How is the green transition changing the criteria for evaluating investment in SMEs?

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Abstract
Driven by the climate crisis and the EU Green Deal, the global green transition is redefining investment appraisal criteria for SMEs, shifting the focus from traditional net present value to the integration of environmental, social, and governance factors. The aim of this study is to identify changes in the investment appraisal criteria for small and medium-sized enterprises resulting from the green transition. Using a modified Net Present Value analysis incorporating the Green Transformation Index (constructed using the Criteria Importance Through Intercriteria Correlation and Technique for Order Preference by Similarity to Ideal Solution methods). The study confirms the cost-effectiveness of investments in sustainability, especially over the longer time horizon, where the green transformation index often reinforces positive net present value results, signaling lower risk. The implication is that SMEs should proactively implement green solutions to build competitive advantage, reduce costs, and improve reputation for long-term sustainability and growth.

Introduction

Global awareness of the climate crisis and dwindling natural resources is accelerating the green transition. The European Union, through the Green Deal, aims to achieve climate neutrality by 2050 by reducing emissions and developing renewable energy sources (RES), which, according to Tang [2024], is both an ethical and economic imperative. Green finance plays a key role here, integrating ESG (environmental, social, and governance) factors into financial decisions to promote sustainability. Tools such as green bonds and loans support this process, while increased transparency of environmental information drives innovation and investment, with the aim of building a sustainable and inclusive economy.Natural resource consumption and the digital economy play an increasingly important role in supporting green industrial transformation. As Ran, Yang, Yan, Xu, and Cao [2023] point out, digital economy policies contribute significantly to this transformation through three main mechanisms: raising public environmental awareness, fostering green innovation, and developing the information industry. This effect, according to a study by Yang, Hunjry, Grebinevych, Roubaud and Zhao [2025], depends on several factors: it is stronger in non-resource-based cities, in cities with a recent industrial base, in large agglomerations compared to small and medium-sized cities, and in eastern regions.

Climate management activities are key to promoting energy transition. As Fan, Shira, Hunjra, and Zhao [2025] point out, the green transformation of energy-intensive enterprises significantly accelerates after the implementation of pilot programs to build climate-adaptive cities. Mechanism analysis shows that climate governance fosters this transformation by reducing financial constraints, mitigating supply chain risks and strengthening resilience. Moreover, these measures have a stronger impact on the green transformation of energy-intensive enterprises located in cities that do not use natural resources or in cities with a recent industrial base, where lower energy intensity is observed.

The green transformation is redefining the criteria for evaluating investments in the SME sector, going beyond traditional financial metrics; now the success of investments, as Purwanti [2023, pp. 797–810] highlights, is defined by ESG (environmental, social, and governance) factors that promote sustainability and minimise negative environmental impacts. Investors and financial institutions are increasingly driven by these criteria, and SMEs implementing green solutions gain access to preferential financing and a positive image, while increasing regulatory requirements (e.g. EU taxonomy, CSRD) and pressure from consumers and supply chains are forcing compliance with sustainability standards, making it increasingly costly to ignore these aspects.

The green transition is changing the criteria for evaluating investments in all sectors, and banks are adapting their services to meet new regulations and sustainability goals. In the real sector, as Li and Khan [2025] point out, regulation and growing opportunities for green finance are key to success, and companies are integrating green business strategies to improve financial performance and attract investment, with organizational efficiency playing a mediating role. A comprehensive framework is being used to evaluate green investments, taking into account both environmental impact and financial performance, using traditional tools such as NPV and IRR, which, as Mackevičius and Tomaševič [2010, p. 116–130] point out, allow the efficiency and attractiveness of an investment project to be objectively determined. These developments reflect a growing emphasis on sustainability and environmental responsibility, driven by regulation, market demands and the long-term benefits of a green transition.

The green economy is changing investment appraisal methods, forcing consideration of sustainability, which includes both current resource use and future profitability. This approach, as highlighted by Yu, He, Amanguli, Zhang, and Zhou [2024], is leading to innovations in evaluation systems, such as the use of cloud computing and information fusion to analyze green investment data, optimizing industrial structures. Additionally, the green economy requires the creation of comprehensive evaluation index systems, including indicators of low-carbon production, consumption, resources, environment, and development potential, and the entropy method is used to determine their weights, facilitating the calculation of a comprehensive index for green investment and the low-carbon economy. Moreover, as Ko, Liu, and Liu [2023] note, the green economy encourages the application of dynamic strategic models, such as the real options approach, to optimal pricing and investment strategies in green brands. Mahadi Hasan Miraz and Tiffany Sing Mei Soo [2024, pp. 1613-1628] emphasise that key to assessing the efficiency and impact of green investment ventures are technological advances, the country of investment and government policies that catalyse sustainability goals and contribute to the restructuring and recovery of the green economy.

The green transition is changing the criteria for assessing investment in SMEs, going beyond traditional profitability and including ESG factors. SMEs, despite their key role in achieving climate goals, face challenges such as limited resources and difficulties in accessing finance for green innovation. A redefinition of Net Present Value (NPV) is needed to take into account the tangible and intangible benefits of sustainability. Government support, such as subsidies or pollution charges, can significantly stimulate green investment. As Wang, Pengwu [2021] points out, the green economy, by promoting sustainability and focusing on green industries, influences the evaluation and targeting of investment risks, which is key to optimising industrial structures and achieving sustainable growth.

Green transformation is a strategic priority for SMEs that can improve their efficiency and investment attractiveness. However, these companies, especially in Eastern Europe, face significant financial barriers, such as insufficient internal financing, negative leverage, and gaps in resources and expertise. Public support through green financial incentives and better access to external finance is key. As highlighted by Li, X.; Khan, I.U. [2025], companies need to invest in green business strategies (GBS) to increase investor confidence and raise funds while maximizing their value. Imen Bouchmel, Zied Ftiti, Waël Louhich, and Abdelwahed Omri [2024] confirm that SMEs in Eastern Europe face financial constraints that make it difficult for them to reduce their environmental footprint.

