



Comparison of NPV and IRR in Investment Decisions and Related Practical Applications

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Abstract. This paper contrasts net present value (NPV) and internal rate of return (IRR) as core discounted cash flow diagnostic indicators for investment decisions, linking their theoretical characteristics to practical evaluations. The study poses three questions: when and why these two standards align; when and why they diverge; and how analysts should construct decisions when diagnostic results conflict. Methodologically, this paper conducts a structured comparative analysis with practical case studies. The cases include: (i) scale conflicts in mutually exclusive choices; (ii) timing conflicts with equal initial expenditures; and (iii) non-normal cash flows with multiple sign changes. Key findings include: NPV is a proper value creation anchor because it aggregates in monetary units and aligns with portfolio selection; IRR remains useful for communication relative to minimum yield but must be interpreted within its mathematical boundaries; robust practice requires evaluating NPV within relevant cost of capital ranges rather than relying on a single rate. This paper provides a clear decision-making framework that coordinates these two metrics and clarifies their most relevant application areas.

Keywords: Net Present Value (NPV), Internal Rate of Return (IRR), Capital Budgeting.

1 Introduction

Capital budgeting for businesses and public institutions is based on discounted cash flow (DCF) analysis, with net present value (NPV) and internal rate of return (IRR) being the two most commonly used and widely applied criteria for project evaluation, with a reported prevalence of 70–100% [1]. NPV discounts each period's cash flow using an interest rate that reflects opportunity costs and risks, and aggregates them into an absolute wealth indicator, accepting projects with $NPV > 0$ [2] [1]. From another perspective IRR is the discount rate that sets NPV to zero and provides relative (per-period percentage) break-even returns for comparison with the firm's minimum required rate of return or weighted average cost of capital (WACC) [3]. Under normal (single-signed variation) cash flow conditions for independent projects, these two diagnostic methods are consistent: when the discount rate is lower than the internal rate of return (IRR), the net present value (NPV) is positive, and when the discount rate is

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higher than the internal rate of return (IRR), the net present value (NPV) is negative [4] [1].

1.1 Research Background: Current Status and Gaps

Although NPV and IRR are both based on the same discounted cash flow (DCF) method, extensive research has shown that there are systematic differences between them in real-world environments [5]. First, the scale effect emerges in mutually exclusive options: a smaller project may show a higher internal rate of return, but the dollar value it creates is negligible compared to a larger alternative; classroom and practical cases have quantified this gap [6] [7]. Second, time conflicts arise when initial costs are equal but inflow patterns differ; NPV-interest rate curves intersect, and sequencing is consequently dependent on the cost of capital region [5] [1] [8]. Third, non-normal cash flows with multiple sign changes can result in diverse or missing internal rates of return (IRR) because the TVM equation is an n -th-degree polynomial with n roots, making any single threshold rule ambiguous [9] [5]. Although practice typically favors using IRR as a percentage benchmark due to its communicability, academia emphasizes the additivity of NPV and its direct association with shareholder value, highlighting the gap between analytical guidance and managerial practice [6] [2].

1.2 Key Issues, Methods, and Content of This Study

This study addresses three questions:

- (i) Under what conditions are NPV and IRR consistent, and why are they consistent?
- (ii) Under what conditions do they diverge, and how do they diverge?
- (iii) When diagnostic results differ, how should analysts construct decisions?

The method employed is a comparative analysis that integrates case evidence on NPV curves, IRR, and issues related to scale, time, and non-normality, comparing their roles and potential issues across various scenarios [1] [5] [9] [8]. Throughout, net present value (NPV) serves as the anchor for value creation, as it is aggregated in monetary units and aligns with company-level valuation. The internal rate of return (IRR), on the other hand, is interpreted within its mathematical boundaries and used to measure performance relative to the weighted average cost of capital (WACC) [3] [1].

1.3 Research Objectives and Significance

This study aims to systematically compare net present value (NPV) and internal rate of return (IRR) to maximize their practical utility: to establish a benchmark for consistency under normal independent cash flow conditions; to diagnose and explain differences in mutually exclusive choices (scale and time); and to reveal how non-normal patterns render the single-rate rule ineffective [4] [6] [5] [9]. Its significance is profound. From an analytical perspective, it aligns the consistency of these two standards within the monetary time value identity and explains the specific domains where each standard provides guidance [1]. In practice, it aligns decision-making guidance with

real-world constraints and stakeholder communication, acknowledging that the industry continues to seek a single, consistent standard but often must make responsible judgments [10] [11].

