The phased approach to time value of money in economic analysis of investment projects

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by

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Abstract

Method discounting cash flow (DCF) is analyzed in the article. Article is demonstrating complete economic insolvency DCF. The fallacy of discounting method causes serious distortion of the results. It's wide usage entails negative consequences not only for the concrete investor, but also for the economy on the whole.
The new method of the phased approach to time value of money in economic analysis of investment is represented in our article. The recommended phased method of allowing for the time factor is distinguished by:

- *reducing investment projects' (IP) cash flow to two evaluation aspects: investments by investment stage completion and cash flow by maintenance completion;*
- *allowing for investment stage fund freezing;*
- *exchange of discount factors for the financial market's capital accrual rate.*

To test operability of allowing for the time factor in modeling IP economic flows, banks' feasibility study of credit repayment was used.

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Important Issue. Methods of analyzing investment profitability developed in the 1960s were seen by analysts as hope for guaranteed economic success. These methods included discounted cash flow analysis (with risk/inflation sensitivity analysis), application of financial accounting methods, etc.

However, the initial high spirits aroused by the new methods of assessing investment decisions soon gave way to a period of debate and disheartenment as economic growth and production efficiency in the United States and other developed markets declined dramatically from the peak levels of the first three-quarters of the 20th century. Although market experts point to a number of factors that depressed growth, they fail to explain a significant portion of the reported decline.

Some analysts believe that the economic slump was triggered by the widespread use of the Net Present Value method, which resulted in lower investment volumes and performance. They argue that the discounting approach is biased against investments, as it makes managers see the future through discounted cash flows, which, like looking through the wrong end of a telescope, makes the future remoter, smaller and less valuable.

The adequacy of using the present value technique to model the generation of and changes in the time value of cash flows from an investment project is questionable, as demonstrated by the irrational nature of such changes. Upfront cash outflows in the investment phase and cash inflows in the operation phase are reduced evenly (under a compound interest formula) each year throughout the projection period by applying a discount rate to future cash flows to arrive at their present value (value at project inception). In practice, cash flow changes over time are uneven. Moreover, during the investment and operation phases, these changes have opposite effects on total investment performance. Thus, investment costs are assumed to be less than budgeted expenses while, in practice, from the project owner's point of view, real project implementation costs exceed the project budget. On the other hand, cash flows in the operation phase (investment return) are reduced over the project life at discount rates, which do not correlate with the timing of cash glow generation. As a result, the total estimated investment return is less than the reasonably expected amount.

The above approach to estimating diachronous costs and earnings produces estimates, which are far from the real picture. Therefore, we can reasonably expect that the actual costs and earnings of an investment project with a zero net present value will not be equal, as projected.

Net Present Value (NPV) is understood as a metric reflecting time-adjusted net return on an investment project. However, the NPV method assumes as natural a situation where separate discounted net income or depreciation charges do not compensate capital expenditure. As a result, the application of the NPV method makes a simple replacement of income-generating capital assets impossible: whatever the discount rate, the discounted amount of depreciation charge over the total useful life of any asset would be less than the present value of capital investments in the reproduction of a similar asset.

The total amount of depreciation can compensate initial investments only at a zero discount rate; i.e., when the discounted value (NPV) is replaced by an integral (not adjusted for time effects) net value (NV). Accordingly, it appears that the theory of monetary depreciation over time contradicts a fundamental economic principle, namely, that depreciation expenses accrued over the useful life of an asset will compensate its replacement.

The very structure of NPV makes no economic sense, since it represents net project income, which assumes that discounted investments can be equal to discounted net income plus depreciation. Similarly, a decision to implement or reject a project on the basis of NPV is equally senseless. Obviously, a situation where the amount of undiscounted net income and depreciation would not compensate the investment cannot be viewed as reasonable. The NPV structure is downright irrational, and its irrationality stems from the attempt to account for time effect by using a discounting method, which leads to depreciation of projected future cash flows as compared to actual earnings. Because of this depreciation of discounted future income, business owners develop a stereotyped negative perception that investments in real production are fruitless and unattractive.

Contradictions of the NPV method. The main elements of the theory (concept) of time value of money are the idea of analyzing alternative costs in estimating investment projects and the discounting technique, which applies the above idea and theoretical requirements to investment valuation practice.