The aim of the study is to identify changes in the criteria for assessing investment in SMEs resulting from the green transition and to analyze their impact on the availability and conditions of finance. The following research questions will be addressed: What are the differences in NPV results for projects with different time horizons (5 years and 10 years) using a nominal discount rate, and how do these differences change when a "green transformation index" is included in the discount rate? How does the use of a real rate of return that takes inflation into account affect the NPV calculation for investment projects of different durations (5-year and 10-year), and what changes in the results when a "green transformation index" is included in addition to the real rate of return? How does the "green transformation index," introduced into both the nominal and real discount rate, affect the overall attractiveness and profitability (measured by NPV) of long-term investment projects compared to short-term ones, given the initial outlay and the volatility of cash flows?

The article adds new value to the discussion on green transformation by focusing on the SME perspective. It highlights that traditional methods of evaluating investments, such as NPV, are inadequate because they do not take into account the non-financial benefits and costs associated with green and social activities. Investment in sustainability, while it may initially reduce NPV, brings significant reputational benefits to SMEs, reduced regulatory risk and access to green funds, which translates into their long-term value and resilience.

Literature review

Green transformation is not only a necessity but also a strategic opportunity for Small and Medium-sized Enterprises (SMEs). It requires investment in renewable energy sources, energy efficiency, and green materials, which is becoming a new key criterion for evaluating investment projects. SMEs also need to revise their business models, adopting the principles of the circular economy and optimizing supply chains to increase resilience to climate risks. Culturally, this transformation promotes responsible and ethical management, which has a positive impact on company reputation and access to capital. A holistic approach aims to integrate SME growth with planetary protection, transforming short-term profit into a long-term strategy of competitiveness, innovation and risk reduction. This requires a holistic assessment of ventures, taking into account the economic, environmental and social dimensions, which is key to sustainable development.

Green transformation is a comprehensive shift of economies and societies towards sustainable development, driven by the urgent need to protect the environment, as noted by Taşel, Bayarçelik [2023, pp. 152-159]. The process seeks to reconcile economic development [Przybytniowski, 2016, pp. 278] with environmental sustainability, promoting a green economy in which production and consumption are consistent with the principles of environmental responsibility, resource efficiency and social justice. Key elements include minimising carbon emissions and ecological footprints in sectors such as energy, transport, agriculture and urban planning, by promoting renewable energy sources, implementing closed-loop economy practices and clean technologies. As highlighted by Cheba, Bąk, Szopik-Depczyńska, Ioppolo [2022], the green transition is a fundamental shift in the approach to sustainability, offering significant opportunities for new technologies, environmental policies and job creation. Kozar, Sulich [2023] point out that it is a comprehensive transition integrating economic growth with environmental and social progress, although it comes with challenges such as financial constraints.

Traditional investment evaluation methods, such as NPV, IRR, ROI, and payback period, form the basis of profitability analysis, focusing on profit maximization. However, as Drozdowski and Dziekański [2022a, p. 66] point out, in the face of the green transition, financial measures should be supplemented with non-financial indicators reflecting the project's impact on the environment and society. Companies that ignore these aspects risk losing their reputation, incurring increasing regulatory costs, and facing difficulties in raising capital from ESG-driven investors. Irani and Love [2002, p. 74–82] emphasize that traditional methods have limitations in evaluating investments in information systems, as they do not fully take into account intangible benefits. Therefore, as Lefley [1996, p. 207-224] adds, more comprehensive approaches are necessary. The key limitation of traditional methods is their exclusive focus on the economic dimension, ignoring non-financial factors: environmental, social, and corporate governance (ESG), which are equally important to investors.

Net Present Value (NPV) is a fundamental method for assessing the profitability of investment projects, taking into account the time value of money. It involves discounting future cash flows to their present value and subtracting the initial investment cost. A positive NPV means that the project is profitable. Despite its popularity, NPV does not take into account non-financial aspects, such as the impact on the environment or society, and is sensitive to the discount rate used. Drozdowski and Dziekański [2022a, p. 66] and Dobrowolski and Drozdowski [2022, p. 353] emphasize that NPV, understood as the difference between the present values of cash inflows and outflows, is widely presented in the literature in the context of capital budgeting and investment planning.

The assessment of economic ventures is becoming more complex, requiring knowledge of climate and decarbonization risks and the use of advanced tools such as life cycle analysis and scenario analysis. SMEs, although faced with a lack of resources, knowledge [Przybytniowski, 2024, pp. 2-17], and complex ESG regulations, can use their flexibility and close relationships with their environment to adapt to the changing needs of customers and local communities (social aspects). Corporate governance is key to building trust. Gürlevük [2024] and Kurtanović and Kadušić [2024] point out that despite limitations, adopting ESG practices can benefit SMEs by increasing operational efficiency, market reputation and access to capital, and the European Union is pushing for ESG regulations to promote sustainable development.

A proactive approach to green transformation is a key strategy for SMEs. It allows them to build a competitive advantage, support innovation, reduce operating costs (energy efficiency, resource management) and strengthen their reputation, which translates into long-term stability and growth. Despite initial financial and knowledge barriers, proactive implementation of a green transition strategy results in long-term competitive advantage and increased resilience to regulatory and market risks (H1). SME investments in sustainable development, despite a potential initial reduction in NPV, will bring significant non-financial benefits (improved image, reduced regulatory risk, easier access to 'green' funds, increased customer and employee loyalty), which in the long term will contribute to the growth of the company's value and its resilience to changing market conditions (H2).

Research methods

Net Present Value (NPV) analysis is a key financial tool for evaluating long-term investment projects, taking into account the time value of money by discounting future cash flows to their present value, making it a representative method for assessing the feasibility and optimisation of investments, as indicated by Stoiljkovic [2010, pp. 17-21]. Although NPV focuses on financial aspects, the contemporary approach requires extending the analysis to include environmental benefits and costs, which are key to building long-term project value. NPV sensitivity analysis, according to Chen [2025, p. 186-194], improves decision-making by taking into account the uncertainty of key variables, which helps investors manage risk and make informed decisions in an uncertain investment environment.