2 Theoretical Foundations and Calculation Methods

2.1 Net Present Value (NPV)

Any critical and rigorous comparison of investment projects commences with the discounted cash flow logic: the net cash flows for each period are converted to today's monetary values and then they are added together [2]. Within this framework, net present value (NPV) measures the absolute wealth created by the project at a discount rate that reflects opportunity costs and risks [2]. Taking Q_t to denote the net cash flow in period t and E to denote the discount rate (e.g., the weighted average cost of capital), the standard discrete time expression is:

$$NPV = \sum_{t=0}^n \frac{C_t}{(1+r)^t} \quad (1)$$

The decision rule is straightforward: accept if $NPV > 0$, reject if $NPV < 0$, and treat $NPV \approx 0$ as marginal [1]. Two characteristics of net present value (NPV) make it central to capital budgeting. First, it is expressed in monetary terms and is therefore directly relevant to shareholder value maximization and business valuation practices based on discounted cash flow (DCF) methods [2] [1]. Second, it makes it easier to assess the sensitivity of financing costs and risks through the net present value curve (which maps discount rates to project values). Graphically, the net present value curve is typically a downward-sloping discount rate curve, which can be used to evaluate the robustness of a company's weighted average cost of capital (WACC) [1] [3]. In practical applications, even minor changes in the selected discount rate can alter the decision to accept or reject a project, which is why scenario analysis and sensitivity analysis of net present values at different reasonable interest rates are standard practices [8]. Finally, the net present value (NPV) curve encodes a basic yet decision-relevant relationship with the internal rate of return (IRR). The NPV curve intersects the x-axis ($NPV = 0$) precisely at the project's IRR; discount rates below this intersection yield a positive NPV, while those above it yield a negative NPV [1] [12]. This relationship is useful when communicating with interest rate-oriented managers, but it does not alter the primary role of NPV: by expressing value in monetary terms under specific capital opportunity costs, NPV provides the most direct standard for measuring whether a project increases corporate wealth [2] [1]

2.2 Internal Rate of Return (IRR)

Where NPV evaluates value at a given discounted rate, the Internal Rate of Return (IRR) finds the rate r^* that drives the same NPV expression to zero:

$$0 = \sum_{t=0}^n \frac{c_t}{(1+r^*)^t} \quad (2)$$

The IRR is a relative (percentage) metric that shows the break-even rate of return incorporated into a project's cash flows. It allows for a direct comparison with a company's cost of capital or minimum required rate of return, which makes it easier to decide whether to accept or reject the project. [13] [4] [11]. The corresponding decision rule is straightforward: the project should be rejected if the IRR is less than the benchmark such as the weighted average cost of capital. [13] [4]. The IRR is the project's net present value (NPV) curve's x-axis intercept, or the discount rate at which the curve crosses zero, represented graphically. [1] [12]. The enduring popularity of IRR in practice stems from two reasons. First, as a scale-free percentage, it is intuitive for managers who are trained to assess performance based on the required rate, and surveys consistently show that it is widely used alongside net present value (NPV) [11] [5]. However, the interpretation and use of IRR depends largely on the structure of the cash flows. Under a “non-normal” pattern (multiple sign changes), the net present value polynomial may have multiple real roots or no real roots, resulting in multiple internal rates of return (IRR) or no finite internal rate of return (IRR), thereby undermining the uniqueness of the decision threshold [9] [12] [5]. When ranking mutually exclusive projects, the internal rate of return (IRR) and the net present value (NPV) may disagree even when cash flows are normal. This is because the IRR does not account for the absolute size of the investment and may be sensitive to time differences, which can cause ranking reversals as the discount rate fluctuates. [1] [7] [8]. In such cases, projects with higher IRRs may create less dollar value than projects with lower IRRs but larger present value surpluses [11]. The reinvestment assumption is another explanation. Comparing projects with different cash flow timings can be distorted by the traditional interpretation of the internal rate of return, which is usually understood to mean reinvesting intermediate positive cash flows at the internal rate of return itself. [14] [3]. Therefore, the internal rate of return (IRR) should not be interpreted as a guaranteed compound interest rate for intermediate returns, but rather as the discount rate that solves for net present value (NPV) = 0. [9] [14]. Taken together, these characteristics explain why the internal rate of return (IRR) is highly informative in measuring performance relative to a threshold but must be used cautiously in cases involving non-normal cash flows, significant scale differences, or mutually exclusive alternatives [1] [7] [5].