The theory of time value of money is based on the idea that investment valuation will take opportunity costs into account. Thus, it assumes that, if a business owner or a company prefers to invest available capital in an investment project, instead of depositing cash in a bank or acquiring bonds, equities, etc., they would lose potential annual income from a bank deposit (other financial investment) while earning income from the project. In order to quantify such opportunity costs, a discounting factor (used to discount future income to its present value in the first year of investment), expressed as $\alpha_t=1/(1+r)^1$, is applied to each year to reduce income from an investment project. The higher the discount rate *r* is, the faster the discount scale slides down. Accordingly, higher alternative earnings would mean higher opportunity costs and more losses to be deducted from net cash flows in order to determine the value of an investment.

NPV calculations include hidden annual opportunity costs, which reduce cash flows from an investment project via the application of discount rates. As a result, instead of income from project implementation, the NPV metric actually represents the difference between actual income and income on financial markets that was lost. Thus, NPV represents not income from a project, as it is generally understood, but only a part (the effect) thereof. It indicates potential additional income from investments in a project instead of investments, say, in a bank deposit. Real project income is higher than NPV by the amount of bank interest or any other alternative earnings. Therefore, the interpretation of NPV as net project income appears incorrect.

In the system of argumentation supporting the discounting of future cash flows, all authors use bank loans and loan interest as alternatives to investment in a real project. However, only owners of large capital, such as financial and industrial groups, large holdings, banks etc., have access to the benefits of bank financing. For millions of companies and business owners, the only opportunity is to accumulate available cash in bank deposits, but even in this case their opportunity costs for investment valuation purposes should be lower. However, discount rates are based on interest rates. A good question arises: whose interests does the existing system of investment valuation serve, and who benefits from it?

Annual inflows and outflows of cash from an investment project are consistently adjusted (reduced) via the application of discount rates, which, according to the developers of this valuation technique, serve to subtract alternative income not received. In fact, the discounting technique is a process of charging a discount tax on the project being valued, where the discount (the difference between NV and NPV) is the amount of tax charged.

This «discount tax» is charged at a relative rate for each year in the projected period. At r=0.1, it will be equal to (1- 0.91) for Year 1, (1-0.83) for Year 2, and $1-1/(1+r)^t$ for Year t of a project. There is no specific alternative to a project, its parameters are determined mathematically using a discount rate. Thus, a set of mathematical templates is introduced into investment valuation practice, where the templates are differentiated by a discount rate and expressed as the generally known discounting scales.

While compound interest rates are applied to determine the amount of initial capital with interest thereon – $C_o(1+r)^1$, discount rates (the opposite of interest rates) are used to deduct interest income and discount capital to its present value $–C_o=C_t/(l+r)^t$. This method of calculating the time effect is accurate, but only for a bank account scenario. In practice, cash flows from a bank deposit and an investment project would grow differently.

In banks, the compound interest formula models a real capital increase process. A bank deposit generates income on the total amount of initial deposit and reinvested capital, which grows annually from the deposit date.

In investment projects, cash is transformed into immobile and much less liquid capital. Also, while investments in a bank deposit are a one-time expense, investments in a project are made over a certain period, sometimes several years. Only when a target asset is put into operation will it generate free cash flows annually. However, discount rates to be applied to such free cash flows are calculated for the period from project inception, rather than from the commencement of cash flow generation. Thus, the time lag (lead time on investment) is ignored.

With investments in real production projects, instead of income on invested capital, income growth will be driven by cash flows generated annually by a commissioned asset throughout its useful life. The total amount of cash flows over the project lifetime materially exceeds initial capital, which is being repaid by depreciation charges only. These free cash flows can easily be invested in bank deposits or other income-earning opportunities.

In summary, the advantages of a bank deposit scenario for generating return on invested capital include a minimum time lag between the date of deposit and the commencement of income generation and the accrual of income in all subsequent years on the total amount of invested capital plus interest thereon.

Meanwhile, the advantages of investments in a business project include guaranteed repayment of capital though the depreciation mechanism (subject to zero or low inflation), earnings in the form of annual net income, which exceeds bank interest, and the ability to earn additional (non-operating) income from cash flows invested in financial markets.