- Determine the initial investment, taking into account green infrastructure. Precisely identify all initial financial outlays (t=0) necessary to launch the project, including the costs of traditional assets and expenditures on green infrastructure (e.g., green roofs, water retention, plantings, ecological certifications).
- Forecast future cash flows, taking into account Green Infrastructure. Estimate all future cash inflows and outflows throughout the project's lifetime. In addition to traditional cash flows, take into account those specific to green infrastructure.
- Determining an appropriate discount rate that takes into account the green transition. Select a discount rate that reflects the cost of capital as well as the risks and opportunities associated with ESG factors. Projects with a strong green infrastructure component may potentially be associated with a lower discount rate.
- Discount future cash flows. Discount each projected future cash flow to its present value using the standard formula:

$$PV=\frac{(1+r)^t}{CF_t} \quad (1),$$

where: PV = Present value; CFt = Cash flow in period t; r = Discount rate (taking into account ESG risk); t = Period number (e.g., year).

Calculation of Net Present Value (NPV). The components of the NPV formula have been enriched with aspects resulting from the green transition, which can be treated as a synthetic measure of all pro-environmental and social activities affecting future cash flows and project risk..

$$NPV=\sum_{t=1}^{n}\frac{CF_t}{((1+r*zt)^t} \quad (2),$$

where: CFt - Net cash flow in period t, taking into account the impact of the green transition (financial benefits/costs, including those from green infrastructure); r - Discount rate, which should also reflect ESG risks and opportunities; zt – Regional/local green transition index (GT) for SMEs, affecting NPV by increasing cash flows (lower costs, higher revenues) and reducing the discount rate (lower risk, easier access to financing); t - Period number (e.g., year); n = Project lifetime.

To construct a synthetic green transition index (GT) that accurately reflects progress in a given region (municipality, province, country), advanced multi-criteria analysis methods can be used, such as combining the CRITIC method (Criteria Importance Through Intercriteria Correlation) with the TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution) method. This synergy allows for the objective determination of weights for individual criteria and then ranks units in terms of their 'greenness'.

The definition and collection of data for green transformation criteria involves precisely defining a set of ESG (Environmental, Social, Governance) indicators and collecting reliable numerical data for these criteria from the analysed territorial units in order to create a decision matrix.

Data normalisation (zero-based unitarisation). Normalisation of the collected criteria is necessary to convert various units of measurement into comparable, dimensionless values (usually from 0 to 1), whereby it is crucial to distinguish whether a given criterion is a stimulant or a destimulant. For stimulants:

$$n_{ij}=\frac{x_{ij}-\min(x_{ij})}{\min(x_{ij})-\min(x_{ij})} \quad (3),$$

for destimulants

$$n_{ij}=\frac{\max(x_{ij})-x_{ij}}{\min(x_{ij})-\min(x_{ij})} \quad (4),$$

where: xij is the value of the i-th unit for the j-th criterion, max(xij) is the maximum value of the j-th criterion, min(xij) is the minimum value of the j-th criterion, nij is the normalised value.

Data normalization is a key process in multidimensional analysis, enabling the comparison of results on different scales, as emphasized by Jałowiecki, Orłowski, Woźniakowski, and Zmarzłowski [2009, p. 123–136]. There are various normalization methods, including zero unitarization, standardization, and quotient transformations. Kukuła [2000, p. 5–17] points to the universality and ease of application of the zero unitarization method, especially in the normalization of stimulants and destimulants. Although studies such as those conducted by Wieczorek and Frejtag-Mika [2021, pp. 74-89] in the context of higher education in Poland did not show significant differences between the methods, Ozga's [2018, pp. 251–262] study on the use of ICT in EU enterprises proved that the choice of normalization formula can affect the results of linear ordering. In particular, the ratio transformation using the maximum value as the base produced the most consistent rankings, highlighting the importance of careful selection of the normalisation method for the reliability of comparative analyses.

Determining the weights of criteria using the CRITIC method. The CRITIC method objectively determines the weights for each criterion based on its variability (standard deviation) and the uniqueness of the information (inverse correlation with other criteria), ensuring that those providing more unique data have a greater impact on the final result. The weights Wj for each criterion j are calculated as follows:

$$\sigma j=\sqrt{\frac{1}{m}\sum_{i=1}^{m}(n_{ij}-\bar{n}_j)^2} \quad (6),$$

$$Rj=\sum_{t=1}^{n}(1-r_{jk})$$

$$Cj=\sigma_j R_j$$

$$Wj=\frac{C_j}{\sum_{k=1}^{n}C_k}$$

where: σj is the standard deviation for the jth criterion, n̄ is the normalised mean value for the jth criterion, rjk is the correlation coefficient between criterion j and criterion k, Rj is the sum of the distance coefficients (1 minus correlation) between the jth criterion and all other criteria. Cj is the measure of information content for the j-th criterion, wj is the weight of the j-th criterion, m is the number of units (rows), and n is the number of criteria (columns).

The CRITIC (CRiteria Importance Through IntercriteriaCorrelation) method, developed by Alinezhad and Khalili (2019), is an objective approach to determining criterion weights in multi-criteria decision making. As Maruf and Özdemir [2024, pp. 1108-1117] point out, CRITIC has been applied in many fields, including the ranking of tourist websites, contributing to more accurate and reliable decision-making.

The concept is based on calculating the distance of an object from:

a reference object

$$d_i^+ = \sqrt{\frac{1}{n}\sum_{j=1}^{m}\left(z^*_{ij} - z_j^+\right)^2}, \quad (7),$$

anti-pattern object;

$$d_i^- = \sqrt{\frac{1}{n}\sum_{j=1}^{m}\left(z^*_{ij} - z_j^-\right)^2}, \quad (8),$$

where: n- denotes the number of variables forming the pattern or anti-pattern, zij– denotes the normalised value of the jth variable of the ith object multiplied by the appropriate weighting coefficient, z_j^+ / z_j^-–- denotes the pattern or anti-pattern object.

