well as the instalment following the design completion. The thesis assumes that the production of the components required for the production will take approximately 2 years, which will be followed by three years of construction and delivery. Assuming that the instalments will be given in three batches, it is estimated that the trains ready for use will be received in 2028, 2029 and 2030. Note should be taken, as highlighted in methodology in Chapter 3 of the thesis, it is assumed that the purchase of the vehicles does not take into consideration the potential devaluation or revaluation of the currency.

Regarding the ERTMS Level 2 implementation, it follows a separate payment schedule. While for the carrier purchases it was highlighted that there are significant differences in the schedules of payment and implementation, in the case of the traffic management system, the thesis is based on recent examples of the Stockholm to Malmö line (Ranjbar, 2020) network developments.

*All data in HUFm

Payment schedule	%	2 025	2 026	2 027	2 028	2 029	2 030
Initial Deposit and Mobilization	10%	330					
Design and Engineering Phase	20%		660				
Procurement of Equipment and Materials	20%		660				
Installation and Testing Phase	30%					990	
System Commissioning and Final Acceptance	20%						660

Table 3 Payment schedule for the ERTMS – 2 signalling and logistics system (Own Calculation)

As industry examples show, an initial deposit of 10% is transferred before actual infrastructure developments begin in 2025. This is followed by the addition of 20% of the design and engineering phase in 2026, and another 20% is allocated for the procurement of equipment and materials in the same year. The installation and testing phase, due to the complexity of the development, is expected to be finalised in 2029, which will be followed by system commissioning and final acceptance scheduled for 2030. Both investment areas take into consideration, it is visible that a significant investment is required for the realisation of the project. These values, to assess the time value of money, are being discounted with the 4% rate proposed by the European Union, resulting in the results shown in Table 4.

*All data in HUFm

Discounted expenses	2025	2026	2027	2028	2029	2030
Stadler FLIRT Train PAX Carrier (60pc)	107 938	-	49 897	95 957	46 133	29 572
ERTMS - 2	330	1 269	-	-	846	542
Total	**108 268**	**1 269**	**49 897**	**95 957**	**46 979**	**30 115**

Table 4. Total Discounted Investment (own table)

Importantly, as the financial model is reviewing the benefits and costs incurred over a 30-year horizon, the value of the capex investments at the end of the lifecycle must also be calculated. For this estimation, the residual values of the two CAPEX investments are calculated in the following way. In both cases, the value is calculated using a straight-line depreciation method. Regarding the Stadler carriers, the method uses the yearly depreciation taken from the train locomotives and thus results in the yearly total depreciation for all the locomotives. This value is received from supposing a useful life of 35 years, a timeframe which is derived from information being publicly disclosed from the Swiss SBB, the national railway company of Switzerland (SBB, 2024). The company for PAX carriers, uses a 40-year lifetime for calculation which results in a 233.04 billion HUF total depreciation for the total period, ending up with a 125.48 billion HUF for the total residual value.

In terms of the ERTMS – 2, the calculation is based on a similar logic, the total lifetime of the asset is based on the European Commission's directive, highlighting that the estimated lifetime of the ETSM – 2 system is 20 years (European Commission, 2025). Using this number of years for depreciation, the final result of the residual value at the end of the project is 0 HUF. Consequently, the total residual value at the end of the financial analysis is 125.48 billion HUF, undiscounted. The summarized findings can be seen below.

Stadler FLIRT Train PAX Carrier (60pc)		
Price/train	5 975	mHUF
Useful life	40	Year
Depreciation/train yearly	149	mHUF
Depreciation Total yearly	8 963	mHUF
Total depreciation over the project lifecycle	233 035	mHUF
Residual Value remaining	125.49	mHUF
ERTMS - 2		
Total Cost	3 300	mHUF
Useful life	20	Year
Depreciation yearly	165	mHUF
Total depreciation over the project lifecycle	4 125	mHUF
Residual Value remaining	-	mHUF
Total Residual Value	**125.49**	mHUF

Table 5. Residual Value of Investments (own table)

4.2.2 Revenues & expense dynamics

To calculate the net present value of the project, the estimated revenue streams must be calculated based on the following methodology. For correctly assuming the revenue items relevant to the project, the theoretical question was raised, 'what is changed in the revenue streams compared to the no-change alternative that creates additional financial benefit for the operator. After analysing the financial statements of the operator MÁV group, the thesis has established two different aspects of revenue generation due to the introduction of the railway line. This income is the increase in ticket prices as demand for the railway line goes up drastically.

The current operator of the lines 30, 30A in the MÁV Group, which has a detailed publicly available financial statement, where the relevant sales revenues are disclosed. To assess the yearly revenue streams from ticket sales, the research focused on the financial reports of the MÁV Start Zrt., the company, which is responsible for the passenger transportation, including the revenue streams of the total ticket sales. In addition, the ownership of assets such as trains and locomotives is also present in the balance sheet of the company. Deriving the latest values from the income statement of 2023, it can be seen that the company generated a total of 57.7 billion HUF for the whole country from domestic ticket purchases (MÁV, 2023). This amount is accompanied by a total of 30.9 billion HUF government subsidy, which is the compensation for the discounts given based on positive discrimination for groups such as elderly people and students. Thus, a total of 88.6 billion HUF was accumulated in the period.

To calculate the revenue allocated to the 30a and 30 lines between Zamárdi and Budapest, the thesis based its calculation on the information provided by the Magyar Vasút repository (2023), which has direct information provided by the MÁV Group concerning internal statistics. Based on this report, in 2022, 8,5% of the total ticket sales of MÁV group were accumulated on the line 30 and 30a altogether between Budapest and Gyékényes. Since the exact revenues between Zamárdi and Budapest are not accessible, the thesis decided to calculate the proportion of the 8.5% relevant to the research (Magyar Vasút, 2023).

Without detailed information available about the train station's utilisation, the volume of passengers is estimated on a population basis. Using this approach, the thesis has decided to apply 6.38% of the total revenue, which serves as the estimation for the scenario without investment. The value received is 5.65 billion HUF for 2023, which is the basis for estimation for the 30-year revenue streams. For the analysis of future sales revenue, due to no available sales growth projections, an annual growth rate of 3% was assumed over the project lifetime which is based on the expected long term inflation projections provided by the Hungarian National Bank, with the assumption that the nominal revenue increases with the rate of inflation (MNB, 2025). With this assumption, we can establish a scenario where no real growth is assumed in the observed period, and a strictly monetary value increase is assumed due to price level changes.

The revenue streams in the scenario where the investment has been realised are calculated in a slightly more complicated manner, as first, the model must account for an expected sales increase, already introduced above. For simplicity purposes, the thesis assumes that the proportion of discounted tickets remains the same as in the no-investment scenario. In light of this presumption, it is estimated that in the years 2028, 2029 and 2030, the revenues will undergo a significant increase along with the arrival of the badges of PAX carriers. This results in a higher revenue stream than the scenario without investment, resulting in significant revenue income for the MÁV group. Taking the difference between the discounted values of the two scenarios where the applied discount rate was, the model estimates that the total revenue generated due to the investment is 61.09 billion HUF. The summarised values can be seen in Table 6.

	2028	2029	2030	2040	2050	2054
	year 4	*year 5*	*year 6*	*year 16*	*year 26*	*year 30*
Revenues w/o Investment	6 548	6 744	6 947	9 336	12 546	14 545
Revenues with Investment	7 403	8 621	10 039	13 492	18 132	21 020
Ticket Sales	4 821	5 614	6 538	8 786	11 808	13 689
State Subsidy	2 582	3 007	3 501	4 705	6 324	7 331
Difference	**855**	**1 877**	**3 093**	**4 156**	**5 586**	**6 475**
Discounted [HUFm]	**39 784**					

Table 6. Revenue change from Sales volume increase (Own calculation)

In addition to revenue generated from ticket sale increase, another crucial factor must also be incorporated into the model, the decrease in the operative expenses related to energy costs. As it has been discussed previously, currently a huge percentage of trains operating on the line of focus is using locomotives with high energy consumption both electric as well as diesel engines. Currently, lines 30A and 30 are operating with Bhv V43 and Stadler FLIRT locomotives which altogether consume significantly more than if only the new models would be used on the railway line. In the case of the Stadler FLIRT carrier, the estimated electricity consumption is around 15 kWh/km, whereas Bhv V43 consumes around 35 kWh/km on average (Fisher, 2015). Using these assumptions, it can be estimated that by changing the locomotives that are currently in use to all Stadler FLIRT commuters, it can be stated that the average consumption would be decreased from average 25 kwh/km to 15 kwh/km, which using the assumption of the yearly total covered km, a 40% decrease overall is estimated. This decrease will be used for the estimated decrease in total energy spendings on the given line.

Currently MÁV group operates 1544 passenger carrier locomotives (MÁV, 2023), whereas the total energy consumption of the MÁV group reached 47.8 billion kwh altogether. About this amount 44.25 billion kwh was used for passenger transport, which means that the yearly average spending on one train is around 28.66 million HUF. Using the assumption that approximately 45 trains commute on this route, the estimated yearly spending in the current state is 1.29 billion HUF. If we suppose that the number of trains is increased to 60 carriers through 3 years of commission, while the energy consumption decreases by 40%, the assumed consumption in the post-investment scenario is around 10.48 billion HUF. This result is achieved by assuming that the energy prices decrease in 2028, 2029 and 2030 according to the installation of the newly purchased locomotives. The table below summarises the findings.

	2025 *year 1*	2026 *year 2*	2027 *year 3*	2028 *year 4*	2029-2055 *year 5-30*
Energy cost w/o Investment	1 290	1 240	1 192	1 146	18 721
Energy cost with Investment	687	661	635	968	10 156
Difference	**601**	**578**	**556**	**178**	**8 565**
Discounted [HUFm]	**10 480**				

Table 7. Energy cost change (Own calculation)

Last but not least, the changes in maintenance expenses must be addressed. According to Guelker (2024), maintenance expenses can decrease up to 30-40% when new locomotives are purchased. Using this assumption, the thesis has set up a model where the change in maintenance expenses is analysed using a conservative 30%, observing if the decreased maintenance expenses counterbalance the increased volume of carriers commuting on the lines.

For the estimation, the thesis used the MÁV Group's latest disclosed financial reports, where it is disclosed that the company spent 31.53 billion HUF on maintenance expenses of passenger locomotives. Using the number of passenger trains in operation, it can be estimated that the yearly expense of 45 trains currently in operation on the given lines is approximately 918.9 million HUF yearly expense. However, in case of the realisation of the investment, although the number of carriers increases, due to the decreased maintenance expenses, the total costs will only amount to 857.64 million HUF. Using the discounted cash flow model, the difference between the alternatives reaches 1.120 billion HUF for the total investment period, which, in light of the fact that the total yearly spending is around 31 billion, is a considerable amount.

All things taken into consideration; the following summary table can be constructed for the NPV calculation. The project yields a negative Net Present Value (NPV) of -221.107 million HUF indicating that it is not financially viable under current assumptions and would result in a significant economic loss without incorporating any additional benefit.

Financial net present value (FNPV)

Calculation of FNPV		NPV
Investment cost	mHUF	-332 486
Revenue	mHUF	61 089
Op. Expenses*	mHUF	11 601
Residual value of investments	mHUF	38 688
FNPV	**mHUF**	**- 221 107**

Table 8. Financial analysis summary table (own calculation)

4.3 Socio-economic analysis

In recent years, the concept of ESG has gained significant importance in evaluating the sustainability and societal impact of various projects. Specifically, the 'S' in ESG stands for the social aspect, which is directly tied to the well-being of individuals and communities affected by an investment. In the context of this thesis, the economic analysis in CBAs intends to go beyond the financial feasibility of a project by incorporating broader economic impacts of an investment made by the country. In contrast to financial CBA, which focuses on direct revenues and costs taken from CF models, economic CBA evaluates assumed externalities such as travel time savings, environmental benefits, and welfare improvements to capture the true economic value of a project. This is highly important in the case of projects where the market prices fail to reflect their full impact. This section of the thesis will elaborate on how the economic benefits of the infrastructure upgrade will contribute to long-term economic efficiency and social well-being.