Based on a comparison of the above alternative investment opportunities, the adequacy of NPV assessments, which rely on the bank deposit model of income generation, appears doubtful when used to account for time effect in investment valuation, due to radical differences in time lag before income generation, as well as the basis, size, and structure of income, etc.

No wonder that the application of the existing theory of time value of money (depreciation of future cash flows) to investment valuation results in paradoxical situations and conclusions.

Thus, in any comparison of two investment projects, there will always be a hidden third one – an alternative investment opportunity; however, appraisers are often unaware of its existence. In fact, instead of total income from the two investment projects, they compare their effects, i.e., income from each project less income from the hidden alternative.

In addition to artificial uncertainties, the approach violates the common principle of comparing investment income rather than effect. It would be quite possible to estimate time-adjusted income from two, three or more investment projects, including the hidden alternative, and then come to a conclusion about which investment is more profitable and by what amount. Still, the application of this natural course of reasoning means the rejection of the existing time value of money theory, which is specifically based on the deduction of opportunity costs.

An analysis of investment performance based on discount metrics cannot answer the main question of the company or business owner: what real income is achievable? At what rate will income and other performance indicators grow? The NPV metric does not provide any clarity, as it represents merely a portion of actual income. Another portion of investment income, invisible to project owners, but often significant, disappears from sight into an unknown direction (and account). Unlike generally accepted and reasonable provisioning (estimated reduction), which sets aside a part of project income to cover potential inflation and risk losses, an alienation of a significant amount of earnings to compensate for the «negative effect» of the time factor on the basis of its present value appears both unreasonable and senseless. The use of the discounting technique results in «ritual» deduction of real cash from investment income as a tribute to the cult of the time value of money.

Discounted metrics are virtual and totally incompatible with real economic data. They cannot be used in business practice for planning purposes or in investment programs for business development.

The theory of the time value of money is fraught with controversy. For example, it assumes that time multiplies capital deposited in a bank (an alternative investment opportunity), while depreciating it in any other economic environment. The theory implies that time has a function of devaluating money, which, in actuality it does not. This fact is proven by practice: a $100 bill deposited in a bank safe will have the same nominal value in five years. In the absence of inflation, its purchasing power will also be the same at the beginning and end of the five-year period. (The purchasing power of Japanese yen on the domestic market remains unchanged for decades). Money devaluation can be triggered by inflation, financial crises or other force-majeure circumstances, but not time as such.

The application of discounting to present value takes investment projects out of their real environment and artificially puts them in a virtual world for valuation purposes. This process is always preceded by mandatory assumption of the following premises:

1. Whatever investment project is planned, bank investments are assumed to be the only alternative opportunity. This agreement makes it possible to take the time factor (i.e., estimate different weight of income and expenses spread across time) into account via a conditional (only at valuation) deduction of lost alternative income from actual net income of an investment project.

2. The fact that net investment income after discounting (NPV) represents only a portion of real investment income will be disregarded. Since each real investment project being compared undergoes the same discounting procedure, the comparison will be valid.

3. There is no need to be «distracted» by certain questions from business practitioners who do not understand the theory, namely:

- Why is 1 conditional currency unit (CCU) transformed into CCU0.39 by the 10th year of a project? *(They fail to realize that we do not cut CCU0.61 off a bank note, but revalue it. Isn't it obvious that if we lend CCU0.39 at 10% p.a. today, we will have CCU1 in 10 years?)*

- Why can't the result of investment valuation provide them with an estimate of total real income, which is the ultimate purpose of an investment project? *(They fail to realize that, in order to estimate the value of investment accurately, the project will be separated from the real world. However, after we have selected the best investment alternative, it will be quite easy for them to calculate income generated by it in the real world.)*.

If there were no other way to account correctly for the time factor, given the assumptions above, we would have to reconcile ourselves to the available theory. However, even the contradictions discussed and the drawbacks of the existing concept of estimating time effect, clearly visible to the unaided eye, lead to the conclusion that it is high time to put forward an alternative concept of investment valuation that is capable of modeling real cash flows from investment projects over time and reflecting changes in them driven by the time factor. To do so, let us expand the breadth and depth of our analysis.