3 Comparative Analysis

3.1 Agreement under Normal Cash Flows

One clear benchmark for understanding the NPV-IRR relationship is an independent project with normal cash flows (where there is only one sign change, and inflows occur earlier in the timeline while outflows occur later) [9] [13] [2]. Since IRR is the root of the NPV function, NPV and IRR now provide the same accept/reject choice. NPV is positive for discount rates below the IRR and negative for discount rates above the IRR. [4]. When normal cash flows occur, the NPV curve is a geometric identity that slopes

downward with the discount rate and intersects zero at the IRR. Therefore, these two indicators are merely different “perspectives” on a single function, rather than competing rules. This explains why NPV and IRR yield the same decision in an independent project setting [1] [4]. If a project category or a portion of an investment portfolio seems to have normal cash flows and independence, any discrepancy between the internal rate of return (IRR) and net present value (NPV) indicates a mistake in the NPV model like a mistake in the discount rate in the NPV worksheet or an incorrect interpretation of the IRR in relation to the company's threshold policy. Conversely, when either assumption (normality or independence) is violated, the discrepancy is not a flaw but a feature that requires analysis [1].

3.2 Scale Conflicts in Mutually Exclusive Choices

Scale is the most obvious reason for this discrepancy. Since the internal rate of return (IRR) is a ratio, the IRR of small projects may be higher than that of large projects that generate more total value, so it ranks small projects with higher returns before large projects with lower returns but greater absolute wealth creation; net present value (NPV), as an absolute monetary indicator, selects projects that create greater value. In Arshad's comprehensive analysis, a large project (-100,000; +50,000 over ten years) was compared with a small project (-1; +0.60 over ten years). The reported IRRs were 49.1% and 59.4%, respectively, but the NPVs were approximately \$202,704 and \$2.43—thus, the IRR rule alone would select the small project, while the NPV rule would decisively choose the large project [6]. The implication of this example is clear: when faced with mutually exclusive choices, we can use a value-priority strategy based on the verified weighted average cost of capital (WACC) and make selections using net present value (NPV) to avoid IRR inflation caused by denominator sensitivity [1]. Therefore, using IRR (or MIRR) becomes a communication and screening tool rather than a ranking criterion in itself [11]. Additionally, when stakeholders ask, “Why not use a higher percentage?” the above example specifically demonstrates that percentages can be misleading when dealing with absolute values. Scale may also interact with capital supply. Since NPV is additive across independent projects, portfolio selection with budget constraints can be transformed into portfolio optimization based on monetary value rather than interest rates [1] [13].

3.3 Timing Conflicts and Crossovers

When project expenditures are the same but the patterns of cash inflows across periods differ, the time factor can lead to a second type of ranking reversal. Osborne provides a concise example of Project A (back-loaded, with increasing cash inflows) and Project B (front-loaded cash inflows), both of which have the same initial cost, i.e., $I_0 = -100$. In the graph illustrating the connection between each project's net present value (NPV) and the discount rate, we can identify a crossover point. At low interest rates, Project A's later, larger inflows dominate; at high interest rates, Project B's earlier inflows dominate. The intersection of each NPV curve with the origin represents the project's internal rate of return (IRR) [5]. Analysis results indicate that when the relevant cost of

capital is not a constant but a range influenced by current financing and risk conditions, single-point comparisons may be misleading [1] [8].

3.4 Dealing with Non-normal Cash Flows

When the signs in a cash flow sequence change more than once, the internal rate of return (IRR) may cause problems. In such cases, the net present value polynomial we solve may have multiple roots or no roots at all, rendering the instruction “accept if $IRR \geq \text{hurdle}$ ” inapplicable. Johnstone provides a very rigorous example in his research, such as [-1200, 500, 850, 500] such a conventional sequence yields a unique 25% internal rate of return (IRR), but an unconventional sequence like [-1600, 10,000, -10,000] yields two IRRs—25% and 400%—both of which satisfy $NPV(r)=0$ [9]. Engineering project evaluations indicate that similar issues arise when financing withdrawals or interim liabilities are inserted after positive cash flows [12]. Remedial actions are usually taken in these situations from two angles. In order to maintain communicability and prevent confusion from multiple internal rates of return (IRRs), MIRR transforms the reinvestment assumption from the internal rate of return (IRR) to the cost of capital. This results in a unique interest rate that is consistent with the logic of the discounted cash flow (DCF) method. [11]. In terms of modeling, CAS/MCAS removes embedded reinvestment returns from the sequence, which typically restores a unique internal rate of return when non-normality is the cause of multiplicity [15] [3]. Regardless of the path taken, net present value (NPV) should serve as the anchor for the ranking itself, as it is unaffected by the ambiguity of multiple roots [2].