Determining the value of a synthetic measure is a key step in many multidimensional analyses, allowing for the aggregation of many diverse indicators into a single, homogeneous value. This process enables the comparison and ranking of complex objects (e.g. companies, regions, projects) based on their multidimensional characteristics, transforming difficult-to-interpret data sets into an accessible and useful decision-making tool. The synthetic measure is determined according to the formula:

$$q_i = \frac{d_i^-}{d_i^- + d_i^+}, gdzie\ 0 \le q_i \le 1, i = 1, 2, \ldots, n; \quad (9),$$

where: q_i∈ [0; 1]; d_i^-- denotes the distance of the object from the anti-pattern (from 0), d_i^+ denotes the distance of the object from the pattern (from 1) [Roszkowska, Filipowicz-Chomko, 2020, pp. 1219-1241; Acuña-Soto, Liern, p., p. 541–569; Perez-Gladish, 2021; Roszkowska, Wachowicz, 2015, pp. 920–932; Popławski, Grzelak, Dziekański, 2025, p. 886].

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a multi-criteria decision-making method that evaluates alternatives based on their proximity to ideal and anti-ideal solutions, as described by Uzun, Taiwo, Syidanova, Uzun Ozsahin (2021). TOPSIS, applicable to numerical data sets with known criterion weights, has been successfully implemented in many industries, such as the automotive, mobile, IT, manufacturing, and biological industries. Its simplicity and versatility, highlighted by Papathanasiou, and Ploskas [2018], have contributed to its widespread use in decision-making processes in various sectors.

When making investment decisions in the context of green transition, NPV is only part of a broader, holistic assessment. When NPV is positive, the project is financially viable, and green infrastructure further enhances its strategic and reputational value. If NPV is negative, the project is financially unviable, but significant ESG benefits (e.g., regulatory compliance, improved image, climate resilience) may justify lower profitability. When the NPV is zero, ESG factors, including green infrastructure, may tip the balance in favor of implementation, even without generating excessive financial returns. Contemporary NPV analysis in SMEs therefore requires not only precise financial calculations but also conscious consideration of the impact of green infrastructure investments on cash flows, risk (discount rate), and intangible strategic and social benefits.

Results

The presented analysis concerns the calculation of the Net Present Value (NPV) for a certain investment project, which is characterized by an initial investment outlay of -500,000.00 units in period zero. The project is expected to last five years (n=5), generating positive cash flows ranging from 100,000.00 to 200,000.00 units per year. A key element of this analysis is the variable nominal discount rate (r), which ranges from 3.00% to 6.00% depending on the period, reflecting the variable cost of capital or risk level in individual years. Each future cash flow has been converted into discounted cash flows using an appropriate discount factor reflecting the time value of money. By summing these discounted cash flows and subtracting the initial investment, a positive NPV of 74,554.32 units was obtained (Table 1). This result indicates that the project is financially viable, exceeding the required rate of return and creating value for the investor. The investment project (Table 2) with an initial outlay of -500,000 units generates varied annual cash flows (100,000 to 200,000). The project is expected to last 10 years. The variable nominal discount rate (3-6%) reflects the dynamic cost of capital. Despite this volatility, the project achieves a very high NPV of 573,566.24 units, which demonstrates its exceptional financial viability in the long term and generates significant added value for the inwestor.

Tabela 1. Calculation of Net Present Value (NPV) for a 5-year Investment Project with a Variable Nominal Discount Rate

size	n (period)	Cash flow	r (discount rate)	discount factor	discounted cash flows
Initial investment	0	-500 000.00	4.00%	1.0000	-500 000.00
flow 1	1	100 000.00	5.00%	0.9524	95 238.10
flow 2	2	200 000.00	6.00%	0.8900	177 999.29
flow 3	3	150 000.00	5.00%	0.8638	129 575.64
flow 4	4	100 000.00	4.00%	0.8548	85 480.42
flow 5	5	100 000.00	3.00%	0.8626	86 260.88
				NPV=	74 554.32

Source: DOI: https://doi.org/10.32843/infrastruct66-7.

Table 2. Net Present Value (NPV) calculation for a 10-year investment project with a variable nominal discount rate

size	n (period)	Cash flow	r (discount rate)	discount factor	discounted cash flows
Initial investment	0	-500 000.00	4.00%	1.0000	-500 000.00
flow 1	1	100 000.00	4.00%	0.9615	96 153.85
flow 2	2	200 000.00	5.00%	0.9070	181 405.90
flow 3	3	150 000.00	6.00%	0.8396	125 942.89
flow 4	4	100 000.00	5.00%	0.8227	82 270.25
flow 5	5	100 000.00	4.00%	0.8219	82 192.71
flow 6	6	150 000.00	3.00%	0.8375	125 622.64
flow 7	7	100 000.00	3.00%	0.8131	81 309.15
flow 8	8	200 000.00	4.00%	0.7307	146 138.04
flow 9	9	150 000.00	5.00%	0.6446	96 691.34
flow 10	10	100 000.00	6.00%	0.5584	55 839.48
				NPV=	573 566.24

Source: DOI: https://doi.org/10.32843/infrastruct66-7.

The NPV analysis for the project, taking into account the green transition index in the discount rate, indicates its profitability. For a 5-year project (Table 3), with an initial investment of PLN 500,000 and positive cash flows (PLN 100,000 - 200,000 per year), the NPV obtained was PLN 105,807.36. For a longer, 10-year project (Table 4), with an identical initial investment and similar cash flows, the NPV amounted to 666,722.39 units. In both scenarios, the variable discount rate, adjusted by the GT index, reflects the impact of environmental factors on the cost of capital. The positive NPV values in both cases confirm the financial viability of the projects and their investment attractiveness, even when taking into account the aspects of the green transition.

Table 3. Net Present Value (NPV) calculation for a 5-year Investment Project with a Variable Nominal Discount Rate Adjusted by the Green Transition Index

size	n (period)	Cash flow	r (discount rate) taking into account the index of real transformation	discount factor	discounted cash flows
Initial investment	0	-500 000.00	0.88%	1.0000	-500 000.00
flow 1	1	100 000.00	1.65%	0.9838	98 376.78
flow 2	2	200 000.00	2.64%	0.9492	189 843.93
flow 3	3	150 000.00	2.75%	0.9218	138 275.67
flow 4	4	100 000.00	2.64%	0.9010	90 101.79
flow 5	5	100 000.00	2.31%	0.8921	89 209.19
				NPV=	105 807.36

Source: own study.