True substance and shortcomings of NPV metric. To facilitate understanding of the issue, let us consider standard investment projects, the implementation of which involves the following:

- At first, cash will be spent (cash outflow), and cash inflows can only be expected thereafter;

- Methodological tools of accounting for inflation rate and risks in investment valuation are well-developed and need no revision; to simplify the understanding of the time factor concept, zero inflation and risks are assumed;

- Investment payback is financed with net income and depreciation charges (cash flow); accordingly, all other intermediate metrics, such as sales, cost of sales, tax expenses, etc., are excluded from valuation to simplify the NPV formula and its analysis;

- Annual cash flows will be equal throughout the total investment period considered.

Investment valuation allows for two methods of reflecting the effect of time: the discounting of investment cash flows to their present value and the estimation of future value of cash flows, usually at the end of a project's lifespan (compounding). Both methods are applied when selecting the best possible financial decisions and in the valuation of going concern companies. However, in investment valuation, the discounting method dominates. It is commonly used as a working tool to estimate the effectiveness of investment projects worldwide, as well as in valuation literature and textbooks published by leading valuation specialists.

To obtain a clearer and broader understanding of our doubts concerning the existing concept of time factor correlations, it is useful to discuss both techniques (discounting and compounding) based on the same methodology. Additionally, contradictions identified help to find a way towards a rational solution of the issue. Table 1 summarizes our calculation of net present value (NPV) of investments in a production upgrade staged in two phases over two years, using the present value (PV) and future value (FV) methods.

In our case study, the investment stage consists of two years, with annual capital investments of 50, or a total of 100. The useful life of a new production line is 8 years, annual depreciation charge is 12.5 (100/8), annual net income is 4.08, annual cash flow is 16.58 (12.5+4.08), projection horizon is 10 years (2+8).

When Method A is applied, discount rates reduce actual annual capital expenditure for subsequent deduction from cash flows and NPV estimation, so that the amount of annual investments (at r=0.06) will now be 47.15 and 44.4. Actually, this fact contradicts real practice: budgeted capital expenditure on a project will increase for the amount of non-earned income for the period when capital does not work. But the discounting results in cost reduction instead of growth, which is wrong, as reduction is inconsistent with the actual project implementation process.

Now let us consider cash flows during the operation phase when the discounting method is used. In the first year of operation (third year from the initial investment), in order to be used in subsequent calculations, cash flows of 16.58 are adjusted for a discount rate of 0.84 and reduced to 13.93 (see Table 1, A). When a bank deposit in Year *t* is discounted to its present value ($K_o = \alpha_t K_t$) in Year t_o, its amount is reduced by the amount of real income gain. When cash flows from an investment project are discounted, they are reduced by the amount of non-existent income gain. As for cash flows of 13.93 in Year 1 of operations (Table 1,A), such a significant reduction in value can be interpreted as a penalty for getting into the «discounting line» only in Year t_3 instead of Year t_o. A similar fate, but with an even greater underserved reduction, will face cash flows in subsequent years.

It is perfectly obvious that, to align the deduction of bank interest income with the time of its origination in the operation phase, the discount rate scale needs to be shifted to the right by two years. If so shifted, discount rates applicable to cash flows from the project would be 0.943 (instead of 0.84) in the first year and 0.89 (instead of 0.792) in the second year. In that case, the real project life would be modeled correctly.

In general, the interpretation of the economic substance and quantitative results obtained from the calculation of NPV and its components under the discounting method is rather problematic, since the method replaces real processes and data with conditional items.

We can only state that, at each step of calculations, cash flows of an investment project are annually reduced, via discount rates, for an amount of cash «as if placed in a bank account» in Year t_0. The fact that free cash flows will occur in Year t, instead of Year t_0, is thus ignored.

Before moving on to a discussion of investment valuation results obtained via the application of the future value technique to the costs and cash flows of the same project, please note that the most important issue is to prove that, using this method, the net present value is also equal to zero (thus, both methods of time value adjustment fix the equality of costs and cash flows) and to interpret the economic substance of estimates obtained.