Based on the available data and methodology applied, the thesis differentiates between two main types of impacts, between qualitative and quantitative methods. In case of the former, due to the lack of quantifiable data, comparable examples and real-life cases will be introduced to get an accurate glimpse of the potential effects. In case of the latter, as results are monetizable, detailed calculation will be presented.

In the first chapters of the economic analysis, the qualitative aspects are discussed in detail. After analysing the potential impacts of the development of the infrastructure, the thesis has established three main areas of study: economic growth and labour market expansion, passenger experience and convenience, and local business development. Faster, more efficient connections expand job and education opportunities, boosting workforce mobility and productivity. Higher frequency of trains and comfort enhance passenger experience, increasing ridership and transportation efficiency. Lastly, better accessibility attracts visitors, driving growth in tourism, retail, and hospitality. Together, these factors strengthen the region, improve quality of life, and support local development.

4.3.1 Better access to services of the Capital

The reduced travel time due to high-speed rail strengthens the connections between cities, helping residents to access better opportunities without relocating to other places. Improved accessibility to workplaces and educational institutions expands the labour market and diversifies learning options (Holley, 2008). Furthermore, shorter travel times enhance productivity and competitiveness. Together, these advantages contribute to higher employment rates and greater workforce mobility, eventually resulting in increased demand for transportation services.

The introduction of high-speed rail has shown clear benefits in improving connectivity between regions. A good example is the Madrid–Seville High-Speed Rail development in Spain, which started in 1992. Before the high-speed rail, travel time between Madrid and Seville was around 6.5 hours, but with the new system, the distance was covered in merely 2.5 hours. This time saving made it easier for people in Seville and nearby areas to access better job opportunities and education in Madrid without moving, allowing businesses there to hire from a larger pool of individuals, while companies in Seville gained better access to the capital's job market. Additionally, students from Seville could attend universities in Madrid, increasing educational opportunities and collaboration. The faster travel time also helped businesses by allowing professionals to attend meetings in Madrid without needing to stay overnight, increasing productivity. (Pita, 1993)

For the case of the Hungarian infrastructure projects, if the travel time between Budapest and Zamárdi were reduced to just 60 minutes, it would bring similar benefits to commuters using an efficient railway line, opening better access to job opportunities, educational institutions, and healthcare facilities in Budapest, without the need to relocate. Consequently, improved connection would also enhance the quality of life in Zamárdi, making it a more attractive place to live, eventually carrying the potential of boosting property values, leading to increased investment in the area.

4.3.2 Better and larger access to labour resources

A faster connection between these two areas increases the access to a larger pool of labour resources, benefiting businesses in Zamárdi. This improved accessibility can help companies in Zamárdi tap into a more diverse talent pool not just in the region, but also along the line of the improved train route until the capital itself, while also providing residents of Zamárdi with better opportunities for work, study, and personal growth in the capital. As Chi and Han (2023) highlighted, this increased mobility can improve overall labour market efficiency, reduce commute times, and create more balanced economic development between urban and rural areas (Chi & Han, 2023).

One real-life example of this type of change is the TGV in France, which has had a significant impact on regional labour markets. For example, the TGV line connecting Paris and Lyon reduced the travel time between the two cities from around 4 hours to just 2 hours (Crozet, 2013). This change opened new labour market opportunities by enabling workers to live in one city while working in the other, particularly in sectors with higher development, being located near the larger urban centres. Consequently, businesses in Lyon were able to access a wider talent pool, including highly skilled workers from Paris, and workers in Lyon gained access to better job opportunities in Paris.

For residents living in Zamárdi, the better connection to Budapest could provide access to a broader range of jobs and career opportunities, allowing them to maintain a better work-life balance, without the need to relocate for employment. Additionally, businesses in Zamárdi would benefit from a more dynamic labour market, as they could attract the capital's workforce more easily.

4.3.3 Increased passenger comfort

Enhancing train service frequency and reducing travel times can significantly improve passenger comfort. Increased frequency reduces waiting times and ceases overcrowding, leading to a better travel experience. Shorter travel times decrease the overall journey duration, minimizing passenger discomfort. A study on train length and service frequency optimisation found that balancing these factors can maximise both operator profit and passenger satisfaction (Hitachi, 2025). Another study highlighted that improvements in service quality and train comfort positively influence passenger satisfaction (Heng, 2021).

Excellent examples of this phenomenon is the case of Sydney Metro line’s 24-hour service push, where in little to no time, passengers responded with a higher-than-expected ridership and positive passenger feedback (Daily Telegraph, 2025). For the Zamárdi-Budapest line, increasing train frequency and reducing travel times to under one hour can significantly boost passenger comfort and satisfaction. Implementing these improvements can lead to higher ridership, increased revenue, and a more efficient transportation system.

4.3.4 Effect of railway upgrade on local businesses in Zamárdi

Analysing from a qualitative point of view, enhancing railway infrastructure can have a strong impact on local businesses by improving its’ accessibility, increasing customer flow, and driving economic growth. Better rail services can reduce travel times and improve connectivity, making commercial areas more attractive to consumers and investors. Improved transportation links can lead to higher consumer spending, increased demand for services, and business expansion. As highlighted by the experts of University of Insubria, such infrastructure improvements can act as catalysts for local economic development, making the area more vibrant and economically robust (Ruocco, Auria, 2024).

One of the key recent examples of this development is the electrification of the Great Western Main Line in the UK and the introduction of new high-speed trains. Although the full impact is subject to ongoing evaluation, expectations included increased employment opportunities and business growth. The analysis carried out by the experts of the UK government also highlighted that improved transport connectivity, and hence significant improvements in connectivity, can deliver a series of impacts on local economies (Steer Davies & Gleave, 2018).

The analysis highlighted that since the development of the railway lines, and the introduction of high-speed trains in a 6-year period between 2009 and 2016, resulted in a 46% increase in the house prices of the local town Swindon, one of the main beneficiaries of the rail development. For Zamárdi, upgrading the railway line to Budapest, resulting in faster travel times and more frequent services, could substantially benefit local businesses. Better connectivity is likely to attract more visitors, boosting sectors like tourism, hospitality, and retail.

In next chapters of the economic analysis the quantitative aspects are discussed in detail. During the process of analysis, the paper has identified two main areas. (1) The first one is the effects that are regarded as positive externalities owning to the railway upgrade. Note should be taken of the fact that these aspects are observable in case of all similar infrastructure upgrades, namely increase in travelling safety, time savings of travel, reduced dependency on cars leading to decrease in traffic congestions, and last but not least, the reduced impact on climate change. (2) Secondly, the thesis has established several factors of change that are directly attributable to the project itself. These include tourism increase in the region of Zamárdi and the general economic benefit attributable to it as well as additional job creation in the city of Zamárdi. In the forthcoming lines, the thesis will elaborate on these factors, assessing these assumed effects case by case.

4.3.5 Effects on the tourism sector of Zamárdi

Zamárdi, notorious for its key position in the southern regions of lake Balaton, in recent decades has started to play a pivotal role in the touristic development of the region.

Internationally known events being organised, such as the Strand or Sound festivals, the fast accessibility of the Tihany-Peninsula or Siófok, and the generally developed local infrastructure of the town have listed the town among the most visited destinations around the lake in recent years. However, as this thesis has highlighted several times, there is but one key feature that Zamárdi has not yet fully capitalised on, the relative proximity to the capital city of Budapest. In the following lines, the potential effects of the infrastructure development will be assessed from the city's touristic point of view, in particular, how a shortened travel time could be achieved through the western 30, 30A lines channelling visitors from Budapest and towns in between to Zamárdi.

When assessing the financial implications of such an infrastructure investment, two principal revenue streams must be carefully analysed: the anticipated rise in daily tourist expenditures and the projected increase in the number of overnight stays. Both of these variables are directly correlated with the overall expected increase in tourist arrivals during the summer period. Given the limited availability of precise data specifically focused on Zamárdi, the thesis employs a logical estimation to approximate the number of visitors the city receives annually. This approach is based on relevant statistical data provided by the Hungarian Tourism Agency, which offers insights into key economic metrics necessary for revenue calculations.

According to the agency's data, the annual gross revenue generated by accommodation providers across the region was reported at approximately 74.8 billion HUF (MTÜ, 2022). This figure is expected to reach 83.6 billion HUF when adjusted to 2024 values through applying the growth rates of 2023/24 years published by the agency for revenue increase in the region. By utilizing the recorded data on total overnight stays in Zamárdi, an estimation was derived indicating that the revenue generated solely by the city's accommodation sector amounted to approximately 474.6 million HUF in 2022, with an estimated increase to 530.7 million HUF in 2024.

For the estimation of increase in the overnight stays and the revenue generated by accommodation sales increase, international guidelines, academic research and real-life examples were analysed. Prideaux (2000) found that an approximated 20% increase can be assumed when the betterment of travel access is the main source of tourist volume increase.

Yet, due to strong differences between each and every investment case, recent examples of similar investments have also been analysed. Looking at the results being obtained in Spain, where due to the development of railway between Barcelona and Perpignan, a 20% increase was observable (Massan, Petiot, 2009). In addition, the case of Marseilles and Avignon was observed where researchers found that the increase was around 20% to 25% in the forthcoming years after the conclusion of the investment (Ligne Nouvelle, 2022). Drawing on these empirical examples, this thesis has formulated conservative growth projections for Zamárdi. In the short term, within an estimated period of three years from 2028 and 2030, a projected 15% increase in overnight stays is anticipated. This assumption is aligned with the planned deployment of Stadler carriers in 2028, 2029, and 2030. In the longer term, the analysis suggests that overnight stays could experience an increase of approximately 15% within three years of enhanced railway accessibility.

Using a nominal discounted cash flow model, the differences between the estimated revenue generation and the projected revenues after the investment have been compared, and the differences have been discounted. Due to a lack of publicly disclosed information, the thesis assumed that the accommodation revenues in both cases will increase by the long-term inflation projections of the Hungarian National Bank, 3% in the project lifetime on a yearly basis. Since these metrics are focused on economic gains, the economic discount rate of 5% has been applied. The summarized discounted figures can be seen below in Table 9:

All values in mHUF

Accommodation revenue increase	**2028**	**2029**	**2030**	**2031**	**2032**	**2033-2054**
	year 4	*year 5*	*year 6*	*year 7*	*year 8*	*year 9-30*
Revenues w/o Investment	531	526	521	516	511	10 076
Revenues with Investment	558	580	603	642	683	13 480

Total Difference [mHUF]	**3 304**

Table 9 Accommodation revenue increase projection (Own creation)

However, when assessing the impact of improved infrastructure on Zamárdi's tourism sector, it is essential to consider not only the expected increase in visitor numbers but also how much these visitors are likely to spend during their stay. The economic benefits of tourism arise from both the number of people coming to the town and the average spending of the visitors. To accurately estimate these factors, this thesis breaks the calculation into two key components: first, the projected increase in the number of tourists visiting Zamárdi, and second, the estimated daily spending per visitor.

For the second component, data from the Hungarian Central Statistical Office (KSH) was used to determine an average spending volume. According to the latest available data, an average tourist spends approximately 22,000 HUF per day, which serves as the basis for revenue calculations (KSH, 2025). However, unfortunately for the analysis, there is no direct data available on the total number of tourists visiting Zamárdi annually. Therefore, a logical estimation method was developed to approximate this number. The first step in this estimation process was analysing overnight stay figures. Since this metric varies from accommodation provider to provider, the thesis has decided to apply an average of 2.4 people stay together per overnight booking. This assumption is backed by Eurostat data, provided by Helgi Library listing the national average figures for European countries (Helgi Library, 2014). Using this estimation, the total number of visitors staying at least one night in Zamárdi each year is approximately 87,240.