4 Case Analysis: Detailed Situations and Cross-case Conclusions

4.1 Large Versus Small, Mutually Exclusive Projects (Scale Conflict)

Comparing a "large-scale project with a lower internal rate of return" to a "small-scale project with a higher internal rate of return" is a common example of a scale conflict. In the comprehensive case study mentioned earlier involving Arshad, the large-scale project requires an investment of \$100,000, yielding an annual return of \$50,000 over 10 years; the small-scale project requires an investment of \$1, yielding an annual return of \$0.60 over 10 years. Both projects have stable and identical discount rates. Although the large project's internal rate of return is 49.1% and the small project's is 59.4%, the two projects have very different net present values (NPVs), with the large project valued at about \$202,704 and the small project valued at about \$2.43. Therefore, the net present value (the absolute value created) unmistakably indicates the large project, while the internal rate of return indicates the small project [6]. The same pattern shows up in practical data according to Juhász's cases study: B1 (expenditure of 50 million forints) has an internal rate of return (IRR) of about 25% and a net present value (NPV) of +14.4 million forints; B2 (expenditure of 125 million forints) has an IRR of about 20% and an NPV of +21.7 million forints; the IRR ranking favors the smaller B1, but

the NPV demonstrates that the larger B2 generates more wealth [7]. These examples summarize the underlying logic. IRR is a ratio and relative performance metric that may appear impressive on a smaller scale—while NPV is an absolute monetary metric that varies with the scale of cash inputs and returns [6] [7]. Since corporate value creation is additive when measured in dollars, NPV is additive across projects, but ratios are not. As a result, NPV provides consistent guidance for mutually exclusive choices when scales differ [1]. Across cases, the decision metrics we use are consistent: when projects are mutually exclusive and of different sizes, NPV reflects shareholder wealth creation; IRR can be retained for screening or communication purposes but should not override monetary metrics in cases of size conflict [6] [7] [1].

4.2 Same Initial Cost, Different Timing

When initial expenditures are the same, time factors alone can cause changes in the priority of NPV and IRR decisions. Osborne presents a typical comparative case where the initial investment $I_0 = -100$ applies to two projects: Project A has cash inflows that are delayed (30, 35, 45, 60), while Project B has cash inflows that are advanced (50, 50, 40, 20). In the net present value-discount rate curve intersection diagram he drew: at low discount rates, Project A dominates (later and larger cash flows), while at high discount rates, Project B dominates (earlier income), with the internal rate of return (IRR) located at the zero intersection point of the curve [5]. Mackevičius & Tomašević also describe the same effect: when cash flow patterns change over time, even if I_0 is equal, IRR and NPV often conflict; the intersection point where net present values are equal (the “Fisher point”) delineates the interest rate regions favorable to different projects [1]. Ren's example (with equal $CF_0 = -430$) illustrates the time reversal with specific numbers. Project A has higher back-loaded costs, with an internal rate of return (IRR) $\approx 20.44\%$; Project B has higher front-loaded costs, with an internal rate of return (IRR) $\approx 18.84\%$. At a zero discount rate, $NPVA = 197$, $NPVB = 278$, favoring B; as the discount rate increases, A's net present value decreases to zero at 20.44%, and the two intersect at approximately 15.29% (calculated via the “A-B” differential cash flow internal rate of return), precisely tracking the time-driven ranking reversal [8]. In summary, if I_0 is the same but the intertemporal patterns differ, the ranking depends on the interest rate; plotting the curve and identifying the intersection point can avoid single-point errors [5] [1] [8].

