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METHODS FOR ASSESSING THE EFFECTIVENESS OF INVESTMENT PROJECTS IN INFLATIONARY CONDITIONS

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Abstract. *The evaluation of investment projects under conditions of inflation remains a critical challenge for both researchers and practitioners, particularly in long-term, capital-intensive, or innovative projects. Traditional approaches, which often assume homogeneous inflation and apply a single discount rate, fail to capture the asymmetric and component-specific effects of inflation on project cash flows, potentially leading to biased assessments of profitability and risk. This study proposes a comprehensive methodology for investment project evaluation under heterogeneous inflation, integrating three key innovations: component-specific adjustment of cash flows using inflation deflators, dynamic determination of period-specific discount rates based on the Fisher equation, and the application of scenario and stochastic analyses to quantify uncertainty and risk. The framework enables disaggregation of revenues, operating costs, capital expenditures, taxes, and working capital flows, allowing for precise modeling of inflation effects on each component. Sensitivity analysis and Monte Carlo simulation are employed to evaluate the impact of alternative inflation scenarios, providing a probabilistic distribution of net present value (NPV) and other performance indicators. An illustrative investment project demonstrates that accounting for heterogeneous inflation substantially modifies project valuation compared to classical discounted cash flow (DCF) approaches, revealing structural effects masked under homogeneous assumptions. The proposed methodology enhances the accuracy and objectivity of project appraisal, improves risk-awareness, and supports strategic decision-making under inflationary uncertainty. This study contributes to investment evaluation theory by offering a robust, practical framework that accommodates asymmetric, time-varying inflation dynamics and informs more effective capital allocation in contemporary economic conditions.*

Key words**:** *inflation, investment projects, accounts receivable, accounts payable, working capital, price indices, discount rate, current expenses, income, forecast.*

Introduction. The methods of evaluating investment projects are based on the concept of the time value of money, reflecting the need to account for the changing value of funds over time. Investment practice constantly requires consideration of various regulatory and economic factors, including inflation, which reduces the real value of money. In many cases, inflation significantly affects project efficiency, financial capacity, financing requirements, and the effectiveness of shareholder participation. This effect is particularly pronounced for innovative projects, which typically have longer investment horizons and rely heavily on borrowed capital.

Methodological recommendations classify the effects of inflation on investment projects into three main types:

- impact on price indicators;
- impact on financing needs;
- impact on working capital requirements.

The impact on price indicators depends primarily on the values of heterogeneity coefficients and the internal inflation rate of foreign currency, rather than on the absolute level of inflation. The impact on financing needs is determined by the volatility of inflation over time. The least favorable scenario occurs when inflation is high at the beginning of the project – leading to higher interest rates on borrowed capital and then declines. The impact on working capital requirements depends on both the level and heterogeneity of inflation. Based on this criterion, projects can be divided into two categories, mainly according to the ratio of receivables to payables: the effectiveness of projects in the first category decreases with increasing inflation, while it increases for projects in the second category.

Despite the availability of these classifications, practical investment appraisal faces several challenges. Inflation affects project components unevenly, and its impact can change over time, creating a non-linear and asymmetric influence on cash flows and project performance. Standard evaluation methods, which often assume uniform inflation or incorporate it into a single discount rate, fail to capture these complexities. As a result, project valuations may be biased, potentially leading to misallocation of resources, inaccurate profitability assessments, and increased financial risk. Accurately quantifying the heterogeneous effects of inflation remains a critical problem for investors, especially in long-term, capital-intensive, or innovative projects.

Analysis of recent researches and publications. The impact of inflation on investment projects has been extensively studied in the literature, yet existing approaches often simplify its effects by assuming homogeneity and predictability. In practice, inflation influences project performance in multiple ways, depending on its duration, magnitude, and variability across project components [1; 2].

Short-term effects of inflation primarily manifest in the management of working capital, particularly accounts receivable and accounts payable [3; 4]. Accounts receivable arise from delayed payments for products or services provided by the enterprise, while accounts payable result from deferred payments for purchased inputs, such as raw materials or supplies. The relative importance of receivables and payables varies by industry. For many manufacturing enterprises, accounts receivable are particularly critical due to substantial payment delays, which can last several months, especially when advance payment is impractical (e.g., electricity production) [2]. Inflation affects these components differently: depreciation of receivables negatively impacts project performance, whereas depreciation of payables has a positive effect. Therefore, when assessing investment project efficiency, it is necessary to account for potential delays in payments and the effect of inflation on both inflows and outflows [5; 6].

Medium-term effects are associated with cash flows related to the receipt and repayment of loans. The influence of inflation on loan servicing depends largely on the specific loan conditions, including interest rate structure and repayment schedule [1; 7]. Consequently, its overall impact on project performance can be ambiguous and requires careful consideration in financial planning.

Long-term effects of inflation depend on its heterogeneity and domestic inflation rates relative to foreign currencies, which affect project income, costs, and depreciation. For example, depreciation expenses calculated based on historical asset costs may lag behind inflation, resulting in higher taxable income as project revenues grow [8]. Although general inflation indices also influence certain taxes, this effect is typically limited [9].