Table 4. Net Present Value (NPV) calculation for a 10-year Investment Project with a Variable Nominal Discount Rate Adjusted for the Green Transition Index

size	n (period)	Cash flow	r (discount rate) taking into account the index of real transformation	discount factor	discounted cash flows
Initial investment	0	-500 000.00	0.88%	1.0000	-500 000.00
flow 1	1	100 000.00	0.88%	0.9913	99 127.68
flow 2	2	200 000.00	1.65%	0.9678	193 559.83
flow 3	3	150 000.00	2.64%	0.9248	138 720.72
flow 4	4	100 000.00	2.75%	0.8972	89 716.57
flow 5	5	100 000.00	2.64%	0.8778	87 784.29
flow 6	6	150 000.00	2.31%	0.8719	130 792.47
flow 7	7	100 000.00	2.64%	0.8333	83 326.57
flow 8	8	200 000.00	2.20%	0.8402	168 043.93
flow 9	9	150 000.00	3.30%	0.7466	111 992.35
flow 10	10	100 000.00	4.62%	0.6366	63 657.98
				NPV=	666 722.39

Source: own study.

The NPV analysis for a five-year project (Table 5), with an initial outlay of -500,000 units, is notable for its use of a real rate of return, which is initially negative (-1.83% to -1.80%) and then positive. Nevertheless, the project generates positive cash flows (100,000 to 200,000), which translates into a high NPV of 151,364.86 units, demonstrating its significant profitability. Similarly, the ten-year project (Table 6), with the same initial investment and similar cash flows, also with initial negative real rates of return, achieves a very high NPV of 711,707.91 units. This result clearly indicates the exceptional financial profitability of the project in the long term, even with atypical real rate of return behavior, highlighting its ability to generate significant added value.

Table 5. Net Present Value (NPV) calculation for a 5-year Investment Project with a Variable Real Rate of Return (taking inflation into account)

size	n (period)	Cash flow	Real rate of return	Discount factor	Discounted cash flows
Initial investment	0	-500 000.00	0.95%	1.0000	-500 000.00
flow 1	1	100 000.00	-1.83%	1.0187	101 869.16
flow 2	2	200 000.00	-1.82%	1.0374	207 475.99
flow 3	3	150 000.00	-1.80%	1.0561	158 409.31
flow 4	4	100 000.00	0.92%	0.9641	96 412.92
flow 5	5	100 000.00	2.78%	0.8720	87 197.47
				NPV=	151 364.86

Source: DOI: https://doi.org/10.32843/infrastruct66-7.

Table 6. Net Present Value (NPV) calculation for a 10-year Investment Project with a Variable Real Rate of Return (taking inflation into account)

size	n (period)	Cash flow	Real rate of return	Discount factor	Discounted cash flows
Initial investment	0	-500 000.00	0.95 %	1.0000	-500 000.00
flow 1	1	100 000.00	-1.83%	1.0187	101 869.16
flow 2	2	200 000.00	-1.82%	1.0374	207 475.99
flow 3	3	150 000.00	-1.80%	1.0561	158 409.31

flow 4	4	100 000.00	0.92 %	0.9641	96 412.92
flow 5	5	100 000.00	2.78 %	0.8720	87 197.47
flow 6	6	150 000.00	2.80 %	0.8471	127 068.47
flow 7	7	100 000.00	2.83 %	0.8225	82 253.72
flow 8	8	200 000.00	2.86 %	0.7982	159 644.64
flow 9	9	150 000.00	2.88 %	0.7742	116 128.10
flow 10	10	100 000.00	2.88 %	0.7525	75 248.11
				NPV =	711 707.91

Source: DOI: https://doi.org/10.32843/infrastruct66-7.

The NPV analysis for a five-year project (Table 7), with an initial outlay of -500,000 units, uses a dynamically increasing real rate of return (from 0.63% to 4.40%), which takes into account both inflation and the green transition index (GT). Despite declining discount rates, the project generates positive cash flows (100,000 - 200,000 units), resulting in a positive NPV, confirming its profitability even in the face of inflation and rising GT costs. Similarly, in the case of a ten-year project (Table 8), with the same initial investment and a variable real rate of return taking into account GT, the very high NPV of 698,386.08 units obtained demonstrates exceptional financial viability in the long term, highlighting the project's ability to generate added value in a dynamic macroeconomic environment and in the context of the green transition.

Table 7. Net Present Value (NPV) calculation for a 5-year Investment Project with a Variable Real Rate of Return using the Green Transition Index

size	n (period)	Cash flow	Real rate of return with index zt	discount factor	discounted cash flows
Initial investment	0	-500 000.00	0.21%	1.0000	-500 000.00
flow 1	1	100 000.00	0.63%	0.9938	99 375.35
flow 2	2	200 000.00	1.26%	0.9753	195 064.69
flow 3	3	150 000.00	2.10%	0.9397	140 953.15
flow 4	4	100 000.00	3.14%	0.8836	88 357.49
flow 5	5	100 000.00	4.40%	0.8063	80 630.16
				NPV=	104 380.84

Source: own study.

Table 8. Net Present Value (NPV) calculation for a 10-year Investment Project with a Variable Real Rate of Return using the Green Transition Index

size	n (period)	Cash flow	Real rate of return with index zt	discount factor	discounted cash flows
Initial investment	0	-500 000.00	0.21%	1.0000	-500 000.00
flow 1	1	100 000.00	0.63%	0.9938	99 375.35
flow 2	2	200 000.00	1.26%	0.9753	195 064.69
flow 3	3	150 000.00	2.10%	0.9397	140 953.15
flow 4	4	100 000.00	3.14%	0.8836	88 357.49
flow 5	5	100 000.00	4.40%	0.8063	80 630.16
flow 6	6	150 000.00	4.19%	0.7817	117 252.77
flow 7	7	100 000.00	2.10%	0.8649	86 489.14
flow 8	8	200 000.00	1.89%	0.8612	172 235.88
flow 9	9	150 000.00	1.47%	0.8772	131 577.22
flow 10	10	100 000.00	1.47%	0.8645	86 450.21
				NPV=	698 386.08

Source: own study.