As the next step of the calculation, the share of people staying less than one night is estimated. Based on the academic study of Mckercher & Lew, the proportion of day trippers can reach up to 60% of total travel if the accessibility of the target place has a small relative proximity to larger cities, centres with high population density (Mckercher & Lew, 2006). This assumption was modified by the findings of the analysis carried out by the EU Tourism Platform in 2024, which highlighted that on a state scale, the share of same-day trips was around 56% of the total (EU Tourism Platform, 2024). Yet, since none of the data found was exactly focusing on the Balaton region, this percentage was decided to be lowered to a conservative 50-50% share.

The following part was estimating the expected increase in revenue figures as a result of improved travel infrastructure. Using publicly available tourism data from 2024 and expected trends for 2025, a discounted cash flow model was created to compare future revenue with and without the planned improvements. In both scenarios, a 3% average annual growth rate was assumed, which corresponds to the long-term inflation target set by the Hungarian National Bank. This conservative estimate reflects expected price increases due to inflation rather than any real growth in demand.

However, apart from this increase, with the infrastructure investment an additional boost to visitor numbers was assumed. For day-trippers, the number of visits was projected to increase by 50% due to easier and faster access from Budapest. To support this assumption, a travel elasticity calculation was conducted. This calculation estimated that a 33% reduction in travel time, combined with an assumed elasticity of 1.5, already introduced in financial analysis section, would result in a 50% increase in day-trip visitors. For overnight visitors, the same growth rates were used as in case of the accommodation revenue projections with total of 30%.

Finally, the overall economic impact was assessed over a 30-year project lifespan. The projected revenue with and without investment was calculated and then discounted to determine its present value with the socioeconomic discount rate of 5%. The values received were compared in both cases, which showed that the investment would generate a net positive value of 45.26 billion HUF. When combined with the projected increase in accommodation revenue, the total estimated economic benefit reaches approximately 48. 56 billion HUF, as shown in Table 10.

All values in mHUF

Revenue projection from increased spending	2028	2029	2030	2031	2032	2033-2054
	year 4	*year 5*	*year 6*	*year 7*	*year 8*	*year 9-30*
Revenues w/o Investment	4 378	4 336	4 294	4 253	4 212	83 080
Revenues with Investment	4 853	5 341	5 895	6 023	6 162	121 536
Total Difference [mHUF]	**45 256**					
Total economic value	**48 559**					

Table 10. Revenue projection from increased spending, discounted [HUFm] (Own creation)

Interestingly, these revenue increases may not be the only sources of economic value to the economy of Zamárdi. Academic research highlights there are so called multiplier effects of such increases describing how tourist spending circulates within the local economy, generating additional income beyond the initial expenditure.

Sinclair and Stabler provided a conservative multiplier of 1.5 in their research highlighting the importance of indirect effects of demand increase for goods and services supporting the tourism industry (Sinclair & Stabler, 1997). However, later analyses such as Dwyer and Foresight (2010) found that spending leading to additional economic activity can result in multiplier as high as 2.5 within proper economic circumstances (Dwyer & Foresight,2010). Based on the studies, the thesis has observed the factors influencing the Zamárdi economic atmosphere and established the following. Zamárdi is predominantly a tourism destination, which tends to create both indirect and induced economic benefits, even though the impact might not be as large as in areas attracting high-end, luxury tourists. Despite the absence of large leakages, the thesis has decided to take the golden mean and calculate with an average of 2.0. Using this multiple, direct and indirect benefits lead to a total value creation of 84.2 billion forints total.

An important aspect of the economic benefits of tourism is the impact of this development on job creation. Tamzil highlights how the tourism sector contributes to the economy by providing direct and indirect employment opportunities for the local population (Tamzil, 2023). Similar infrastructure improvements in other countries have demonstrated significant job creation effects. For instance, the railway upgrades between Málaga and Madrid (Hrushka et al., 2021) and the development of Thailand's rail infrastructure (Travel and Tour World, 2025) both led to substantial increases in local employment. Using these examples, the thesis assumes that for every 1 million EUR in additional revenue generated by tourism, approximately 12.33 jobs are created. Using this assumption, it is estimated that the direct benefits of the development would create 1,298 new jobs in Zamárdi. When considering the broader economic effects, the total number of new jobs could rise to 2,596. This highlights not only the increased revenue that the development could generate but also the broader economic benefits.

4.3.6 Increased travelling safety

When conducting a Cost Benefit Analysis for travel-related projects or policies, the importance of travel safety cannot be overstated. Safety is a key factor in assessing the overall social and economic value of a project, as it directly impacts public well-being and quality of life. Incorporating travel safety into a CBA ensures that the potential benefits of reducing accidents, injuries, and fatalities are accurately quantified. By valuing these safety improvements, policymakers can make informed decisions that reflect not only financial costs and benefits but also the broader social impact, contributing to more sustainable and human-centred transportation systems. Additionally, prioritizing travel safety in the analysis helps align public investments with the goal of protecting individuals and fostering societal trust in transportation infrastructure.

Economic analysts of the European Union in 2022 have estimated that the statistical value of saving a life for the government is approximately 4.3 million Euros (European Commission, 2022) which for purposes of calculation was adjusted with EU average inflation of 2023 and 2024, resulting in a value of 4,9 million EUR. In light of the available statistical information provided by the EU, the thesis set up a model which intends to quantify the economic value of passenger safety by estimating the expected fatalities from both car and train travel in two scenarios, first the state where the investment is not realised and secondly the state where the development of the line is realised. This effect is then converting them into monetary terms.

The expected number of fatalities per year is calculated using fatality rates per billion passenger kilometres of 0.1 for car transport mode and 0.35 for railway. These figures are then adjusted based on seat utilization and total travel distances for each mode of transport (International railway Safety Council, 2025). In case of the Stadler trains, the current official parameters of the Hungarian locomotives were taken as source of calculation and for the passenger per car, the average utilized car capacity provided by the EU external cost of transport handbook was incorporate into the model (European Commission, 2019). Taking the yearly number of vehicle rides in both the pre-investment as well as the post-investment scenarios, these figures are then multiplied by one way km length arriving at the total km taken by the railway. This value is then multiplied by the per km fatality rates.

To translate these risks into economic terms, the estimated fatalities are multiplied by the estimated value of statistical life. By taking the total number of fatalities for both transportation modes in both scenarios, the study provides a comprehensive measure of travel-related risks. The final result as shown in Table 11. highlights that by ensuring safer travel opportunities for passengers, the monetised value of the infrastructure upgrade is 818 661 514 HUF, discounting the yearly generated cashflows over the project lifetime with an annuity method.

All values in mHUF

	Passenger fatalities per billion kilometres	Current number of vehicles	Current number of passengers	Expected number of vehicles	Expected number of passengers	Total km driven	Current number of Fatalities	Expected number of Fatalities
Car	0.1	302 500	438 625	216 735	314 265	37 207 500	0,09443	0,06766
Train	0.35	3 597	1 007 181	4 617	1 292 739	442 440	0,00004	0,00006

Yearly total Impact	53 252 945
Discounted	**818 628 288**

Table11. Economic value of increased passenger safety (Own Calculation)

4.3.7 Increased travel time savings

In cost-benefit analysis of transport projects, travel time savings often represent a significant portion of the quantified benefits. Reducing travel time enhances productivity by allowing individuals and goods to reach their destinations more quickly, thereby increasing economic efficiency. Accurately valuing these time savings is crucial for informed decision-making, as it ensures that resources are allocated to projects that yield the highest net benefits to society.

To quantify the monetary benefits of a railway upgrade, the concept of the value of time is applied, retrieved from the 2019 EU report Handbook on the External Costs of Transport.

This report provides average hourly valuations of passenger time, distinguishing between personal and business travel, with an average value of time established at 35 euros per hour. Consequently, the per-passenger time value used for calculations is determined as 17.5 euros per hour, which reflects a proportional rate for the 30-minute reduction in travel time assumed in the thesis. Using this value, the total yearly benefit of the time savings is calculated. The yearly benefit is derived from the product of the annual passenger volume using the 30% increased number and the monetized time savings per passenger. This results in a total value of 22,750 K euros per year, which is for sake of consistency is converted to 9.1 billion HUF. To assess the overall economic feasibility of the railway upgrade, a discounted cash flow analysis is conducted, yielding a final discounted solution valuation of approximately 139.89 billion forints. This valuation takes into account the time value of money, ensuring that future benefits over the project lifetime are appropriately adjusted to reflect present-day values.

4.3.8 Benefits to the Environment – Climate Change

In ESG principles, through the environmental aspect, significant focus is put on environmental responsibility, encompassing aspects like climate change mitigation, resource conservation, pollution reduction, and ecological protection. In the context of this thesis, ESG principles play a vital role in understanding the broader impacts of infrastructure projects beyond mere financial feasibility. Shifting from road-based transport to rail offers significant economic and environmental benefits, particularly in decreasing the monetary costs associated with climate change. Rail transport benefits from economies of scale, meaning that as more passengers switch from private vehicles to trains, the cost per passenger-kilometre decreases due to higher capacity utilisation and lower marginal operational costs (Nash et al., 2019). This shift contributes to reduced greenhouse gas emissions and lower external costs, such as air pollution, congestion, and road maintenance. In the context of the proposed railway upgrade, the anticipated increase in train ridership translates into substantial reductions in external costs, reinforcing the project's economic viability. The monetised benefits of shifting passengers from cars to trains extend to broader climate and sustainability gains, which are essential for long-term economic and environmental stability.

Regarding the steps of calculations, the model started from the same core assumptions, aiming to estimate the total vehicle kilometres done on a yearly basis by the two modes of transport, cars and passenger carrier trains. After addressing the decrease of car use by an estimated 28% and an increase of 29% in the case of railways, car-kilometres driven significantly reduce annually, while rail travel increases substantially. The two percentages are received after conducting comparative research on similar projects and their potential effects. Altogether, five cases were analysed, and the experience gained from these cases was supported by four research analyses. Another crucial element of the calculation is the estimated cost of emissions for both transport modes per vehicle kilometre. The cost of emissions per vehicle km is higher for trains (€0.1267) than for cars (€0.0602) based on the 2019 study of the European Commission, but due to significant differences in passenger capacity, the total cost per passenger-kilometre is substantially lower for rail.

To estimate the monetary impact of these changes, the climate change cost per vehicle type is applied to the respective total kilometres travelled. The monetized climate cost for cars decreases from 2 239 892 EUR to 1 604 832 EUR, generating a savings of 635 059 EUR. Conversely, the increased rail use raises its climate cost from 74 743 EUR to 95 934 EUR, resulting in an additional 16 697 EUR. The net benefit of the modal shift is therefore 613 868 EUR in annual terms. This yearly reduction is then converted into HUF and discounted into a present value using an annuity method, yielding a total discounted benefit of 3 774 660 720 HUF. These calculations demonstrate that shifting passengers from cars to trains not only reduces emissions but also leads to significant long-term economic benefits by mitigating the external costs of climate change.

All values in mHUF

	Cost [EUR/vkm]	Current number of vehicles	Expected number of vehicles	Current total km driven	Expected total km driven	Current Monetised Cost	Expected Monetised Cost
Car	0.10	302 500	216 735	37 207 500	26 658 347	2 239 892	1 604 832
Train	0.35	4 796	6 156	442 440	567 882	56 057	71 951

Yearly total Impact	247 666 224
Discounted	**3 807 236 902**

Table 12. Economic value of decrease in climate change (Own Calculation)

4.3.9 Benefits to the Environment – CO_2 and other gas emissions

In the context of cost-benefit analysis, one of the key advantages is the reduction of environmental externalities, particularly those related to CO_2 and other gas emissions. Transportation is a major contributor to air pollution and climate change, with road vehicles emitting significant amounts of greenhouse gases and pollutants per kilometre travelled. By shifting passenger travel from cars to trains, which have lower or zero direct emissions per kilometre, substantial reductions in environmental costs can be achieved.