Two common classifications in the literature distinguish inflation impacts by homogeneity and temporal uniformity [10-12]. Inflation is considered homogeneous if all monetary indicators of a project’s income and expenses change at the same rate over time. Non-homogeneous (heterogeneous) inflation exhibits different dynamics across project components, such as resource costs, wages, or product prices [13]. Similarly, inflation is uniform if its rate remains constant across time periods, and uneven if it varies from period to period [14]. In practice, neither uniform nor fully homogeneous inflation occurs; however, assuming such conditions can simplify calculations. More accurate evaluations require accounting for both heterogeneity and temporal variability [15].

Inflation also differentially affects cash inflows and outflows. Depreciation of inflows reduces project performance, while depreciation of outflows can increase it [4]. This asymmetry underscores the importance of component-specific adjustments in project valuation.

Measurement and forecasting of inflation are critical for investment projects. Common indicators include [1 – 4; 16]:

- Consumer Price Index (CPI) – a weighted average of consumer goods and services, reflecting typical household expenditures;
- Producer Price Index (PPI) – a measure based on industrial goods prices;
- Gross Domestic Product (GDP) deflator – a broad measure capturing price changes across all goods and services in the economy;
- Core inflation index – excludes volatile or seasonal prices to reflect underlying trends.

For innovation projects, additional forecasts may be required, such as exchange rate movements, commodity prices (e.g., oil, gas, energy, raw materials), wage levels, and anticipated changes in taxes, fees, and refinancing rates [9; 17]. While calculation of these indicators is straightforward, the main challenge lies in accurate forecasting, as inflation can be predictable (e.g., regulated tariffs or seasonal changes) or unpredictable (driven by demand shocks, consumer preferences, or other stochastic factors).

Despite extensive literature on inflation-adjusted discounted cash flow (DCF) models, most studies assume homogeneous inflation and neglect component-specific price dynamics [1; 5]. This simplification can lead to significant biases in evaluating long-term, capital-intensive, or innovative projects, particularly in volatile macroeconomic environments. Addressing these gaps is essential for improving the accuracy of project valuation, risk assessment, and strategic decision-making.

The formulation of the objectives of the article. The aim of this study is to develop and substantiate a methodology for evaluating investment projects under heterogeneous inflation, which enhances the accuracy of forecasting net present value (NPV) and other performance indicators, provides a more objective assessment of risks, and supports strategic decision-making under inflationary uncertainty.

Statement of the main material of the research. In the economic literature, several principles have been established for accounting for inflation when evaluating investment projects [18 - 20]:

– cash flows and the discount rate should be expressed on the same price scale – either nominal (including forecasted inflation) or real (excluding inflation);

– if the project involves borrowed funds, the interest on the loan must also be adjusted to the same scale;

– at initial stages of project development, calculations can be carried out in current (constant) prices, which facilitates evaluation of the project idea and simplifies the analysis of performance indicators;

– overall project efficiency should be calculated both in current and forecasted prices;

– the development of a financing scheme and assessment of participation efficiency should generally be carried out only in forecasted prices;

– to calculate performance indicators, cash flows determined in forecasted prices should first be discounted.

Several methods for accounting for inflation in evaluating investment and innovation projects are widely described in the scientific and educational literature and are incorporated in automated investment assessment packages [19; 21].

The objectivity of such assessments is associated with the accuracy of determining initial capital investments, current expenses, and revenues throughout the project lifecycle. This conditionality exists even in stable economies with predictable price levels and high market knowledge [18]. In national economic conditions, the number of assumptions required for cash flow calculations is significantly higher [21].

At the feasibility study stage, forecasts and estimated prices are used. Calculations are primarily performed using domestic prices and, when necessary, world prices. The assessment of project effectiveness is based on correctly correlating costs with the results obtained from implementation.

Evaluating funds over time is necessary because the value of monetary resources changes with the profit rate, which is typically the loan interest rate in the money market. Investment is usually a long-term process, so it is necessary to compare the value of funds at the start of the investment with the value expected to be returned in the form of future profits, depreciation deductions, etc. In practice, two main concepts are used: the future value (FV) and present value (PV) of funds [2].

The future value of funds represents the amount of money invested today that will grow over a certain period at a given interest rate, reflecting income earned from the use of funds in the money market [1–3; 9]. The interest rate acts both as a means of increasing the value of funds and as a measure of the rate of return on investment operations.

The present value of funds is calculated by discounting its future value. Discounting reduces the future value to its present value, determining how much investment is required today to achieve a specified future amount. Both simple and compound interest models are used in these calculations [8].

Simple interest is the amount calculated from the current (initial) value of the investment at the end of a payment period determined by the terms of the investment of funds (month, quarter, year, etc.). The calculation of the amount of simple interest (S) in the process of increasing investments is carried out according to formula:

$$S = PV \cdot r \cdot t, \tag{1}$$

where PV is the current (initial) value of the deposit (investment);

r - the rate of return on invested funds, expressed as a decimal fraction;

t is the number of periods during which the invested funds will be in circulation.