Discussion

The presented Net Present Value (NPV) analyses confirm the profitability of the investment in various scenarios, with a positive NPV in all cases. A longer time horizon (10 years) consistently generates higher NPV, and the inclusion of the green transition index (GT) often reinforces the positive result, suggesting that sustainable investments can be perceived as less risky. Although the green transition may impose higher profitability requirements, the projects remain profitable, demonstrating their long-term value and compliance with sustainability principles. However, a longer investment horizon increases exposure to market, regulatory, and technological volatility. This requires careful risk management and continuous monitoring of the environment. Flexibility in planning is key to balancing value maximization with the need to adapt to changing market circumstances.

The green transition is redefining the criteria for evaluating investments in SMEs, going beyond NPV alone. ESG factors, especially environmental ones, are becoming key. SMEs are under increasing regulatory, business, and consumer pressure to implement environmentally friendly solutions. Profitability is assessed not only by profit but also by positive impact on the environment (e.g., emission reduction, energy efficiency). Companies that fail to adapt risk losing competitiveness, limited access to green financing, and damage to their reputation. Assessment criteria include environmental audits, decarbonization targets, and commitment to green innovation, making compliance with green transition principles an integral part of success.

The volatility of discount rates has a fundamental impact on the profitability of investments. Fluctuations in nominal rates (3–6%) and real rates (-1.83–4.40%) illustrate how dynamic market conditions affect the present value of future cash flows. Higher discount rates at the beginning of a project reduce the discounted value of cash flows, while lower rates over longer horizons can increase NPV, suggesting a stabilization of risk over time. Negative real rates may result from deflation, low interest rates, or interventions supporting green projects. They lead to higher NPV values, especially in long-term projects. However, it should be remembered that negative rates may be temporary, resulting from short-term policies. This risk requires dynamic financial modelling and rapid adaptation. A strategic response to negative rates should be balanced by risk management, e.g. portfolio diversification.

Research by Zhang, Guo, and Lin (2023) highlights the significant impact of green transition measures on corporate investment and performance. The development of green finance increases the scale of investment and financing, particularly for non-state-owned companies and those in western regions, as confirmed by Zhu, Bian, Ren, and Liu (2024). In the thermal energy sector, the effectiveness of green transformation varies, with wastewater costs being a key factor. According to Sun and Yang (2022), the adoption of a green value-added index shows that investments in environmental protection do not reduce operating performance, encouraging capital providers to favor green investments. Furthermore, green investments have a positive impact on a company's overall performance, although their impact varies depending on size, ownership form, and region. In the context of real estate, Grzeszczyk and Waszkiewicz [2020, p. 2363-2381] emphasise the need to include sustainability in valuation to increase its accuracy and provide a basis for innovative project assessment methods. These findings highlight the importance of green transformation in improving investment assessment and overall performance, as well as the need for strategies tailored to different types of companies and regions, supported by integrated evaluation methods that offer flexible strategic recommendations.

These analyses clearly emphasize the importance of sustainable development by highlighting the need to integrate ESG factors into the decision-making process. This approach can not only increase the profitability of projects but also support environmental goals. In dynamic market conditions, the need for flexibility in the approach to investment is crucial, requiring investors to continuously monitor and adjust their strategies to maximise added value in a changing environment.

The study makes a theoretical contribution to the discipline of economics and finance by integrating environmental factors (GT index) into traditional investment valuation models such as NPV. It demonstrates the possibility of quantifying the impact of the green transition on the discount rate, which is an innovative approach to incorporating ESG risks and opportunities into discounted cash flow analysis. This highlights the need to revise standard capital valuation models and to view sustainability as an integral part of project value..

The practical implications are multifaceted. For SMEs, this signals that a proactive approach to green transition is key to long-term stability and access to capital, despite potentially higher initial profitability requirements (lower NPV when taking into account green transition). Financial institutions should develop and simplify their green financing offerings, adapting risk assessment criteria to the specific characteristics of SMEs. Policymakers need to simplify regulations, create a coherent support framework (grants, tax breaks), and increase the availability of ESG self-assessment tools for SMEs.

Methodologically, the green transition (GT) index used simplifies the complexity of ESG factors, and its impact may go beyond the discount rate itself. The study did not take into account the regional specificity of Poland and was based on simulations rather than actual market data for SMEs, which limits the possibility of generalizing the results. Furthermore, the time horizons (5 and 10 years) may be too short for long-term investments in green infrastructure, and the volatility of discount rates was determined arbitrarily. Therefore, future research should focus on analyzing the sensitivity of the model to different methods of constructing the ZT index and its integration with the discount rate (e.g. through premiums or discounts to WACC), comparing the impact of the green transition on the profitability of SMEs in different sectors of the economy, and examining the impact of specific support instruments (EU funds, subsidies, tax breaks) on the profitability of green investments. It will also be crucial to develop tools and methodologies for SMEs to monitor and report ESG indicators, which is essential for their access to green financing and building a competitive advantage.

Summary

The simulations indicate that incorporating the green transition (GT) into the discount rate modifies the calculated NPV. Including the GT index in the real discount rate reduced the NPV, suggesting that the green transition may increase the cost of capital or risk, placing higher demands on projects. Despite this, all cases analyzed showed a positive NPV, demonstrating the overall profitability of the project even in a rigorous green transition environment. Furthermore, long-term (10-year) projects are significantly more profitable than short-term (5-year) projects, regardless of the discount rate. The inclusion of the ‘green transition index’ in the nominal discount rate has a positive effect on NPV, suggesting a reduction in the perceived risk of ‘green’ investments. In contrast, at the real rate of return, negative discount rates initially increased NPV, but the addition of the GT index slightly reduced it, which may indicate potential additional costs or variable benefits associated with GT requirements, partially offsetting the initial effects of low rates. In summary, the green transition index increases the NPV of projects at the nominal discount rate, making them more financially attractive. In the case of the real rate of return, the impact is less clear, but long-term investments consistently show higher NPVs, highlighting their greater potential to generate value in a volatile environment.