Accumulated future income (at the end of Year t_{10}), represented in our case study by the sum of cash flows (in equal annual amounts) multiplied by discount rates, are defined as the future value of annuity. It can be calculated using a general formula for unequal annual cash flows:

$$16.58\times1.504+16.58\times1.419+\ldots+16.58 = 164.15 \text{ (see Table 1, B);}$$

or with special pre-calculated tables with ready aggregate discount rates (in our case, 9.898):

$$16.58\times(1.504+1.419+...+1)=16.58\times9.898=164.15$$

Let us analyze the economic substance of the future value of accumulated earnings (in our case, the annuity) of 164.15. Cash flows for each year are accumulated and then multiplied by appropriate discount rates to arrive at their future value at the end of the projection period. The financial result of the investment project determined using the future value technique is unquestionable. It consists of the amount of net income and depreciation charges accrued for the total project lifetime plus interest on free cash invested in financial markets.

Next, we will discuss the calculation procedure and economic essence of estimating the future value of costs (investment) totaling 164.15 (Table 1, B). Our calculations assume that investments attain the target amount by yearend. Accordingly, in the remaining nine years of the projection period $t_2\div t_{10}$, first year investments are multiplied by a discount rate of 1.689 ($\beta=(1+0.06)^9$), and second year investments by a discount rate of 1.594. It can be easily seen that, in our case, 164.15 is the sum of capital invested over two years (100) and interest (64.15) accrued over 9 and 8 years on the first and second half of invested capital, respectively, if placed in financial markets at an interest rate of 6%. However, only cash invested in financial structures can earn income at compound interest on the total amount of capital (100) over the total projection period (8 and 9 years in our case study). The discount rate of 1.64x for investments in a real production project, which remain idle for two years only, also appears overstated. If we consider the situation from this point of view, serious discrepancies are obvious.

First, generally accepted procedures of discounting or compounding of investments in a project interpreted as NPV estimation, in fact, represent the estimation of comparable income from investments in material production and alternative investments in financial markets. The metric obtained as a result of the calculations above (a difference between cash flows generated by capital and financial investments) reflects the effect of investments in real production projects rather than their NPV (net present value of investments).

Second, benefits from investments are believed to be equal on the basis of equality of cash flows (164.15) instead of net income (earnings), which is incorrect. Obviously, the two opportunities will no longer be equally profitable if cash flows are the same but costs are different (as will be demonstrated later in our case study). Accordingly, equal benefits from investments in financial investments and a real project, as well as the ability of a project to reimburse and pay back a loan from accumulated cash flows, can only be possible if net income is equal in both cases. This equality is stated by both approaches to time value of money but unattainable in practice.

To prove the statement above, a model of loan repayment by a borrower will be used

(Table 2). All input data for the model will be taken from Table 1, A and comments thereto. Additional information can be summarized as follows: the loan is issued in two tranches of 50 in the beginning of each year of construction and has a maturity of 10 years. Loan repayment is expected to be financed with amortization expenses charged annually at 12.5 over 8 years of project operation. If net income is insufficient on the date of interest payment (at 6% p.a.), the outstanding balance is capitalized into the loan principal, while excessive net income is used to repay the loan principal.

The resulting estimates, summarized in Table 2, demonstrate that, contrary to the theory of cash devaluation over time, if NPV=0 (which means that the discounted cash flows are equal to investments), net income will be insufficient to pay loan interest (outstanding balance: 9.92). If the amount of accrued interest is 42.56, the outstanding portion not covered by the return on investments will be 22%.

A small increase in the return on project assets, e.g., from 4.08%, which means a zero NPV (see Table 1), to 4.5%, does little to improve the situation. In this case, annual net income will increase from 4.08 to 4.5, and NPV_{IP} will become positive.

Even now net income from the investment project is insufficient to cover the interest payments due to the investor. The above analysis leads to the following conclusions:

1. NPV does not represent net income of an investment project. Instead, it represents the result of its comparison to a financial investment.

2. If NPV=0, the investment project does not demonstrate the expected credit solvency.

3. The incorrectness of measurements based on equal cash flows from capital and financial investments, irrespective of potential difference in costs, is clearly demonstrated (Table 3). The methodology fails to take into account the fact that capital and financial investments can be equally profitable only if net income (rather than cash flows) is the same.