Since electric trains do not produce any harmful materials, the calculation for the estimated impact of the train pollution is equal to zero. The emission cost calculated for car transport will represent the cost saving due to the modal shift. Other than these assumptions, the approach for estimating the reduction in gas emission costs follows the same methodology as the climate change cost analysis. The per-vehicle kilometre (vkm) cost of emissions is €0.0602 for cars, while rail transport is assumed to have zero direct emissions per vkm. With the railway upgrade, annual car trips decreased from 438 625 to 314 265, while train trips underwent a similar scale increase, leading to a reduction in total car-kilometres driven from 37 207.50 km to 26 658.35 km. Applying the gas emission cost per vehicle km to these values, the monetised cost for cars decreases from 732 988 EUR to 525 169 EUR, yielding savings of 207 818 EUR. Since train travel does not contribute to gas emissions in this model, there are no additional costs from increased rail usage, meaning the entire amount represents the net savings. After conversion from euros to forints, using a discounting method, this annual reduction is translated into a total discounted benefit of 1 277.87 million HUF, demonstrating that shifting from cars to trains eliminates direct gas emissions, providing environmental advantages.

All values in mHUF

	Cost [EUR/vkm]	**Current number of vehicles**	**Expected number of vehicles**	**Current total km driven**	**Expected total km driven**	**Current Monetized Cost**	**Expected Monetized Cost**
Car	0.02	302 500	216 735	37 207 500	26 658 347	732 988	525 169
Train	0.00	4 796	6 156	589 920	567 882	-	-

Yearly Impact	83 127 326
Discounted	**1 277 870 752**

Table 13. Benefits to the Environment – CO_2 and other gas emissions (Own Calculation)

5. Financing structure and sensitivity analysis

So far, the thesis has elaborated on the potential net present value of the investment from a simplified aspect, where the sole financing body of the infrastructure upgrade is the Hungarian State itself. However, as it has been discussed in the theoretical chapter, this is almost never the case as capital is a scarce resource, countries usually do not have the opportunity to fully invest in projects with such characteristics.

Consequently, as it has been highlighted in the introduction of the thesis, the thesis has decided to look for alternative financing sources, exploiting the underlying potential of the socioeconomic and sustainability-related advantages of the project. The thesis has established three main sources of financing, apart from capital allocated from the state budget. First, as a member of the European Union, Hungary is eligible for funds provided by the EU for transportation upgrades and developments that are in line with the sustainability and ESG-related targets of the Union. Secondly, the issuance of green bonds was used, and thirdly, the decision was made that a significant amount of the investment will be covered from a green loan received from the EIB.

5.1 European Grant Projections

First of all, the estimated volume of the EU grant was estimated using the method based on the calculation of the discounted net revenue. The core idea of the method is that a pro-rata rate is applied to the eligible cost of funding. As it has been highlighted in the methodology description, to estimate the total cost eligible for EU subsidy, the thesis, apart from the CAPEX expenditures, also had to estimate and add the types of socioeconomic benefits that the European Union acknowledges as economic value added for the society. Notably, the European Union does not approve economic benefits such as an increase in tourism when the calculation of the funding scheme is built up. Only those expenses can be taken into account that are directly linked to the EU agenda, having effects measurable on an EU scale, such as harnessing cohesion between member states or environmental aspects that influence the whole continent. Thus, the thesis did not take the tourism aspect into consideration.

Using the methodology described in the cost-benefit analysis guide of the European Commission, the total investment cost was taken as the base amount, which was increased by the four undiscounted economic value-adding effects accountable for the calculation. The sum of the investment expenses and the four economic factors can be seen on Table 14., which end with an eligibility rate of 528 466 mHUF value for the project.

Financial net present value (FNPV)		
Eligible Cost Calculation Table		**NPV**
Investment Expenses	mHUF	361 816
B1. Travel time savings	mHUF	155 129
B2. Travel safety improvement	mHUF	1 598
B3. Climate change reduction	mHUF	7 430
B4. CO_2 emission decrease	mHUF	2 494
FNPV	**mHUF**	**528 466**

Table 14. Calculation of the size of the EU grant received for the realisation of the investment (own calculation)

The pro-rata rate resulted in a 67%, which is then multiplied by the eligible cost amount, as well as the co-financing rate of 85% applied by the standards of the European Union. The formula gives 298.722 billion HUF that the Hungarian state would be eligible to call. Importantly, as a base scenario, it is assumed that the rest is to be completely covered by the Hungarian state as a form of EIB, which the thesis will shortly elaborate on after the assessment of the EU grant financing. The detailed steps of calculations can be seen in the table below, where the discounted investment costs as well as net revenues are summarised.

Note should be taken of the fact that the project is not expected to bring any increased level of operational expenses inasmuch as both energy and maintenance-related expenses are expected to decrease following the implementation of the project. Since it is assumed that all other operational expenses such as noise walls, track maintenance or personal expenses that are not expected to change or not related to the project are not included in the cost-benefit analysis, the total operational expense line is added to the net revenue as a “negative expense”, as a generated cash flow item. Additionally, since the service time of the locomotives is longer than the project’s lifetime, the residual value calculated in the financial analysis is added to the discounted net revenues.

All values in mHUF

EU Grant Calculation Table		2025 *1*	2026 *2*	2027 *3*	2028 *4*	2029 *5*	2030 *6*	2031-2055 *7 - 30*
		Installation						**Operation**
Discounted Investment cost	332 486	108 268	1 269	49 897	95 957	46 979	30 115	-
Investment cost cash flow	**332 486**	**108 268**	**1 269**	**49 897**	**95 957**	**46 979**	**30 115**	**-**
Revenue	61 089	-	-	-	760	1 604	2 542	56 183
Op. Expenses*	11 601	-	-	-	233	395	545	10 428
Residual value of investments	38 688	-	-	-	-	-	-	-
DNR / Net revenue cash-flow	**111 378**	**-**	**-**	**-**	**993**	**1 999**	**3 087**	**66 611**
Eligible Cost (EC)	**528 466**							
Pro-rata DNR	67%							
Co-financing (CF)	85%							
EU GRANT	**302 827**							

Table 15. Calculation of the size of the EU grant received for the realisation of the investment (own calculation)

It is hardly surprising that the role of the grant given by the Union strongly affects the financial net present value and the rate of return ratio of the project. Based on the calculation carried out, it can be stated that without the EU grant, the net present value is -221.107 billion HUF, and the financial rate of return is -5.97%, indicating that the project is unviable without support from a strictly financial perspective. However, when the EU grant is included, the state's contribution is significantly reduced to 33.764 billion HUF, and the project becomes financially attractive. As can be seen in the tables below, the FNPV turns positive 77.614 billion HUF, and the FRR improves to 4%, demonstrating the critical role of EU funding from the national financing perspective.

All values in mHUF

Financial Rate of Return w/o EU Grant		2025 *1*	2026 *2*	2027 *3*	2028 *4*	2029 *5*	2030 *6*	2031-2055 *7 - 30*
		Installation						**Operation**
Return on Investment	**NPV**							
Investment cost	332 486	108 268	1 269	49 897	95 957	46 979	30 115	-
Revenue	61 089	-	-	-	760	1 604	2 542	56 183
Op. Expenses*	11 601	-	-	-	233	395	545	10 428
Residual value of investments	38 688	-	-	-			-	-
FNPV - before EU grant	**221 107**	**108 268**	**1 269**	**49 897**	**94 964**	**44 980**	**27 028**	**66 611**

FRR - before EU grant	**-5,97%**

Financial Rate of Return with EU Grant		2025 *1*	2026 *2*	2027 *3*	2028 *4*	2029 *5*	2030 *6*	2031-2055 *7 - 30*
		Installation						Operation
Return on National Capital	**NPV**							
State Contribution	-33 764	-10 995	-129	-5 067	-9 744	-4 771	- 3 058	-
Revenue	61 089	-	-	-	760	1 604	2 542	56 183
Op. Expenses*	11 601	-	-	-	233	395	545	10 428
Residual value of investments	38 688	-	-	-	-	-	-	-
FNPV - after EU grant	**77 614**	**-10 995**	**-129**	**-5 067**	**-8 751**	**- 2 771**	**29**	**66 611**
FRR - After EU grant	**4,00%**							

Table 17. Financial rate of return comparison tables (own calculation)

Finally, the financial sustainability of the project was assessed by evaluating whether the project can generate enough revenue to cover its operating costs. The result obtained in the model is the net operating cash-flow, calculated annually by subtracting operating expenses from revenues, and analysing whether the implementation phase concludes, the project would be able to sustain its operations through internal revenue generation. As can be seen below, on condition that the project receives funding from the European Union, it will be able to show financial resilience. As shown in the table, the net operating cash flow amounts to 72.690 billion HUF, which confirms that, assuming the project receives financial support from the European Union, it will be able to demonstrate long-term financial resilience without requiring additional operational subsidies.

All values in mHUF

Financial Sustainability		2025 *1*	2026 *2*	2027 *3*	2028 *4*	2029 *5*	2030 *6*	2031-2055 *7 - 30*
	NPV	Installation						Operation
EU grant	298 722	97 273	1 140	44 830	86 212	42 208	27 057	-
National grant	33 764	10 995	129	5 067	9 744	4 771	3 058	-
Revenue	61 089	-	-	-	760	1 604	2 542	56 183
Total cash inflows	**393 575**	**108 268**	**1 269**	**49 897**	**96 717**	**48 583**	**32 657**	**56 183**
Investment cost	- 332 486	-108 268	- 1 269	- 49 897	- 95 957	-46 979	- 30 115	-
Op. Expenses	11 601	-	-	-	233	395	545	10 428
Total cash outflow	**-320 885**	**-108 268**	**- 1 269**	**- 49 897**	**- 95 724**	**- 46 584**	**- 29 570**	**10 428**
Net operating cash flow	**72 690**	**-**	**-**	**-**	**993**	**1 999**	**3 087**	**66 611**

Table 18. Financial sustainability of the investment (own calculation)

As the final step of the calculation of the analysis, the total net benefit on the project was estimated both with and without the support of an EU subsidy. In the base scenario without the EU grant funding, the project's financial net present value was significantly negative, amounting to -221.107 billion HUF, indicating a large funding gap from a purely financial perspective. While the project generated moderate revenues, the overall economic net present value of the investment remained negative at -38.595 billion HUF. This result shows that despite the large economic benefits, such as travel time savings, tourism contributions in Zamárdi or environmental improvements, the project would not be considered economically viable under standard cost-benefit analysis without external support from the EU. In contrast, when incorporating an EU grant, the financial landscape of the project improves dramatically. The investment cost of the government decreases from 332.486 billion HUF to 33.764 billion HUF, resulting in a positive net present value of 77.614 billion HUF. This shift translated directly into a strong net benefit of 260.127 billion HUF. The comparison underscores the important role of EU financing in ensuring the financial sustainability and economic justification of infrastructure projects, transforming an otherwise non-viable project into one that delivers positive net social and economic value.

Economic Rate of Return w/o EU Grant

Calculation of the Net benefit		**NPV**
Investment cost	mHUF	-332 486
Revenue	mHUF	61 089
Op. Expenses*	mHUF	11 601
Residual value of investments	mHUF	38 688
FNPV - before EU grant	**mHUF**	**- 221 107**
B1.Travel time savings	mHUF	79 490
B2.Travel safety improvement	mHUF	819
B3.Climate change reduction	mHUF	3 807
B4.CO_2 emission decrease	mHUF	1 278
B5.Tourism contribution	mHUF	97 119
Total Economic Value	**HUF**	**182 513**
ENPV / Net benefits	**HUF**	**- 38 595**

Economic Rate of Return with EU Grant

Calculation of the Net benefit		**NPV**
Investment cost	mHUF	- 33 764
Revenue	mHUF	61 089
Op. Expenses*	mHUF	11 601
Residual value of investments	mHUF	38 688
FNPV - after EU grant	**mHUF**	**77 614**
B1.Travel time savings	mHUF	79 490
B2.Travel safety improvement	mHUF	819
B3.Climate change reduction	mHUF	3 807
B4.CO_2 emission decrease	mHUF	1 278
B5.Tourism contribution	mHUF	97 119
Total Economic Value	**mHUF**	**182 513**
ENPV / Net benefits	**HUF**	**260 127**

Table 19 Net benefit of the project (own calculation)

5.2. Green bonds and loans as sources of National financing

In this chapter of the thesis, the focus is directed towards the financing of the remaining amount of expenses that the EU-level grant cannot cover. In particular, after analysing recent trends in Europe, two main sources of funding have been examined, green bonds and green loans.