Example. It is necessary to determine the amount of simple interest for the year under the following conditions: the initial deposit amount is 1000 manat; the interest rate paid quarterly is 20 %. Substituting these values in formula (5), we get $S = 1000 \cdot 4 \cdot 0.2 = 800$.

At the end of each period, the investment increases by the amount kt. Therefore, the numerical amount of interest, taking into account the future value of the investment (FV), is determined by formula:

$$FV = PV + S = PV(1 + r \cdot t). \tag{2}$$

In our example, the future value of the deposit will be 1,800 manat (1,000 + 800).

The multiplier (1 + r · t) represents the compound interest rate. Its value must always be greater than one.

In the process of discounting the value of funds, the formula (D) is used to calculate the simple interest amount, that is, the discount amount.

$$D = FV - FV\frac{1}{(1+r\cdot t)}. \tag{3}$$

Example. It is necessary to determine the discount amount based on simple interest for the year under the following conditions: the final deposit amount is determined as 1000 manat; the discount rate is 20 % per quarter. Substituting these values into the formula, we obtain:

$$D = 1000 - 1000\frac{1}{(1+4\cdot 0{,}2)} = 444 \text{ manat.}$$

In this case, the present value (PV) of the funds, taking into account the calculated discount amount, is determined by formula:

$$PV = FV - D. \tag{4}$$

In our example, the present value of the investment required to receive 1000 manat in one year equals 1000 – 444 = 556 manat.

The multiplier used in both cases (1 / (1 + r · t)) is called the discount rate or simple interest rate, its value should always be less than one.

It is recommended to evaluate the investment project, compare different project options, and select the most efficient alternative using the following indicators:

- Net Present Value (*NPV*);
- Profitability Index (*PI*);
- Internal Rate of Return (*IRR*) or investment profitability;
- Payback Period (*PP*);
- Other indicators reflecting the interests of participants or specific characteristics of the project.

The deflator is an index used to convert economic indicators, such as components of the gross domestic product, into comparable prices. It is also applied to assess a number of variables that influence price changes. A combination of different indices can form a comprehensive measure characterizing the scale of inflation.

The *NPV* method evaluates project efficiency by comparing the cost of initial investments (*IC*) with the total amount of net cash flows discounted over the forecast period. Cash flows are distributed over time and are discounted using a rate *r*, which is independently determined by the analyst or investor based on the annual interest rate achievable from invested capital [6].

The Net Present Value (*NPV*) represents the excess of aggregate project returns over total costs, that is, the difference between discounted cash inflows generated by the project and the sum of discounted initial and subsequent investments. It reflects the total income reduced to the initial point in time over the entire project horizon.

NPV is calculated as:

$$\mathrm{NPV} = -IC + \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} \tag{5}$$

where *NPV* is the net present value (discounted) income;

IC is the initial investment;

CF_t is the cash flow over a certain period of the project's payback period, reflecting the sum of cash inflows and outflows for each specific period t ($t = 1...n$);

r is the discount rate.

Depending on the value of this indicator, the investor assesses the attractiveness of the project. If:

1. NPV > 0, then the project is profitable, generating a return above the cost of capital;
2. NPV = 0, then the project breaks even, producing neither profit nor loss;
3. NPV < 0, the project is unprofitable and promises a loss to the investor.

The discounting principle used in calculating net present value (NPV) assumes, from an economic perspective, the possibility of continuous attraction and investment of financial resources at the selected discount rate. When comparing multiple projects, a single discount rate and a uniform time interval – typically corresponding to the longest implementation period among the projects – are applied.

In most practical cases, a constant discount rate is used for NPV calculations. However, depending on anticipated changes in market interest rates or project-specific conditions, the discount rate can be differentiated across years. The basic discounting formula is given by:

$$PV = \frac{FV}{(1+r)^n} \tag{6}$$

where PV is the present value of money, FV is the future value of money, r is the interest rate, n is the number of periods.

Example of NPV calculation using the traditional approach:

Suppose an investor intends to modernize the automation system of a production process. The estimated cost of re-equipping the conveyor is 100,000 manat (conditional figures). The investment is expected to increase production volumes and, consequently, sales over the next five years. Cash flows are projected as follows: Year 1: 90,000 manat; Year 2: 80,000 manat; Year 3: 70,000 manat; Year 4: 60,000 manat; Year 5: 50,000 manat. The required rate of return (discount rate) is 10 %. The required rate of return is 10 %.

Calculation of the present value of cash flows is presented in Table 1.