The hypotheses have been positively verified. The proactive approach of SMEs to green transformation translates into long-term competitive advantage and resilience, confirmed by higher NPV values for projects taking into account the ZT index, especially in the long term. Despite a potential initial reduction in NPV at the real rate of return, the analysis clearly shows that non-financial benefits (image, reduction of regulatory risk, access to green financing) significantly contribute to the overall profitability and resilience of projects in a volatile market.

The simulations clearly showed that the use of a real discount rate, especially one that takes into account the ZT index, significantly affects the NPV of SME projects. Increasing ZT requirements can reduce financial profitability, while a low or negative real interest rate can increase NPV. The volatility of discount rates, resulting from inflation dynamics and ZT progress, is crucial for the assessment of long-term projects.

The analysis shows that the green transition is a fundamental factor influencing the valuation of investments in SMEs, changing the profitability paradigm from purely financial to holistic, taking into account environmental risks and opportunities. Companies, financial institutions, and policymakers need to adapt their strategies and assessment tools. SMEs should view investments in green infrastructure as a strategic necessity and a source of competitive advantage, access to capital and long-term resilience.

References

Acuña-Soto C., Liern V., Perez-Gladish B., (2021), Normalization in TOPSIS-basedapproaches with data of differentnature: application to the ranking of mathematicalvideos, Annals of OperationResearch", 296.

Alinezhad, A., Khalili, J. (2019), Critic Method. In: New Methods and Applications in MultipleAttributeDecisionMaking (MADM), International Series in Operations Research& Management Science, vol 277. Springer, Cham. https://doi.org/10.1007/978-3-030-15009-9_26.

Bouchmel, I., Ftiti, Z., Louhich, W., Omri, A. (2024), Financing sources, green investment, and environmental performance: Cross-country evidence, Journal of Environmental Management, Vol. 353, 120230, https://doi.org/10.1016/j.jenvman.2024.120230.

Cheba, K., Bąk, I., Szopik-Depczyńska, K., Ioppolo, G., (2022), Directions of greentransformation of the European Union countries, EcologicalIndicators, Vol. 136, 108601, https://doi.org/10.1016/j.ecolind.2022.108601.

Chen, S. (2025). Net Present Value (NPV) Sensitivity Analysis: Understanding, Risk in Investment Projects, Advances in Economics, Management and Political Sciences, 150.

Dobrowolski, Z.; Drozdowski, G., (2022), Does the Net Present Value as a Financial Metric Fit Investment in Green Energy Security? Energies, 15, https://doi.org/10.3390/en15010353.

Drozdowski, G. Dziekański, P. (2022), Internal rate of return as an enhancement of the decision-making process in the aspect of choosing the investment process, doi: https://doi.org/10.32843/infrastruct66-8.

Drozdowski, G. Dziekański, P. (2022a), Net present value (npv) as a reinforcement of the decision-making process in terms of investment selection: doi: https://doi.org/10.32843/infrastruct66-7 ІНФРАСТРУКТУРА РИНКУ Електроннийнауково-практичнийжурналВипуск.

Fan, M., Shira, R.K., Hunjra, A.I. Zhao, S., (2025), Climategovernanceactions, financingconstraints, and greentransformation of energy-intensivefirms, Research in International Business and Finance, Vol. 79, 103041, https://doi.org/10.1016/j.ribaf.2025.103041.

Grzeszczyk, T. A.; Waszkiewicz, M. (2020), Sustainable Investment Project Evaluation, Entrepreneurship and Sustainability Issues 7(3), https://doi.org/10.9770/jesi.2020.7.3(60).

Gürlevük, E., (2024), Role of ESG reporting in small and medıum-sized enterprises: benefits, challenges and the EU's regulatory push, Energy Policy Studies 1(14): doi.org/10.62316/NUSP3381.

Irani, Z., & Love, P. E. D. (2002), Developing a frame of reference for ex-ante IT/IS investment evaluation, European Journal of Information Systems, 11(1), https://doi.org/10.1057/palgrave.ejis.3000411.

Jałowiecki, P., Orłowski, A., Woźniakowski, T., & Zmarzłowski, K. (2009), Porównanie ocen zróżnicowania szkolnictwa wyższego w latach 1999 – 2006 w Polsce na podstawie różnych metod normalizacji danych, Zeszyty Naukowe SGGW, Polityki Europejskie, Finanse I Marketing, (2(51), https://doi.org/10.22630/PEFIM.2009.2.51.31.

Ko, C-C., Liu, C-Y., and Liu, C., (2023), Socialsustainable development greenbrandvalue in educationimpactstrategicalliance investment decisionevaluation, Front. Energy Res. 10:1050603. doi: 10.3389/fenrg.2022.1050603.

Kozar, Ł.J. and Sulich, A., (2023), Energy Sector's Green TransformationtowardsSustainable Development: A Review and FutureDirections, Sustainability, 15, 11628. https://doi.org/10.3390/su151511628.

Kukuła, K., (2000), Analiza własności metody unitaryzacji zerowanej, Zeszyty Naukowe SGGW - Ekonomika i Organizacja Gospodarki Żywnościowej, (42), https://doi.org/10.22630/EIOGZ.2000.42.69.

Kurtanović, M. and Kadušić E., (2024), Catalysts of Sustainability: The Transformative Role of Small and Medium Enterprises in ESG Practices of EU Candidate Countries, Journal of Forensic Accounting Profession, Vol. 4(2).

Lefley, F., (1996), The paybackmethod of investment appraisal: A review and synthesis, International Journal of Production Economics, Volume 44, Issue 3, https://doi.org/10.1016/0925-5273(96)00022-9.

Li, X. and Khan, I.U., (2025), Green Transformation in Portfolio: The Role of SustainablePractices in Investment Decisions, Sustainability, 17, 1055. https://doi.org/10.3390/su17031055.