5.2.1. Market outlook of green bonds and loans

Regarding the green bond market, it is visible that there is a growing increase in the number of bonds issued. Based on the latest Eurostat comprehensive research (2023), it is visible that solely between 2019 and 2022, there has been a drastic increase in the stock of green bonds. Figure 2. gives a profound comparison of the two periods, showing the amounts relative to the national GDP in each case.

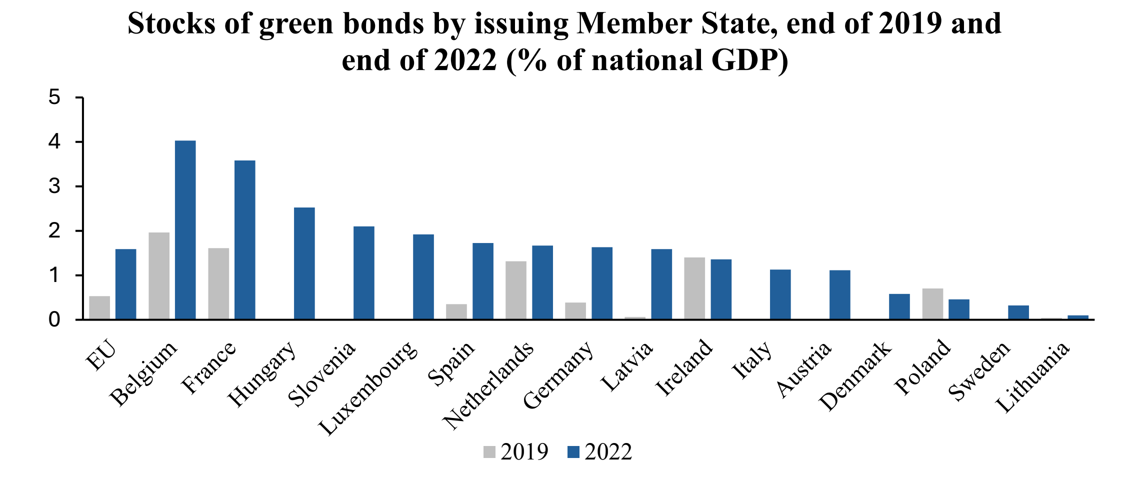

Figure 2. Stocks of green bonds by issuing Member State, Own Graph (Eurostat, 2023)

The figure shows a significant increase in the stocks of green bonds as a percentage of GDP across EU member states from 2019 to 2022, with the EU average increasing from 0.5% to 1.6%. Hungary demonstrated remarkable growth, moving from no bond investment at all in 2019 to 2.5% in 2022, while Belgium and France also saw their green bond stocks double, reaching 4.0% and 3.6%, respectively. These figures illustrate that the green bond market is expanding rapidly in some EU countries, but significant differences persist in the pace of adoption.

Similarly, taking a look at the volume of green bonds in contrast to the gross debt of the observed entities, it is visible that there was a significant increase in the share of green bonds as a percentage of gross debt across the EU, rising from 0.8% in 2019 to 2.2% in 2022. Hungary experienced a substantial shift, with its green bonds growing from 0.0% to 3.5% of gross debt, highlighting its rapid adoption of green financing within a short period. This places Hungary among the leading EU countries in green bond adoption relative to debt, just behind Luxembourg (7.8%) and Latvia (3.9%).

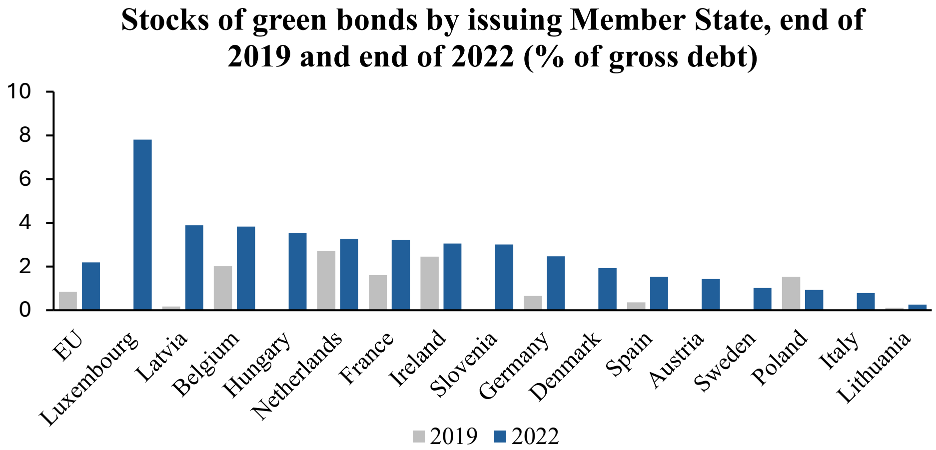

Figure 3. Stocks of green bonds by issuing Member State, Own Graph (Eurostat, 2023)

Turning towards the Hungarian Green bond market, green bonds have been receiving more and more attention in recent years. Using the reports published by the Hungarian National Bank (2024), it is visible that Hungary has demonstrated a growing commitment to sustainable financing. The country initially introduced its Green Bond Framework in May 2020, which was updated in July 2023 to align with the International Capital Market Association (ICMA) Green Bond Principles of 2021 and incorporates relevant EU regulations such as the EU Taxonomy Regulation and the EU Climate Delegated Act (MNB 2021).

In recent years, Hungary's green bond issuance has largely focused on financing clean transportation, particularly railway infrastructure. Between January 2022 and May 2023, approximately 89% of the green bond proceeds, amounting to HUF 791 billion, were allocated to Clean Transportation projects (MNB 2021). This funding primarily supported rail transport, covering operating expenses, personnel costs, and investments in modernization and electrification. Additional funds were used to develop urban public transport, environmentally friendly vehicles, and projects in other green sectors such as Energy Efficiency and Renewable Energy. Thus, it is visible that the Hungarian government's strategic use of green bonds, especially in railway infrastructure development, highlights the country's dedication to sustainable development and climate goals, highlighting its effectiveness in directing investments towards sustainable, eco-friendly projects.

Similarly, as it has been highlighted in Chapter 2, in the theoretical discussion, there is a growing volume of green loans as well in the area of infrastructure investments. Interestingly, apart from the grant schemes of the European Union, financial institutions such as the EIB provide favourable loans for large-scale government investments. In 2023, based on an agreement between the country and the institution, the EIB secured €288 million for climate investments (EIB, 2023).

Using loans to finance the discussed upgrades, apart from ensuring sustainable development, would also allow governments to manage their liquidity effectively. Rather than relying solely on limited annual budget resources, which for several years now have little space for extra spending, the government could initiate large-scale projects. Using debt instruments would enable the spreading of costs over time, ensuring that immediate funding needs for infrastructure improvements are met while maintaining financial stability. As it has been shown in the financial analysis, the project would generate a significant anticipated revenue increase due to ticket sales increases. This approach also allows governments to channel the received revenues to the repayment of the interests it is required to pay.

Furthermore, governments benefit from access to loans at favourable terms, often secured from international financial institutions, just like the European Investment Bank, which provides long-term financing at concessional rates for sustainable projects. These loans typically offer lower interest rates and extended maturities, reducing the annual repayment burden. Financing infrastructure upgrades through borrowing also aligns with the principle of intergenerational equity. Apart from this, since the benefits of infrastructure projects, such as improved transportation networks or enhanced energy systems, often last for decades, it is logical to ensure that the cost is shared by the generations that will benefit. This approach avoids placing the entire financial burden on current taxpayers and disperses the burden over the forthcoming generations.

In light of the above detailed trends, the thesis has decided to partly finance the remaining amount that the EU grant does not cover from a mixture of debt instruments, green bonds issued by the Hungarian government, and a green loan to be received from the EIB.

5.2.2. Analysis of the effects of green debt instruments

In this chapter of the thesis, the detailed analysis of the financing structure is reviewed, showing how the financial as well as economic net present values would change if the national sources were not sourced only from external debtors.

To understand the appropriate effects of financing through green bonds, the first and most important challenge was to establish what the expected and realistic interest rate is that the state could use for borrowing. Since the length of the project investment period is estimated for 6 years in the CBA analysis, the thesis argues that it is a sound estimation to use a 10 y green bond to not only cover the construction period itself but also to include a 4 year grace period for potential lags in procurement, construction and to ensure that there is sufficient disposable financial resource for post-construction works as well if necessary, as a buffer. Additionally, during the construction phase, only interest payments will be made, reducing the financial burden on the project until it is operational and generating revenue from which the government can allocate funds for the repayment of the bonds.

As the next step of the calculation, the coupon rate for the green bond was determined. Thankfully, the Hungarian government has recently issued a green bond, in the first month of 2025, with a 15-year maturity with expiry in 2040, which can be taken as a basis for estimation. In January, the risk from government bonds issued by the Hungarian State was around 7.05% for a 15-year bond, whereas the green bond issued at the same time was published with 4.88% (ÁKK, 2025). Interestingly, the amount of 'greenium', the yield discount associated with green bonds, was 2%. Building on this assumption, as the current 10-year government bonds offer a coupon of 6.87% (ÁKK, 2025), it can be estimated that the coupon the green bond issued for the financing of the project would be around 4.7%.

However, regarding the interest rate for the EIB loan, unfortunately, no information was available that could be used as a basis of estimation, since the financial institution does not disclose any details of loan agreements. Thus, in the case of the receivable loan, an estimation was carried out, based on the investment philosophy and characteristics of the two parties, of what would be a realistic rate. The EIB's funding model is characterised by low-cost borrowing, where the institution secures funds at favourable rates in international capital markets. These low borrowing costs are then directly transferred to borrowers, allowing for low-priced loans. Significantly, for green projects, this effect is further strengthened by the EIB's commitment to supporting sustainable development, often resulting in reduced interest rates. Analysis of EIB (2024) indicates that interest rate reductions for qualifying green projects are typically 0.5%. Additionally, it is also known that the country's adjusted default spread is around 1.89% according to the database published by Aswath Damodaran (2025). Thus, although the EIB rates are negotiated on a case-by-case basis, it is reasonable to assume that the interest rate applicable would be around 3% in the case of the project.

At this point, the thesis has arrived at one of the most important segments of the analysis. As it has already been introduced in Chapter 3 of the methodology of the thesis, throughout the CBA, there was a concern about whether it is adequate to use the 4% discount rate for discounting all the benefits and costs of the project. The relevant chapters of the EU guidance clearly state that it is an acceptable methodology to apply simply the offered rates of the Union. Yet, looking at the above detailed financing sources and the interests the Hungarian State shall pay for financing, it is clear that the 4% would not necessarily be realistic. Obviously, as the Union consists of more than two dozen member states with different costs of capital, risk profiles and economic conditions, applying one single rate for the whole area can lead to false results.

Thus, the thesis decided to review and recalculate the key elements of the model according to a realistic cost of capital that resembles the financing structure of the project. First and foremost, the sources covered from the national sources are using a rate equal to the risk-free government bond 10y of 6.87% (ÁKK, 2025), which reflects the opportunity cost of public funds. From the government's perspective, every unit of capital invested in a project has an implicit cost, the gone earnings that could have been generated if the same funds were invested in government bonds.

This approach aligns with the concept that the government, as a rational economic agent, would expect at least the return it could achieve in a risk-free investment, ensuring that the project's benefits are properly weighed against the most secure alternative use of public funds. Regarding the two debt instruments, in both cases, the paid interests serve as the basis for estimation. In the case of the sources covered from the green bonds, a 4.7% has been applied, and in the case of the sources covered from the EIB green loan, a 3% has been applied.