Table 1

Calculation of the present value of the project, manat

Period (t), years	Cash flow	Discount (r)	Net present value $PV = \frac{FV}{(1+r)^n}$
0	–100,000	10%	–100,000.00
1	90,000	10%	$\frac{90000}{(1+01)^1}$ = 81,818.18
2	80,000	10%	$\frac{80000}{(1+01)^2}$ = 66,115.70
3	70,000	10%	$\frac{70000}{(1+01)^3}$ = 52,592.04
4	60,000	10%	$\frac{60000}{(1+01)^4}$ = 40,980.81
5	50,000	10%	$\frac{50000}{(1+01)^5}$ =31,047.62
Net present value			172,552.80

Note: The table is compiled by the authors

Based on the positive NPV, the project can be considered profitable under the traditional method.

However, in practice, it is often difficult to fully account for fluctuations in inflation. A common approach to incorporating inflation effects is to adjust the discount rate to reflect forecasted inflation levels. This adjustment ensures that projected cash flows remain comparable over time and that the NPV calculation reflects the real economic value of the project.

In this case, the interest rate will be calculated as follows:

$$R = (1 + \mathrm{r}) \cdot \mathrm{J} \quad (7)$$

where R – discount rate taking into account inflation;

r – base discount rate;

J – forecasted inflation rate.

Accordingly, the higher the projected inflation over the project horizon, the lower the effective profitability, so that after discounting, the project remains financially viable.

This traditional adjustment, however, does not capture heterogeneity in inflation effects across different project cash flow components or the time-varying dynamics of inflation. While the classical discounted cash flow (DCF) approach adjusts cash flows using a single inflation rate, the following methodology incorporates heterogeneous inflation effects across different cash flow components and time periods, providing a more accurate and risk-aware project valuation. To address these limitations, this study proposes an enhanced methodological framework that integrates component-specific inflation indices and dynamic discounting, allowing for a more precise and risk-aware assessment of project efficiency under inflationary uncertainty.

The classical DCF approach assumes either homogeneous inflation or its implicit incorporation in a single discount rate. However, such simplifications can lead to systematic misestimation of project value, particularly in environments with heterogeneous and time-varying inflation dynamics that differently affect various cash flow components (e.g., revenues, costs, capital goods) [22; 23].

In capital budgeting, inflation impacts both future cash flow estimates and the required rate of return. If inflation expectations are embedded in the nominal discount rate, then the cash flows being discounted must also incorporate the same inflation expectations;

similarly, real cash flows should be discounted using real rates to ensure consistency [18]. Failure to maintain such consistency may lead to biased NPV and IRR estimates.

The relationship between nominal and real discount rates in the presence of inflation is formalised by the Fisher equation, which decomposes the nominal rate into real components and inflation expectations:

$$(1 + R_t) = (1 + r_t)(1 + \pi_t), \tag{8}$$

where R_t is the nominal rate, r_t is the real rate, and π_t is the expected inflation rate in period t [18; 24]. The Fisher effect underlies the correct conversion between real and nominal valuation bases and is widely recognised in investment appraisal literature.

Despite its theoretical grounding, aggregate (homogeneous) inflation adjustment does not account for the fact that different cash flow components may be influenced by inflation differently. For example, labour costs, raw material prices, and product prices often exhibit distinct inflation behaviour due to supply chain rigidities, competitive pressures, and regulatory constraints [22; 25]. Consequently, investment appraisal methods that rely on an aggregate inflation rate may mask asymmetric inflation effects, leading to undervaluation or overvaluation of projects – especially long-term, capital-intensive ones.

To address these limitations, this study proposes a multi-stage methodological framework that integrates heterogeneous inflation effects into cash flow modelling and discount rate determination. The procedure consists of the following steps:

- Identification of cash flow components – disaggregation of revenue streams, operating costs, capital expenditures, taxes, and working capital flows.
- Estimation of component-specific inflation indices – deriving or selecting inflation indices that reflect distinct price dynamics for each category rather than relying solely on aggregate indices.
- Transformation of nominal cash flows into real terms via component-specific deflators, isolating the inflation impact on each stream.
- Determination of dynamic discount rates using period-specific Fisher adjustments based on expected inflation forecasts.
- Calculation of performance metrics such as NPV, Profitability Index (PI), Internal Rate of Return (IRR), and discounted payback period (DPP) using inflation-adjusted cash flows and dynamic discounting.

– Scenario and sensitivity analysis to evaluate how alternative inflation profiles affect project performance.

– Stochastic analysis (e.g., Monte Carlo simulation) to quantify the impact of inflation uncertainty on investment outcomes [23; 26].

To operationalise the proposed methodological framework, the following mathematical formulations are applied. These express the dynamics of cash flows, inflation adjustment and discounting in a manner consistent with both theoretical foundations (real vs nominal valuation) and practical investment appraisal under inflation uncertainty.

1. Net Present Value with Component-Specific Inflation

The net present value (NPV) of an investment project adjusted for heterogeneous inflation is defined as:

$$\mathrm{NPV} = \sum_{t=1}^{n} \frac{CF_t^{\mathrm{real}}}{(1+r_t)^t} - IC \tag{9}$$

where CF_t^{real} is the real cash flow in period t, adjusted for component-specific inflation;

r_t is the real discount rate in period t;

IC represents initial capital investment;

n is the total number of periods in the project horizon [22; 24].