Mackevičius, J. and Tomaševič, V., (2010), Evaluation of investment projects in case of conflict between the internal rate of return and the net present value methods, Ekonomika, 89(4), doi:10.15388/Ekon.2010.0.962.

Maruf, M., & Özdemir, K. (2024), Ranking of Tourism Web SitesAccording to Service Performance Criteria with CRITIC and MAIRCA Methods: The Case of Turkey, UluslararasıYönetim Akademisi Dergisi, 6(4), https://doi.org/10.33712/mana.1352560.

Miraz M.H., & Sing, T., Soo, M., (2024), Factorsaffecting the greeneconomy: the mediating role of foreigndirect investment, Journal of Economic Studies, Vol. 51(8), 1613-1628, DOI: 10.1108/JES-01-2024-0012.

Ozga, P., (2018), Ocena stanu gospodarki odpadami komunalnymi w Polsce w 2016 roku przy użyciu metody unitaryzacji zerowanej oraz metody rangowej, Metody Ilościowe W Badaniach Ekonomicznych, 19(3). https://doi.org/10.22630/MIBE.2018.19.3.23.

Papathanasiou, J., Ploskas, N., (2018), TOPSIS. In: MultipleCriteriaDecision Aid, Springer Optimization and Its Applications, Vol 136. Springer, Cham. https://doi.org/10.1007/978-3-319-91648-4_1.

Pengwu, W., (2021), Application of Cloud Computing and Information Fusion Technology in Green Investment Evaluation System, Journal of Sensors, 2292267, https://doi.org/10.1155/2021/2292267.

Popławski, Ł., Grzelak, A., & Dziekański, P., (2025), Still trade-off oralreadysynergybetween waste management and the environment? In the light of experienceat the level of the voivodeship in Poland, Economics and Environment, 91(4), https://doi.org/10.34659/eis.2024.91.4.886.

Przybytniowski J.W., (2016), Współczesne funkcje i mechanizmy transmisji między sektorem ubezpieczeniowym a sferą realną gospodarki. Teoria i praktyka, CeDeWu, Warszawa, ISBN: 978-83-7556-758-8.

Przybytniowski J.W., (2024), Corporate social responsibility in the era of the changing business insurance market, Business and Public Administration Studies, Vol. 18, No. 1, ISSN: 2374-5916.

Purwanti, A., (2023), Green Investment Appraisal: A Comprehensive Framework for Evaluating Environmental and Financial Returns, Atestasi: JurnalIlmiah Akuntansi, 6(2), https://doi.org/10.57178/atestasi.v6i2.778.

Qiying, R., Xiaodong, Y., Hongchuan Y., Yang X., Jianhong C., (2023), Natural resourceconsumption and industrialgreentransformation: Does the digitaleconomymatter?, Resources Policy, Vol. 81, 103396, https://doi.org/10.1016/j.resourpol.2023.103396.

Roszkowska, E., Filipowicz-Chomko, M., (2020), Measuringsustainable development in the educationareausingmulti-criteriamethods: a casestudy, Central EuropeanJournal of Operations Research, 28.

Roszkowska, E., Wachowicz, T., (2015), Application of fuzzy TOPSIS to scoring the negotiation offers in ill-structur end negotiation problems, “EuropeanJournal of OperationalResearch” 242, 3.

Stoiljkovic, V., (2010), Net presentvalueanalysis Comparing engineering projects by financial return, in IEEE Potentials, Vol. 29, no. 3, pp. 17-21, doi: 10.1109/MPOT.2010.935831.

Sun, Y.; Yang, F., (2022), Does Green Investment Improve the Comprehensive Performance of Enterprises? A Study on Large and Medium-Sized Steel Enterprises in China, Sustainability, 14, 15642. https://doi.org/10.3390/su142315642.

Tang, C., (2024), Green Finance and Investment: EmergingTrends in Sustainable Development, Journal of Applied Economics and Policy Studies.

Taşel, F., & Bayarçelik, E. B., (2023), A bibliometric analysis and review of green transformation. Research, Journal of Business and Management, 10(4).

Uzun, B., Taiwo, M., Syidanova, A., Uzun Ozsahin, D., (2021), The Technique For Order of Preference by Similarity to Ideal Solution (TOPSIS), (In:) Uzun Ozsahin, D., Gökçekuş, H., Uzun, B., LaMoreaux, J. (eds), Application of Multi-CriteriaDecision Analysis in Environmental and Civil Engineering, Professional Practice in Earth Sciences. Springer, Cham. https://doi.org/10.1007/978-3-030-64765-0_4.

Wieczorek, P., Frejtag-Mika, E., (2021), Normalizacja zmiennych a porządkowanie krajów Unii Europejskiej pod względem stopnia wykorzystania technologii ICT w przedsiębiorstwach, Nierówności Społeczne a Wzrost Gospodarczy, 1, doi: 10.15584/nsawg.2021.1.4.

Yang, X., ImranHunjra, A., Grebinevych, O., Roubaud, D., Zhao, S., (2025), Roads to sustainable development: Pioneering industrial green transformation through digital economy policy, Journal of Environmental Management, Vol. 387, 125721, https://doi.org/10.1016/j.jenvman.2025.125721.

Yu, N., He, F., Amanguli, M., Zhang, X., Zhou, Z., (2024), Analysis of the Coupling and Coordinated Development of Green Investment and Low Carbon Economy, International Journal of Global Economics and Management, Vol. 2(3), doi: https://doi.org/10.62051/IJGEM.v2n3.68.

Zhang, G., Guo, B., Lin, J., (2023), The impact of greenfinance on enterprise investment and financing, Finance Research Letters, Vol. 58, Part D, 104578, https://doi.org/10.1016/j.frl.2023.104578.

Zhu, H., Bian, Y., Ren, F., Liu, X., (2024), An Efficiency Evaluation and Driving Effect Analysis of the Green Transformation of the Thermal Power Industrial Chain. Evidence Based on Impacts and Challenges in China, Energies, 17, 3840. https://doi.org/10.3390/en17153840.