As for the weights of the instruments, based on international practice, the decision was made that 20% of the investment will be covered from national resources. Due to the small interest rate payable, a further 50% is covered from the EIB green loan, and the remaining 30% is to be covered from the green bond issued by the government. The received cost of capital is 4.28%. It is important to mention that the project is expected to receive significant EU grants, but that amount is not taken into account when calculating the cost of capital. The reason for this is that the CBA is prepared independently of the EU grant, focusing solely on the financial costs directly borne by the national sources and external loans. This ensures that the project's financial viability is assessed based on the actual costs of the capital utilized rather than relying on external subsidies that merely decrease the volume of the investment cost, leading to a more accurate and realistic analysis.

Using the cost of capital, the financial sustainability of the project was re-assessed by evaluating whether the project can generate enough revenue to cover its operating costs. Like in the previous case when solely the effects of the EU grant was taken into consideration, the result obtained in the model is the net operating cash-flow, calculated annually by subtracting operating expenses from revenues, and analysing whether the implementation phase concludes, the project would be able to sustain its operations through internal revenue generation.

Notably, the recalculation involves two effects visible in the new model. First, as the discount rate of the project changed, all elements of the NPV calculations had to be revised, including the investment costs as well as residual value, revenue, and effects of changes in operating expenditures. Parallelly, the interest payment effects of the two debt instruments were also incorporated into the model. In terms of the green bonds, the model includes the coupon payments as well as the final repayment of the face value.

In case of EIB loans, although interest payments are made on a yearly basis, the repayment of the loan only starts after the six-year grace period, equal to the investment phase of the project, carried out in equal instalments. As can be seen below, on condition that the project is able to channel all required funding sources, it will be able to show financial resilience. As shown in the table, the net operating cash flow amounts to 46.7 billion HUF, which confirms that it will be able to demonstrate long-term financial resilience without requiring additional operational subsidies.

Financial Sustainability		**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031-2055**
		1	*2*	*3*	*4*	*5*	*6*	*7 - 30*
		Installation						**Operation**
	NPV							
EU grant	298 722	97 273	1 137	44 586	85 510	41 751	26 690	-
National grant	6 221	2 199	26	1 008	1 933	944	603	-
Bond funding	10 466	5 497	64	2 520	4 833	2 360	1 508	-
Loan Funding	15 103	3 298	39	1 512	2 900	1 416	905	-
Revenue	58 556	-	-	-	581	1 416	2 339	54 221
Total cash inflows	**389 560**	**108 268**	**1 266**	**49 626**	**95 756**	**47 885**	**32 046**	**54 221**
Investment cost	- 330 511	-108 268	-1 266	-49 626	- 95 175	-46 470	-29 707	-
Op. Expenses	11 221	-	-	-	231	391	538	10 061
Total Interest paid	-7 964	-	- 942	- 903	-866	- 831	-797	- 3 624
Repayment	-15 530	-	-	-	-	-	-	- 15 530
Total cash outflows	**-342 785**	**- 108 268**	**- 3 150**	**-51 433**	**- 96 677**	**- 47 740**	**-30 763**	**- 12 718**
Net Operating CF	**46 775**	**-**	**- 1 884**	**- 1 807**	**-921**	**145**	**1 283**	**49 959**

Table 20. Financial Sustainability using green debt instruments (Own Calculation)

All things taken into consideration, it is visible that the project has strong viability and substantial benefits. The initial investment due to the EU grant is reduced to -31.790 billion HUF, which results in a Financial Net Present Value of 50.14 billion HUF Economically, the project results in a Total Economic Value of 182.51 billion HUF. The Economic Net Present Value of 233.65 billion HUF underscores the project's overall positive impact. In summary, the project is expected to yield considerable financial returns and socio-economic benefits, contributing positively to societal welfare and environmental sustainability. If we compare the results with the solution without using green debt sources, only the EU grant, it seems that they decrease the overall net benefit of the project, due to the increased discount rate and the increased cost of borrowing. However, using such sources would have several positive effects, such as decreased pressure on the state budget, increased transparency and alignment with sustainability goals, and promoting long-term financial stability.

ENPV w/o green debt instruments		
Calculation of the Net benefit		**NPV**
Investment cost	mHUF	-33 764
Revenue	mHUF	61 089
Op. Expenses*	mHUF	11 601
Residual value of investments	mHUF	38 688
-	-	-
FNPV - before EU grant	**mHUF**	**77 614**
B1. Travel time savings	mHUF	79 490
B2. Travel safety improvement	mHUF	819
B3. Climate change reduction	mHUF	3 807
B4. CO_2 emission decrease	mHUF	1 278
B5. Tourism contribution	mHUF	97 119
Total Economic Value	**mHUF**	**182 513**
ENPV / Net benefits	**mHUF**	**260 127**

ENPV with green debt instruments		
Calculation of the Net benefit		**NPV**
Investment cost	mHUF	-31 790
Revenue	mHUF	58 556
Op. Expenses*	mHUF	11 221
Residual value of investments	mHUF	35 649
Total cost of borrowing	mHUF	-23 494
FNPV - after EU grant	**mHUF**	50 142
B1. Travel time savings	mHUF	79 490
B2. Travel safety improvement	mHUF	819
B3. Climate change reduction	mHUF	3 807
B4. CO_2 emission decrease	mHUF	1 278
B5.Tourism contribution	mHUF	97 119
Total Economic Value	**mHUF**	182 513
ENPV / Net benefits	**mHUF**	**232 655**

Table 21. Financial Sustainability using green debt instruments (Own Calculation)

5.3 Sensitivity analysis

In this chapter, the thesis has arrived at the important theoretical question of how certain one can be, concerning the results of its own analysis. In light of the already raised concerns regarding the reliability of the core assumptions of the thesis, a sensitivity analysis was carried out to examine how strong an effect these assumptions have on the final results of the analysis. In light of this method, four key areas of variables have been isolated to carefully observe the individual effects of these key metrics.

During the research, the focus will be on the observation of the changes in the financial net present value as well as the economic net present value, which are the most important parameters to determine the overall value and performance. It should be noted that regardless of the fact that the applicable discount rate had been revised in the previous chapter, due to the fact that the advised rate of the European Union is fixed 4%, in this chapter, the thesis conducts the calculations using this rate. The reason for this decision is that, usually, cost-benefit analyses are conducted to secure financing for projects with questionable financial returns.

Since the European Union grant scheme plays a pivotal role in the financing of the project, the thesis decides to keep the discount rate as it is. Fortunately, during the recalculation of the discount rate, the received 4.28% cost of capital was higher than the Union's rate, making the corrected version a conservative estimation.

5.3.1 Capital expenditures of the investment

As the largest item of the financial analysis, it the investment expense required for the realisation of the project, it is essential to examine how the changes in the price of procured locomotives as well as of the ERMTS-2 system affect the overall viability of the project. For the base case, when the expenditure does not change, the cost amounts to approximately 332.486 billion HUF, and the financial and economic present values are 221.1 and 38.6 billion HUF, respectively. However, if we take a 20% increase in the expenditure, the FNPV significantly increases to 287.6 billion. Consequently, the ENPV also turns negative and remains at approximately -105.1 billion. Interestingly, a decrease of 20% in CAPEX improves the financial net present value to 154.61, and the economic net present value to 27.9 billion, which would turn the project viable if the economic benefits are also incorporated. Nevertheless, a 10% decrease compared to the initial amount would still yield a negative NPV from both aspects, suggesting that it is extremely sensitive to fluctuations in costs. These results highlight the importance of an adequate procurement strategy, as any unplanned rise in the need for investment would result in negative financial outcomes and diminished economic benefits, summarised below.

All values in mHUF

% Change in CapEx	CAPEX value	FNPV	ENPV
-20%	265 989	- 154 610	27 903
-10%	299 237	- 187 859	- 5 346
-5%	315 861	- 204 483	- 21 970
0%	**332 486**	**- 221 107**	**- 38 595**
5%	349 110	- 237 732	- 55 219
10%	365 734	- 254 356	- 71 843
20%	398 983	- 287 605	- 105 092

Table 22 Sensitivity analysis of capital expenditures (own calculation)

However, apart from the general price increases in the capex expenditures, another important factor must be considered, which has not yet been assessed in the analysis. As it was introduced in the methodology chapter of the thesis, due to the lack of information regarding the state of the line 30 connecting Székesfehérvár and Zamárdi, the thesis assumed that apart from the ERTMS level 2 system, the line is suitable for a speed that would ensure the one-hour travel time between the two destinations.

On the other hand, the obvious question may arise in the reader: what if the line is unable to fulfil the core criteria necessary for the project's success? To address this issue, the thesis has created an alternative capital expenditure analysis, observing the special scenario that if the original hypothesis raised in the methodology does not correspond to reality. As discussed previously, two important areas of potential extra investments have been identified. First, the potential necessary upgrade of the electrification system to conform to the ECTS – 2 system, and secondly, the track upgrade of the 57 km long line connecting the two towns. Since the analysis of this potential extra investment does not change a large variety of inputs of the model, the decision was made not to handle it as an independent scenario. Instead, this change of input is observed in light of whether it falls within the range of the original +/- 20% or has a larger significance on the overall output.

All values in mHUF

Discounted expenses	2025	2026	2027	2028	2029	2030
Stadler FLIRT Train PAX						
Carriers	107 938	-	49 897	95 957	46 133	29 572
ERTMS - 2	330	1 269	-	-	846	542
Track & electrification upgrade	23 560	22 654	-	-	-	-
Total	**131 828**	**23 923**	**49 897**	**95 957**	**46 979**	**30 115**
Total Capital Expenditure	**378 700**					

Economic Rate of Return w/o EU Grant		
Calculation of Net benefit		**NPV**
Investment cost	mHUF	- 378 700
Revenue	mHUF	61 089
Op. Expenses*	mHUF	11 601
Residual value of investments	mHUF	38 688
FNPV - before EU grant	**mHUF**	**- 267 321**
B1. Travel time savings	mHUF	79 490
B2. Travel safety improvement	mHUF	819
B3. Climate change reduction	mHUF	3 807
B4.CO2 emission decrease	mHUF	1 278
B5. Tourism contribution	mHUF	97 119
Total Economic Value	**mHUF**	**182 513**
ENPV / Net benefits	**mHUF**	**- 84 808**

Economic Rate of Return with EU Grant		
Calculation of Net benefit		**NPV**
Investment cost	mHUF	- 51 485
Revenue	mHUF	61 089
Op. Expenses*	mHUF	11 601
Residual value of investments	mHUF	38 688
FNPV - after EU grant	**HUF**	**59 893**
B1. Travel time savings	mHUF	79 490
B2. Travel safety improvement	mHUF	819
B3. Climate change reduction	mHUF	3 807
B4.CO2 emission decrease	mHUF	1 278
B5. Tourism contribution	mHUF	97 119
Total Economic Value	**mHUF**	**182 513**
ENPV / Net benefits	**mHUF**	**242 406**

Table 23. Modified capex expenses, and the total economic net present value of the project (own table)

Regarding the first step of calculation, the electrification examples, the thesis applied the price of 400 000 EUR price per km for the reconstruction of the electrification system. This value was retrieved from the Ernst & Young benchmark analysis being used for a similar investment in the Baltic region (EY, 2017). Assuming that the length of railway to be updated is around 57 km, the total expense is 9.12 billion HUF.

Secondly, the case of the track update was considered. Luckily, the Hungarian state has done an almost identical track upgrade project in 2024 on the Miskolc - Mezőnyárád section (Magyar Építők, 2024). The upgrade included earthworks, bedding, track regulation and ballast replacement on the track that, overall, amounted to 18 billion HUF for 27 km of rail track. Using the derived 666.66 million HUF price per km, the track upgrade for the project would require approximately 38 billion HUF. Assuming a roughly 2-year upgrade for the project, the recalculated capex plan and the effect of the economic net present value can be seen below.