This formulation explicitly incorporates heterogeneous inflation effects across cash flow components, thereby addressing limitations inherent in homogeneous inflation models.

2. Transformation of Nominal to Real Cash Flows

Nominal cash flows are converted to their real equivalents using component-specific inflation deflators:

$$CF_t^{\mathrm{real}} = \frac{CF_t^{\mathrm{nom}}}{DF_t}, \quad DF_t = \prod_{k=1}^{t} (1+\pi_k^c) \qquad (10), (11)$$

where CF_t^{nom} denotes the nominal cash flow in period t;

DF_t is the deflator at period t;

π_k^c is the inflation rate specific to cash flow component c in period k [23; 25].

Using component-specific deflators enables isolation of inflation dynamics for distinct categories (e.g., revenues, operating costs, capital expenditures).

3. Dynamic Discount Rate via the Fisher Equation

The Fisher equation provides the theoretical basis for relating real and nominal discount rates in the presence of inflation:

$$R_t = (1 + r_t)(1 + \pi_t) - 1 \tag{12}$$

where R_t is the nominal discount rate in period t;

r_t is the real discount rate;

π_t is the expected inflation rate in period t [24; 27].

This relation ensures consistency between inflation-adjusted cash flows and appropriate discounting.

4. Scenario and Sensitivity Analysis

To assess the robustness of project performance under alternative inflation profiles, scenario analysis is employed:

$$\mathrm{NPV}_{\mathrm{scenario}} = \sum_{t=1}^{n} \frac{CF_t^{\mathrm{real}}(\pi_t^{\mathrm{scenario}})}{(1 + r_t)^t} - IC \tag{13}$$

where $\pi_t^{\mathrm{scenario}}$ represents inflation under a particular scenario (e.g., high, baseline, low). Scenario analysis allows identification of critical inflation thresholds affecting project viability.

5. Stochastic Modelling of Inflation: Monte Carlo Simulation

To quantify the impact of inflation uncertainty, inflation is modelled as a stochastic process, and a Monte Carlo simulation is performed:

$$\mathrm{NPV}_i = \sum_{t=1}^{n} \frac{CF_t^{\mathrm{real}}(\pi_{t,i})}{(1 + r_t)^t} - IC, \quad i = 1, \ldots, N \tag{14}$$

where $\pi_{t,i}$ is the random inflation rate for period t in simulation i;

N is the number of simulation iterations [28; 29].

This approach yields a distribution of NPV outcomes, enabling estimation of:

- the probability of positive NPV under uncertainty;
- the spread (dispersion) of NPV values;
- quantitative measures of risk exposure to inflation variability.

6. Performance Indicators under Heterogeneous Inflation

Using the inflation-adjusted cash flows and discount rates, key investment performance indicators are computed as follows:

- Profitability Index (*PI*):

$$PI = \frac{\sum_{t=1}^{n} \frac{CF_t^{\mathrm{real}}}{(1+r_t)^t}}{IC} \tag{15}$$

A *PI* > 1 indicates that the present value of future cash flows exceeds the initial investment.

- Internal Rate of Return (*IRR*):

IRR is defined as the discount rate r^* that satisfies:

$$0 = \sum_{t=1}^{n} \frac{CF_t^{\mathrm{real}}}{(1+r^*)^t} - IC \tag{16}$$

Unlike traditional *IRR*, here the cash flows are inflation-adjusted.

- Discounted Payback Period (*DPP)*:

The smallest *t* such that:

$$\sum_{k=1}^{t} \frac{CF_k^{\mathrm{real}}}{(1+r_k)^k} \geq IC \tag{17}$$

DPP gives the time required to recover the initial investment in present value terms.

This framework captures non-linear and asymmetric inflation impacts on valuation metrics, enhancing both theoretical coherence and practical relevance in investment decision-making. Compared to traditional homogeneous inflation models, the proposed method offers a more precise assessment of project profitability under inflationary uncertainty, improving risk awareness and strategic decision support.

The following analysis demonstrates the application of this heterogeneous inflation methodology to the same investment project previously evaluated using the classical *DCF* approach, allowing a direct comparison of results and illustrating the added accuracy and risk-awareness of the proposed method.

To illustrate the application of the proposed heterogeneous inflation methodology, consider an investment project with initial capital expenditures of 100,000 manat and projected nominal cash inflows over a five-year horizon. In this context, inflation does not affect all cash flow components uniformly; revenues and operating costs exhibit distinct inflation sensitivities. The forecasted annual inflation rates are assumed as follows:

$$\pi_t = \{8\%, 10\%, 12\%, 11\%, 9\%\}, \quad t = 1,\dots,5$$

The real discount rate is assumed at $r = 6\ \%$. Following the methodological framework presented above, nominal cash flows (CF_t^{nom}) are converted into real cash flows (CF_t^{real}) using component-specific deflators (10), and the real discount rate is transformed into the period-specific nominal rate (R_t) via the Fisher equation (12). This approach ensures consistency between inflation-adjusted cash flows and discounting, capturing the heterogeneity of inflation across project components.