4.3 Non-normal Cash Flows and Multiple IRRs

When cash flow signs change multiple times (e.g., due to mid-term reinvestment, retirement costs, or financing flows), the net present value polynomial may have multiple real roots (or none), making it difficult to determine whether the “internal rate of return \geq threshold” is met. The project is treated as a virtual bank account in Johnston's teaching methodology: two internal rates of return (25 percent and 400 percent) satisfy net present value = 0 for alternating signs like [-1600, 10,000, -10,000], and the single rate decision rule fails for cash flows like [-1200, 500, 850, 500]. [9]. Osborne puts this in the commonly used TVM polynomial: a n-period cash flow equation has n roots (some

of which may be negative or complex), and when the sign is reversed, multiple actual IRRs are completely consistent with the algebra, so the “trap” is structural rather than a calculation error [5]. Irwanto's example demonstrates the existence of this error in practice. He shows that introducing negative cash flows after early positive cash inflows can yield two economically meaningful IRRs: one around 25% and another near 400%, at which point the NPV curve crosses zero twice—this is precisely the multiple IRR scenario that renders the single-threshold rule ineffective [12]. The implications are uncertain: if the internal rate of return (IRR) is not unique, comparing it with the minimum required rate of return (Hardle Rate) no longer yields a clear accept/reject decision [9] [12]. In practical applications, under non-normal cash flows, if the uniqueness assumption of the internal rate of return (IRR) fails, analysts should default to using net present value (NPV) for decision-making and exercise caution with IRR outputs. Before interpreting any “interest rate,” first verify whether the cash flow signs imply multiple roots [9] [12]. Mackevičius & Tomašević also attribute many IRR-NPV conflicts to the temporal distribution of cash flows, which exacerbates inconsistencies and multiplicity under non-normal conditions [1].

5 Conclusions

This study conducted a structured, practice-oriented comparison of the application of net present value (NPV) and internal rate of return (IRR) in investment decision-making. First, the study established a benchmark case consistent with both diagnostic methods: several independent projects with normal (single-sign variation) cash flows, as IRR is the root of the NPV function. Then, the study explained the reasons for discrepancies in real-world scenarios. There are three main scenarios: scale conflicts in mutually exclusive choices, where smaller projects may show higher percentage rates of return but create significantly less value; time conflicts, where initial expenditures are the same but intertemporal patterns differ, resulting in NPV interest rate curves crossing, with rankings dependent on the capital cost zone; and non-normal cash flows, where multiple sign changes may produce multiple or no IRRs, rendering any single threshold rule ambiguous. Across these cases, the core conclusion is clear: NPV should serve as the value creation anchor for ranking, while IRR, when interpreted within its mathematical limits, remains useful for conveying performance relative to a threshold and aiding managerial intuition. In practical application, verifying the net present value within the relevant discount rate range and checking the uniqueness of any calculated internal rate of return (IRR) are critical safeguards. This analysis integrates two widely used diagnostic methods into a single monetary time value framework and translates this integration into operational guidance. It reduces the risk of misranking projects with different sizes, timing, or cash flow patterns; it combines project evaluation with portfolio selection by leveraging the additivity of net present value; and it retains the communication advantages of IRR without allowing it to dominate decision-making in ways that may be misleading. Consequently, the framework can be used directly for capital budgeting, acquisition screening, and project prioritization.

The following areas warrant attention in the future: (1) Decision protocols that incorporate uncertainty in discount rates while strictly adhering to DCF logic; (2) Industry-specific evidence illustrating how scale and timing patterns manifest in practice, and the frequency of multiple IRR anomalies; (3) Behavioral drivers behind management's persistent preference for interest rate-based summaries, and how training materials can bridge this gap; (4) Tool support to automate net present value (NPV) overview visualization and internal rate of return (IRR) uniqueness checks for large project portfolios. These measures collectively strengthen the connection between rigorous financial analysis and day-to-day investment decisions. In addition to expanding industry-specific evidence and discount rate uncertainty, future research could use other potentially more precise metrics to assess decision accuracy, including: Standardized net present value (NPV%) and equivalent annual value (EAV) to compare alternatives of different sizes and durations on a common annualized basis; Adjusted Present Value (APV) to separate operational value from financing effects and test whether this decomposition improves ranking stability; Profitability Index (PI) and Incremental Net Present Value (NPV) for capital allocation portfolios, along with portfolio-level optimization.

These methods can quantify the aspects in which each alternative outperforms standard NPV/IRR in terms of out-of-sample decision accuracy and contribute to the development of toolkits for profile-based, risk-aware, and portfolio-consistent project selection.

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