5.3.2 Financial and Socioeconomic Effects

The avoided cost of climate change is the second element considered in the analysis. This parameter, as discussed in the previous section of the analysis, is equal to the environmental benefits achieved by increased transportation through environmentally friendly means like rail. The avoided climate cost in the base case equals 3.8 billion HUF, while ENPV amounts to 38.6 billion.

The 20% deviation of this parameter both upwards and downwards results in negligible fluctuations in economic net present value, with results remaining close to the baseline. Therefore, it can be concluded that, although there are environmental benefits from the decrease in climate effect, and they should be included in the calculation, they are not the main contributor to the project's financial success. They play an important part in social and environmental sustainability, but have very little influence on the investment decision based purely on economic considerations. The reason behind this is that weight of climate change effects of shifting from other modes of transport to train proportionately grows with the distance covered by the railway line. Since the environment-related expenses are measured in Ft/km based on the standards of the European Union, the relative shortness of the railway line results in low added value to the investment. The summarized results can be seen below.

All values in mHUF

% Change	Climate change	FNPV	ENPV
-20%	2 665	- 221 107	- 39 737
-10%	3 046	- 221 107	- 39 356
-5%	3 427	- 221 107	- 38 975
0%	3 807	- 221 107	- 38 595
5%	4 188	- 221 107	- 38 214
10%	4 569	- 221 107	- 37 833
20%	4 949	- 221 107	- 37 452

Table 24. Sensitivity analysis of Climate change costs (own calculation)

Similarly, CO_2 emissions were also modelled as a sensitivity category, arising from the reduction of air pollution and greenhouse gases from the anticipated decrease in the volume of car rides between the cities. For the base scenario, the benefit arising from the reduction is expected to amount to 1.3 billion HUF, and the ENPV is 38.56. Changing the CO_2 benefit by plus or minus 20% produces ENPV values of between about 38.98 and 38.21 billion. As in the case of climate change effects, there is little variation in the received results, entailing that although the benefits of the project are environmentally valuable, the savings in CO_2 emissions do not make a significant difference to the overall financial or economic performance.

All values in mHUF

% Change	CO_2 Emissions	FNPV	ENPV
-20%	895	- 221 107	- 38 978
-10%	1 022	- 221 107	- 38 850
-5%	1 150	- 221 107	- 38 722
0%	1 278	- 221 107	- 38 595
5%	1 406	- 221 107	- 38 467
10%	1 533	- 221 107	- 38 339
20%	1 661	- 221 107	- 38 211

Table 25 Sensitivity analysis of CO2 costs (own calculation)

As the next step of the analysis, the travel safety-related benefits of the investment were measured. Based on the European Union's reports, as the rail network overall is safer than travel by road, its benefits are quantifiable in terms of avoided accident costs. For the base case, the travel safety benefit is 819 million HUF, and the economic value is 38,595. A 20% change in this parameter in either direction results in an insignificant difference in ENPV. This means that, like climate and CO_2, safety is a supporting but not determining factor in the overall value of the project. It adds credibility and popular appeal to the project but does not change its financial or economic grade.

All values in mHUF

% Change	Travel Safety	FNPV	ENPV
-20%	573	- 221 107	- 38 840
-10%	655	- 221 107	- 38 758
-5%	737	- 221 107	- 38 676
0%	819	- 221 107	- 38 595
5%	900	- 221 107	- 38 513
10%	982	- 221 107	- 38 431
20%	1 064	- 221 107	- 38 349

Table 26 Sensitivity analysis of travel safety benefits (own calculation)

However, travel time savings are a more sensitive parameter in the analysis. This is perhaps the most important benefit assumed in the project, apart from the tourism-related benefits, as faster trains and improved connections will reduce the travel time of passengers. In the base case, the travel time saved is 79.5 billion HUF, where, not surprisingly, the economic net present value is much more sensitive to variation. A 20% increase in travel time savings raises the ENPV to around -14.7 billion HUF, while a 20% decrease reduces the ENPV to -62.5 billion. The results show that the project is less economically viable when the passengers save less time with travel than is assumed.

All values in mHUF

% Change	Travel Time	FNPV	ENPV
-20%	55 643	- 221 107	- 62 442
-10%	63 592	- 221 107	- 54 493
-5%	71 541	- 221 107	- 46 544
0%	79 490	- 221 107	- 38 595
5%	87 439	- 221 107	- 30 646
10%	95 388	- 221 107	- 22 697
20%	103 337	- 221 107	- 14 747

Table 27. Sensitivity analysis of travel time savings (own calculation)

As the next step of the calculation, the changes derived from revenue changes were observed, resulting from the anticipated ticket sale changes. As the demand for the service changes and thus the ridership of the carriers varies, so do the financial and economic benefits derived from the investment. Although the impact of the changes in revenues is significant in both directions, even with the best possible estimation, both FNPV and ENPV remain negative, which means that the project will neither become profitable nor generate enough economic value under the assumptions. Needless to say, small fluctuations in ridership have a measurable effect on the outcomes, highlighting the importance of demand forecasting in such analyses.

All values in mHUF

% Change	Ticket sales	FNPV	ENPV
-20%	48 871	- 233 325	- 50 812
-10%	51 926	- 230 271	- 47 758
-5%	58 035	- 224 162	- 41 649
0%	61 089	- 221 107	- 38 595
5%	64 144	- 218 053	- 35 540
10%	70 253	- 211 944	- 29 431
20%	73 307	- 208 890	- 26 377

Table 28. Sensitivity analysis of ticket sale revenues (own calculation)

Demand for tourism is another important parameter that is tested in the sensitivity analysis. The assumption is that the rail improvement would increase tourist visits to the region, especially during summer and weekend periods. These increases are tested with three economic multipliers: 1.50, 2.00, and 2.50, generating additional value for the region of Zamárdi apart from the accommodation as well as the daily spending of tourists. If the multiplier is 1.50 and tourism demand drops by 20%, the ENPV remains negative at -77,4 billion, whereas if it rises, the observed value is -48.3 billion HUF.

The same methodology is applied in the case of the other multipliers, where it is important to highlight that at the 2.50 multiplier, in case of a 10% or higher increase, the value of the project turns positive with 3.9 billion HUF. These results suggest that the economic value of tourism is not only a function of the volume of tourists but also of the wider economic effects of the increased spending. When tourism has large multiplier effects, there can be a significant economic benefit, whereas in the case of a low rate applied, the overall impact is small.

All values in mHUF

% Change	Tourism	ENPV	Tourism	ENPV	Tourism	ENPV
multiplier	*1,5*	*1,5*	*2,0*	*2,0*	*2,5*	*2,5*
-20%	58 271	- 77 442	77 695	- 58 018	97 119	- 38 595
-10%	61 913	- 73 800	82 551	- 53 162	103 189	- 32 525
-5%	69 197	- 66 516	92 263	- 43 451	115 329	- 20 385
0%	72 839	- 62 874	97 119	- 38 595	121 398	- 14 315
5%	76 481	- 59 232	101 975	- 33 739	127 468	- 8 245
10%	83 765	- 51 948	111 687	- 24 027	139 608	3 895
20%	87 407	- 48 306	116 543	- 19 171	145 678	9 965

Table 29. Sensitivity analysis of tourism benefits (own calculation)

All things taken into consideration, the sensitivity analysis shows that capital expenditures and travel time variables are the most important variables in this project. Environmental parameters like CO_2 emissions and climate impact are much less sensitive but still highlight the positive effects of the project. On the other hand, tourism effects have a moderate sensitivity, subject to high reliance on the multiplier applied in the analysis.

5.3.3 EU subsidy volume analysis

Due to the recent risks regarding access to European financing sources, a sensitivity analysis of the EU co-financing on the investment's financial performance was carried out. The purpose of the analysis is to see how different amounts of funding support from the European Union influence the Net Present Value of the investment from the perspective of the state. It assumes the same eligible investment expense. Thus, the DNR of 67% is applied throughout the calculation. The EU co-financing ratio, as the changing variable, is modified from 85%, the most favourable funding regime, to 0%, where the state entirely finances the investment without any support from the EU.

All values in mHUF

Sensitivity Analysis							
	Base Case						
Eligible Cost (EC)	528 466	528 466	528 466	528 466	528 466	528 466	528 466
Pro-rata application of DNR	67%	67%	67%	67%	67%	67%	67%
Co-Financing rate	85%	75%	65%	55%	35%	15%	0%
EU Grant	**298 722**	**267 201**	**231 574**	**195 947**	**124 694**	**53 440**	**-**
Investment cost	- 330 511	-330 511	-330 511	- 330 511	- 330 511	- 330 511	- 330 511
EU grant	298 722	267 201	231 574	195 947	124 694	53 440	-
Total state contribution	**-31 790**	**- 63 311**	**-98 938**	**- 134 564**	**- 205 818**	**- 277 071**	**- 330 511**
Cost of borrowing	- 23 494	3 298	39	1 512	2 900	1 416	905
Revenue	58 556	58 556	58 556	58 556	58 556	58 556	58 556
Op. Expenses	11 221	11 221	11 221	11 221	11 221	11 221	11 221
Residual value	35 649	35 649	35 649	35 649	35 649	35 649	35 649
FNPV - after EU grant	**50 142**	**56 408**	**6 655**	**- 22 587**	**- 87 828**	**-165 511**	**- 221 164**
Economic Value	182 513	182 513	182 513	182 513	182 513	182 513	182 513
ENPV / Net benefits	**232 655**	**238 921**	**189 168**	**159 926**	**94 685**	**17 002**	**-38 651**

Table 30. Sensitivity analysis of EU financing scheme (own calculation)

With a decreasing EU co-financing amount, the size of the EU grant allocated to the project decreases in a proportional way resulting in a growing financial burden on the national budget as the state is forced to finance the resulting funding gap. With the maximum co-financing ratio, the national contribution is minimal, and the overall financial outlook of the project is highly positive, giving a strong financial as well as economic net present value. But as steadily more EU financing is being withdrawn, the FNPV starts decreasing and finally goes into negative values. The results demonstrate that, in weaker co-financing conditions, the project can no longer generate sufficient financial income to justify the investment from a national point of view.

The model holds other financial variables constant, including revenue, operating costs, and the residual value. Therefore, the variations that are observed in FNPV between the scenarios are attributed solely to the variation of the financing structure. The result of the sensitivity analysis highlights the strategic importance of having high levels of EU funding for the investments. The analysis confirms that in the absence of considerable EU support, the national government must undergo extreme increases in contributions needed, which may undermine the financial feasibility of the investment highlighting the strong dependence of the project on third-party finance source of the European Union. With the EU co-financing, it demonstrates a favourable financing condition with strong financial sustainability which at the same time would mitigate fiscal pressure of the national government seen below.

6. Discussion

The purpose of this thesis was to assess the economic and financial viability of the development of railway infrastructure between Budapest and Zamárdi, with the intention of determining whether a public investment with a massive expense volume can be supported from a monetary perspective, also relying on social and environmental considerations. To answer the question, a cost-benefit analysis has been carried out, in line with the European Union's methodological approach of evaluating infrastructure projects. Thus, the study investigated direct financial effects as well as other socio-economic impacts that can be regarded as direct benefits of the investment, to give a realistic image of the actual value of the planned railway expansion.

As discussed in the analysis chapters, the thesis concluded that, strictly from a financial perspective, the project would not be profitable under the current assumptions proposed. Specifically, the net present value for the project based on a time horizon of 30 years turned out to be significantly negative and amounted to -221.1 billion HUF if the assumption is made that the state is the only financing body of the investment. This expense covers the necessary capital investment required to implement the upgrade, including the acquisition of an entirely new fleet of Stadler FLIRT electric trains and the installation of ERTMS Level 2 signalling infrastructure.

However, despite presumed improvements in operating efficiency, such as increased ticket revenues, energy savings from running more efficient trains, and reduced maintenance costs, these improvements were not sufficient to achieve a positive financial outcome highlighting the difficulty to ensure profitability of large public transport initiatives with significant upfront investments and limited revenue generation potential. As it was observed from similar projects all around the globe, many states therefore intend to introduce extra charges for a predefined time horizon to collect the initial investment faster. In case of the Hungarian railway system, however, the thesis assumes that it would not be realistic to pose such assumptions, as a key principle of the Hungarian state is not to differentiate between the line of service based on location or upgraded status.