Table 1 presents the resulting inflation-adjusted cash flows, nominal discount rates, and discounted cash flows for the project.

Table 1

Inflation-adjusted cash flows and discounted project values

Year	Nominal *CF*, manat	Inflation rate, %	Real *CF*, manat	Nominal discount rate, %	Discounted *CF*, manat
0	-100,000	–	-100,000	–	-100,000
1	95,000	8	87,963	14.48	76,821
2	110,000	10	90,909	16.60	66,784
3	130,000	12	92,557	18.72	56,493
4	150,000	11	98,705	17.66	57,011
5	160,000	9	104,094	15.54	50,267
NPV	–	–	–	–	207,376

Note: The table is compiled by the authors

The results in Table 1 demonstrate that accounting for heterogeneous inflation substantially modifies project valuation compared to the classical DCF approach, which assumes homogeneous inflation. Specifically, discounted cash flows in early periods are lower due to asymmetric inflation effects, while the overall net present value (NPV = 207,376 manat) exceeds the baseline NPV of 172,555 manat obtained under the standard homogeneous inflation assumption. These findings confirm that integrating component-specific inflation indices and dynamic period-specific discount rates (10-13) enhances the precision of project evaluation and provides a more risk-aware assessment of investment performance.

The increase in NPV under the heterogeneous inflation framework compared to the baseline homogeneous approach can be explained by the asymmetric inflation dynamics of different cash flow components. In the proposed example, revenue streams are assumed to be more sensitive to inflation than operating costs, reflecting typical market conditions where output prices adjust faster than input prices due to demand-side effects, contractual rigidities, and regulated cost structures. As a result, real revenue growth outpaces real cost growth, leading to higher real net cash flows and, consequently, a higher NPV. Therefore, heterogeneous inflation does not necessarily reduce project value; instead, it reveals the structural effects of inflation on different cash flow components, which are masked in the homogeneous inflation approach.

Following the methodological framework outlined in the previous sections, the proposed heterogeneous inflation approach is applied to the investment project. The evaluation proceeds in a stepwise manner, consistent with the theoretical foundations established earlier, ensuring that both cash flow transformation and discounting account for component-specific inflation effects.

Step 1. Conversion of Nominal Cash Flows to Real Cash Flows

Nominal cash flows (CF_t^{nom}) are first adjusted using component-specific deflators to isolate the effects of heterogeneous inflation across revenues and operating costs, as described in (10). The results of this conversion are presented in Table 2.

Table 2

Conversion of nominal cash flows to real cash flows (manat)

Year	Nominal *CF*	Inflation	Heterogeneity Adj.	Real *CF*
1	95,000	8%	1.1 / 0.9	87,963
2	110,000	10%	1.1 / 0.9	90,909
3	130,000	12%	1.1 / 0.9	92,557
4	150,000	11%	1.1 / 0.9	98,705
5	160,000	9%	1.1 / 0.9	104,094

Note: The table is compiled by the authors

Step 2. Discounting with Dynamic Fisher Rates

Once the nominal cash flows have been converted to real terms, the real cash flows (CF_t^{real}) are discounted using period-specific nominal discount rates (R_t) derived from the Fisher equation (12). This dynamic adjustment accounts for the time-varying impact of inflation on each period's cash flow, maintaining consistency with the theoretical framework established earlier. The discounted cash flows and resulting net present value (*NPV*) are summarized in Table 3.

Table 3

Discounting of real cash flows using dynamic Fisher-adjusted nominal rates (MANAT)

Year	Real *CF*	Nominal Discount Rate R_t	Discounted *CF*
0	-100,000	–	-100,000
1	87,963	14.48%	76,821
2	90,909	16.60%	66,784
3	92,557	18.72%	56,493
4	98,705	17.66%	57,011
5	104,094	15.54%	50,267
NPV	–	–	207,376

Note: The table is compiled by the authors

The results in Table 3 demonstrate that applying dynamic, period-specific discounting significantly affects project valuation. Compared to the classical homogeneous approach, the proposed methodology captures the nonlinear effects of inflation, leading to a more accurate and risk-aware estimate of NPV.

Step 3. Sensitivity Analysis

To evaluate the robustness of project performance under alternative inflation trajectories, a sensitivity analysis is conducted. This involves adjusting the forecasted inflation rates (π_t) by ±3 % to identify critical thresholds affecting NPV. The results are presented in Table 4 and visualized in Fig. 1.

Table 4

NPV under alternative inflation scenarios (MANAT)

Inflation Scenario	NPV, manat
Low (πt – 3%)	223,000
Baseline (πt)	207,376
High (πt + 3%)	185,000

Note: The table is compiled by the authors

The relationship between NPV and inflation is visualized in Fig. 1. This figure highlights how higher projected inflation reduces the present value of expected cash flows, while lower inflation increases project attractiveness.