In addition, when the project was socio-economically analysed, the results obtained from the analysis proved to be much more favourable. The CBA model included a wide range of public benefits like reduced travel time, enhanced regional accessibility, reduced emissions due to less use of automobiles, as well as enhanced mobility of labour. These externalities were observed to significantly contribute to the total economic benefit of the project. Greater mobility between Budapest and Zamárdi could indeed drive economic growth, especially in the tourism sector, owing to the characteristics of the town of Zamárdi, not just in the tourism sector, but in the establishment of new companies and residents for the area as well. The project is also strengthening broader green and strategic goals of the EU and the Hungarian state towards a more sustainable, lower-emission means of transportation. As a result, the thesis established that, taking all these indirect advantages into account, the railway development project is not only reasonable but also highly desirable from a long-run public interest point of view. Yet, with all the positive economic effects of projects, based on the negative ENPV of -38.5 billion HUF, the project would still not be realised, due to the incredibly high investment expenses.

Due to the fact that this is a regular problem in the case of infrastructure upgrades, the European Union decided to set up a funding scheme to contribute to the financial expenses of the states. Based on the information disclosed by the European Union, the thesis has calculated the approximate funding it would receive, which would highly alter the results of the project. With the EU grant received, the total FNPV would yield a positive 77.61 billion HUF due to the decreased capex investments and the anticipated revenue generated. After incorporating the total economic benefits, the project signals a 260 billion HUF positive benefit.

Only state budget sources		State budget & EU grant		State budget & EU grant & green loans, bonds	
National Resource	**332 486**	**National Resource**	**29 658**	**National Resource**	**6 221**
National budget	332 486	National budget	29 658	National budget	6 221
Eu grant	-	Eu grant	302 827	Eu grant	302 827
EIB loan	-	EIB loan	-	EIB loan	15 103
Green Bond	-	Green Bond	-	Green Bond	10 466
FNPV	**-221 107**	**FNPV**	**81 720**	**FNPV**	**50 142**
ENPV	**- 38 595**	**ENPV**	**264 233**	**ENPV**	**232 655**

Table 31. Summary table of potential financing structures (own calculation)

By conducting this analysis, the thesis supported the assumptions and statements of the academic literature introduced in the first chapter of the thesis by illustrating the importance of integrating financial and economic assessment methods in assessing infrastructure projects. The one-dimensional traditional investment analysis methods, focusing only on internal rates of return or financial payback periods, are not capable of assessing the true value of public goods. This thesis intends to demonstrate, by means of a cost-benefit analysis methodology, how a more sophisticated and multidisciplinary approach can reveal the broader contributions of the construction of infrastructure to the economy.

Based on Ramey's (2020) framework, which was introduced in the theoretical summary of the thesis, the Budapest–Zamárdi railway upgrade must be discussed through the three main aspects of success: public capital productivity, societal alignment, and financing structure. Starting with the productivity of public capital, the thesis presented a strong depiction of how the investment would harness economic development and public utility. The current infrastructure is still operating with an outdated signalling system and old models of locomotive carriers, which result in slow travel times ranging from 90 to 120 minutes. This issue creates economic fallout, eventually limiting integration and diminishing the attractiveness of rail travel, particularly during the summer tourism season, putting extra pressure on the roads and highways that suffer significant overpressure during these seasons. By investing in new Stadler FLIRT trains capable of running at 160 km/h speeds and by implementing ERTMS-2 signalling on the whole railway line, the project could effectively decrease travel time to approximately one hour. This would lead to an increase in passenger volume, a higher level of tourism, and enhanced productivity with lower per-capita operating costs for the whole period.

Regarding the second pillar of being aligned with societal needs, the thesis provides evidence that the project could indeed promote social equity and environmental protection. By improving accessibility between Zamárdi and Budapest, the investment would enable residents from smaller, peripheral communities to access jobs, education, and healthcare in the capital without the necessity to relocate, not to mention the already discussed environmental benefits as well as the positive effects on the tourism sector. Finally, regarding the financing structure, the thesis provides an overview of the sustainability and financial risk exposure of the investment. The thesis explored various ideas that combine national and EU funds, particularly through the Connecting Europe Facility and Cohesion Fund, which would enable the project to become a financially viable investment.

6.1 Limitations of the study

However, the research also must elaborate on a certain number of limits. One of the obvious limits revolves around data availability and quality. Since there is a serious shortage in the availability of comprehensive public transport statistics, including passenger volumes and seasonality, some of the most significant numbers were thus approximated using assumptions. While these were based on logical reasoning and more often than not supported by external evidence, the chance of a lack of precision added the element of uncertainty to the analysis. In addition, the model has also used static parameters for elasticity of demand, ticket price, and other such key variables, despite these being subject to change over the time of the project.

Future changes such as technological advancements, policy reforms, and changes in the preferences of users are all factors that could potentially affect the true impacts of the investment. To counterbalance the risk underlying these limitations, a sensitivity analysis was also carried out that helped to address the uncertainty related to the project. Apart from the obvious effects of changes in investment expenses, travel time savings as well as revenue generation ability were found to heavily influence the forecasted outcomes, and the inclusion of other economic benefits, due to the size of their contribution, had lesser significance on the final output, underlining the importance of proper procurement and planning of investment expenses. Not to mention, the question of the discount rates applied throughout the analysis.

As discussed in the theoretical literature, experts such as Broughel (2020) raised concerns about whether applying a single discount factor for the whole period would truly reflect reality. Since the number of financing entities of the project urged to use a 4% discount rate (presumably for simplicity purposes), the thesis applied this for discounting. Yet, as an important aspect of limitation, it must be highlighted that in the case of a real-life analysis, this method should be reviewed by state authorities and advisory entities when calculating the outputs of the investment.

Apart from this, some benefits in the form of increased property value, urban revival, or enhanced regional image were only assessed in a qualitative manner due to a lack of trustworthy data, which were eventually not included in the monetised final estimate due to limitations in methodology. These intangible benefits may also be part of the real contribution of the project, and the consequence of not including these factors may possibly lead to an underestimation of the final value.

Lastly, another crucial limitation of the thesis is the underlying core assumption itself that the railway upgrade line would only yield a touristic benefit to Zamárdi as if it were the only stop of the train until Lake Balaton. This assumption, although being hypothetically assumed for this thesis, is highly unlikely to happen in real life, as next to Zamárdi, Siófok, a much larger and more important city, can be found, thus not including these cities in the cost-benefit analysis would be a serious mistake. The anticipated financial expenses would not be significantly higher, yet the touristic value added would be highly beneficial for the project evaluation.

6.2 Future research potential

Considering these limitations, the thesis proposes several avenues for future research. One of them would be making the underlying assumptions more accurate by gathering detailed data, including real-time traffic monitoring, user feedback, as well as other internal statistical information about car and train ridership and touristic trends of the region. In real life, detailed collaboration with national transport authorities and MÁV would also ensure that the data required for analysis would be more accessible.

In addition, researchers in the future might build up an advanced modelling approach to estimate future trends of key input variables used in this thesis, which could also help to observe further interregional effects. The inclusion of more detailed as well as advanced environmental analysis, such as climate risk analysis, would also provide a more complete picture of the sustainability aspects of railway investment, rather than solely taking EU standards that may be easy to use but make the assumption of equal effects over the whole continent.

As discussed in the financing chapter of the thesis, it is visible that even with the EU grants, the state would have to make significant investments in the first years of the project, which could cause liquidity issues for the government. For this reason, the thesis assumed that the government would use additional funding sources of green bonds as well as EIB loans. However, it should be highlighted that green bonds are rarely issued in real life for financing only one project, but rather several projects in parallel. Thus, in a real-life investment situation, the government could use a larger bond volume to finance multiple goals and allocate a fraction of the amount received for the realisation of this particular project. This would also decrease the cost of borrowing that must be incorporated into the model of calculating the ENPV.

On the other hand, public-private partnerships could be another form of investment where public authority and private companies, based on contractual terms, share responsibility for financing, development, and operating infrastructure assets. Under PPP arrangements, the private sector is usually expected to contribute a certain level of capital investment, technical expertise, and operational efficiency. For the Budapest–Zamárdi railway modernisation, it could be an interesting area of research in the future, how the governmental burdens would alter if the development were realised in such a form. As can be seen from successful examples, a well-structured PPP would better distribute the investment over time, lowering the burden for the state and, through using private incentives, offering better operating standards as well.

7. Conclusion

This thesis tried to investigate the viability of a sustainability-driven public utility railway investment, carried out on the Budapest–Zamárdi railway line. In recent years, it has become widely accepted that electrified railway systems significantly contribute to principles of ESG, and core pillars of modern transportation, such as sustainability and efficiency. Often, such a project is relatively hard to realise due to high investment costs and low financial returns. Thus, in this thesis, an analysis was carried out, revolving around the question, What if other factors were incorporated into our models? What if, due to effects such as decreased travel time, decreased ecological footprint and increased travel safety, the real value generated by the investment would result in a positive rate of return?

Answering this question, the approach applied was using a cost-benefit analysis as a main method recommended in European Union practice. The project was composed of two principal components: the acquisition of new Stadler FLIRT trains and the implementation of the European Rail Traffic Management System (ERTMS) Level 2, both of which would significantly improve service efficiency, reduce travel time, and align the line with EU railway standards and sustainability goals.

The calculation of the financial part concluded that, when only the commercial strategy is taken into account, the project holds a negative financial net present value of approximately -221.1 billion HUF. Even with expected increases in ticket prices, reduced maintenance and energy costs, and enhanced operational efficiency, the benefits are not sufficient to offset the large capital investment requirement. However, when the socio-economic results are incorporated, the situation is more optimistic. Considering broader externalities such as savings on travel time, reduced road traffic, lower emissions, and better tourism opportunities, the project appears to generate substantial public value. Improved rail connection between Budapest and Zamárdi will help stimulate regional mobility, support local tourism, and connect the South-Eastern Balaton area more directly to the capital.

All these benefits, although not translated as revenue within a financial analysis, are real economic values to society and are worth public investment. Yet, since the economic net benefit of the investment was still negative, the thesis determined that for success of the investment, the state, building on the ideal that the project is in line with the ESG and sustainability principles, it should use green bonds, loan from the EIB for sustainability financing and EU grants. During the analysis, a sensitivity test was also conducted to test the robustness of the results against different assumptions. The test revealed that even though the financial outcome is unfavourable in most scenarios, the socio-economic justification for the investment continues to hold in a variety of conditions.

The research concedes some limitations. Several key variables, such as passenger volumes and local traffic patterns, were estimated on the basis of logical estimations rather than primary data, since they were not publicly available. The model also made the assumption of constant operating and pricing conditions over a 30-year horizon, which may not be valid in the presence of future technological, social, or economic changes. Lastly, some of the indirect effects, such as changes in real estate values or urban migration patterns, were not quantifiable but were treated qualitatively. Thus, while the analysis finds strong evidence of the socio-economic value of the project, it also highlights the need for further research to assess all fields of the investment.

All things taken into consideration, while the Budapest–Zamárdi railway development is financially unprofitable, it has considerable socio-economic potential underlying. Through reduction of travel time, improvement in service quality, and modal switch from road to rail, the investment is in line with both national and EU-level goals for sustainable transport, regional integration, and inclusive economic growth. Accordingly, the thesis recommends a hybrid financing deal with state-level as well as EU-level funding to realise the development of the railway line, being vital for long-term development and sustainability in Hungary.

The examined project clearly demonstrates the importance of evaluating ESG projects by considering all impacts through monetizing external effects, which is the key to the success of green finance. Only adopting a comprehensive approach that integrates social, environmental, and economic dimensions can ensure decision makers that sustainability-driven investments can generate long-term value, aligning financial objectives with societal benefits and environmental sustainability.

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