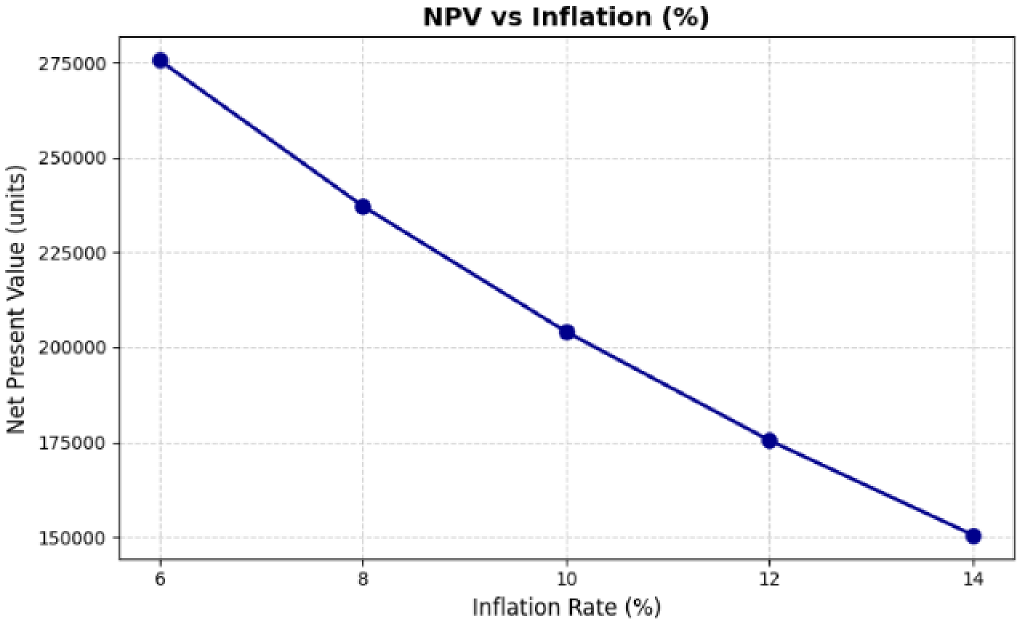

Fig. 1. **Sensitivity of project NPV to inflation scenarios**

This figure illustrates the nonlinear relationship between projected inflation and NPV, emphasizing the importance of incorporating component-specific inflation adjustments. As expected, higher inflation generally reduces the present value of expected cash flows, while lower inflation enhances project attractiveness. However, when cash flows are adjusted for heterogeneous inflation, the NPV is higher than the baseline homogeneous scenario at each inflation level. This outcome arises from the asymmetric sensitivity of revenues and costs: revenue streams respond more strongly to inflation than operating costs, partially offsetting the discounting effect. Thus, the heterogeneous inflation methodology provides a more accurate and risk-aware assessment of project performance under inflationary uncertainty, without implying that NPV increases with higher inflation.

Step 4. Monte Carlo Simulation for Stochastic Inflation

To incorporate inflation uncertainty into the project evaluation framework, the inflation rate πt is modeled as a stochastic variable following a normal distribution with a standard deviation of σ = 2 %.

This assumption reflects empirical evidence on moderate inflation volatility in emerging and transition economies.

Formally, inflation in each simulation run i and period t is generated as:

$$\pi_{t,i} = \bar{\pi}_t + \sigma_\pi \cdot \varepsilon_{t,i}, \quad \varepsilon_{t,i} \sim N(0,1), \tag{18}$$

where $\bar{\pi}_t$ denotes the baseline inflation forecast and σ_π represents the standard deviation of inflation shocks.

Revenue and cost cash flows are indexed to heterogeneous inflation processes. In particular, revenue inflation is assumed to exceed cost inflation due to asymmetric price pass-through and partial cost indexation. This structural assumption explains why NPV under heterogeneous inflation is relatively higher compared to the baseline homogeneous scenario, even though NPV still decreases as overall inflation rises.

A Monte Carlo simulation with 10,000 iterations is conducted to generate a probabilistic distribution of net present value (*NPV*). In each iteration, inflation paths are randomly generated, and corresponding nominal discount rates are computed using the Fisher equation, followed by recalculation of inflation-adjusted cash flows and discounted values. This approach enables a comprehensive assessment of downside risk and variability in project outcomes.

The simulation results indicate the following key statistical characteristics of the NPV distribution:

- Mean NPV: 207,100 manat
- Probability of positive NPV: 92 %
- 5th percentile NPV: 181,500 manat
- 95th percentile NPV: 228,500 manat

These results demonstrate that the project remains financially viable under stochastic inflation dynamics, with a high probability of positive economic value creation. The relatively narrow percentile range suggests moderate risk exposure, while the asymmetric dispersion of outcomes confirms the nonlinear impact of inflation uncertainty on investment efficiency.

The Monte Carlo framework thus complements the deterministic sensitivity analysis by quantifying the probability distribution of project performance indicators. Incorporating heterogeneous inflation effects and stochastic modeling provides a more robust and risk-aware decision-support tool compared to traditional deterministic discounted cash flow methods.

This study contributes to the investment appraisal literature by proposing a heterogeneous inflation-adjusted valuation framework that integrates component-specific deflators, dynamic Fisher-based discount-ting, and stochastic inflation modeling. Unlike existing homogeneous inflation approaches, the proposed model captures asymmetric inflation effects across cash flow components and time, thereby reducing systematic valuation bias.

Thus, the proposed methodology for evaluating investment projects under heterogeneous inflation differs from existing approaches by accounting for component-specific effects of inflation on individual cash flows, applying dynamic discount rates based on period-specific Fisher adjustments, and integrating scenario and stochastic analyses to assess inflation risk and uncertainty. This framework enables more accurate forecasting of net present value (NPV) and other performance indicators, improves the objectivity of risk assessment, and provides a robust basis for strategic decision-making under inflationary uncertainty. Consequently, the methodology makes a significant contribution to the development of scientific approaches for investment project evaluation in contemporary economic conditions.

Conclusion. This study demonstrates that incorporating heterogeneous inflation effects into investment project evaluation significantly improves the accuracy and risk-awareness of financial assessments. Unlike traditional approaches assuming homogeneous inflation, the proposed framework accounts for asymmetric inflation dynamics across different cash flow components, such as revenues and operating costs, and adjusts discount rates dynamically using period-specific Fisher-based calculations.

The analysis shows that higher projected inflation reduces the present value of expected cash flows and, consequently, lowers net present value (NPV), reflecting the typical inverse relationship between inflation and project profitability. However, when comparing the heterogeneous inflation scenario with the baseline homogeneous approach, the expected NPV is higher under heterogeneous assumptions, due to revenues being more sensitive to inflation than costs. This indicates that capturing component-specific inflation can reveal structural effects that are masked in conventional models, providing a more precise estimate of project value.

Scenario and sensitivity analyses confirm that the project remains financially viable under a range of inflation trajectories, while Monte Carlo simulation quantifies the probability distribution of NPV under stochastic inflation. The results indicate a high likelihood of positive project returns, moderate dispersion of outcomes, and non-linear risk exposure, highlighting the importance of stochastic modeling in investment appraisal under inflation uncertainty.

Overall, the proposed heterogeneous inflation-adjusted framework integrates component-specific deflators, dynamic discounting, and stochastic simulation, offering a robust tool for assessing project efficiency, enhancing decision-making under uncertainty, and reducing systematic valuation bias compared to classical homogeneous inflation models.

Conflict of Interest: The authors declare that they have no conflicts of interest.

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МЕТОДИ ОЦІНЮВАННЯ ЕФЕКТИВНОСТІ ІНВЕСТИЦІЙНИХ ПРОЄКТІВ В УМОВАХ ІНФЛЯЦІЇ

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Анотація. *Оцінка інвестиційних проєктів в умовах інфляції залишається ключовим викликом для дослідників та практиків, особливо щодо довгострокових, капіталомістких або інноваційних проєктів. Традиційні підходи, що часто припускають однорідну інфляцію та застосовують єдину ставку дисконтування, не здатні врахувати асиметричні та компонентно-специфічні ефекти інфляції на грошові потоки проєкту, що може призводити до упереджених оцінок прибутковості та ризику. У дослідженні пропонується комплексна методика оцінки інвестиційних проєктів за умов гетерогенної інфляції, яка інтегрує три ключові інновації: компонентно-специфічне коригування грошових потоків за допомогою дефляторів інфляції, динамічне визначення періодично-специфічних ставок дисконтування на основі рівняння Фішера та застосування сценарного й стохастичного аналізів для кількісної оцінки невизначеності та ризику. Методика дозволяє дисагрегувати доходи, операційні витрати, капітальні вкладення, податки та обігові кошти, забезпечуючи точне моделювання впливу інфляції на кожний компонент. Чутливісний аналіз та моделювання методом Монте-Карло використовуються для оцінки впливу альтернативних сценаріїв інфляції, надаючи ймовірнісний розподіл чистої приведеної вартості (NPV) та інших показників ефективності. Ілюстративний приклад демонструє, що врахування гетерогенної інфляції суттєво змінює оцінку проєкту порівняно з класичними підходами дисконтованих грошових потоків, виявляючи структурні ефекти, приховані за умов однорідної інфляції. Запропонована методика підвищує точність та об'єктивність оцінки проєктів, покращує обізнаність щодо ризиків і підтримує стратегічне прийняття рішень в умовах інфляційної невизначеності. Дослідження робить внесок у теорію оцінки інвестицій, пропонуючи практичний та надійний підхід, який враховує асиметричну та часозалежну динаміку інфляції та сприяє ефективнішому розподілу капіталу в сучасних економічних умовах.*

Ключові слова: *інфляція, інвестиційні проєкти, дебіторська заборгованість, кредиторська заборгованість, обігові кошти, цінові індекси, ставка дисконтування, поточні витрати, доходи, прогноз.*

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