4. We can state with certainty that the functional parameters and objective of NPV can be much better and more clearly realized in a standard bank loan repayment model, which does not rely on discounting technique and the theory of time value of money (Table 2). Such calculations are an integral part of any loan agreement and they can determine the real income available to the owner of an investment project in each year of the projection period.

As can be seen, no solution to the important issue of estimating the value of investment projects, as separate systems interacting with the real economic environment, including the time effect thereon, has been found yet. The existing concept of applying discounting methods in order to acknowledge the time factor (the dominant approach in investment valuation) interprets financial investments as an antipode to capital investment projects and a factor leading to devaluation of project earnings. However, financial markets are an integral part of any investment activity and an instrument of accumulating investment resources. To analyze the gaps in current solutions to the issue in more detail and find a reasonable answer to the question of what benefit can be obtained from an investment project on a standalone, rather than comparative, basis let us discuss Table 3, which is based on data from Table 1, B.

Modeling the real effect of time on cash flows of an investment project. The modeling of project costs using the future value method (Table 3, 1b), in fact, represents the estimation of future value of two bank deposits placed at the end of the first and second years of the projection period, respectively.

Financial investments (in bank deposits, equity or debt securities) are one-off costs unaffected by the factor of time. The position of both deposits on the time scale meets the requirements of the discounting /compounding method – they occur at the end of the first and second years of investments. By the end of the projection period, the amount of deposits with interest accrued will grow to 164.15, and the resulting income of 64.15 (164.15-100), is unquestionable, if we consider financial investments instead of capital ones.

The inconsistencies become evident when we try to estimate the amount of investments (costs) that has to be deducted from cash flows generated by an investment project to determine the net income thereof. Using the future value method, investments in the project are separated from it and represented by two placements (e.g., bank deposits). The estimated future value of such placements at the end of the projection period is used as the basis for comparison with the investment project. As a financial alternative to investments in real production, such manipulation is quite correct. However, in this situation, the financial result of the project remains without investments (K=0).

It is true that the budgeted capital (100) transformed upon completion of the construction process (t_2) into production assets is included in the future value of project cash flows in the form of amortization charges of 12.5 spread over the years. Since the future value technique is applied to a completed and operating production project, when capital investments in the budgeted amount (at actual value without any adjustment for the time factor) are already included in balance sheet assets as plant and equipment and the timing of construction and allocation of investments over years are no longer of any relevance, the inclusion of the budgeted value of the project in the amount of 100 (the value of production assets is 100) reflects this specific situation adequately. With these economic assumptions, the future value of the net income of an operating business (not an investment project), would actually be 64.15 (164.15–100). In this case, the net income of financial investments and an operating business will, in fact, be equal (64.15).

However, in investment valuation analysis, the duration of the construction stage and the allocation of capital investments over years are critical factors, as in the situation when capital is tied up temporarily and actual project implementation costs depend directly thereon. Also, actual costs of implementing an investment project exceed budgeted costs reported in the balance sheet. Table 3 (II) clearly illustrates the investment stage with the assumed allocation of investments of 50 in each year. The theory and practice of investment feasibility studies commonly use Model A for calculating the future value of investments at the date a project is put into operation, while we recommend Model B. The two models have different discount rates and, accordingly, a different increase of actual costs vs. budget. Model A provides for a lesser burden of capital investments tied up compared to Model B. We will discuss which model is more justified later in the study, but now it should be noted that the estimated amount of investments with a minimum tie-up of capital (A) is 103, which exceeds the amount obtained under the future value method – 100 (12.5×8) (Table 3, II, A).

The increase in project implementation costs leads to a decrease in net income from 64.15 to 61.15 (164.15-103), according to Table 3, II, A, which means that the balance of the future value of costs and project cash flows fixed under the two methods (zero NPV in both cases) does not exist in practice: net income on financial investments is not equal to net income on capital investments. Net income on an investment project adjusted for the time value of money is less than net income on financial investments. For this very reason, in the case of a bank loan, the loan amount will be refinanced with depreciation charges, but net income will be insufficient to cover interest payments (see Table 2). Project owners will be unable to meet their debt obligations. Our conclusion means that both existing methods of taking the factor of time into account in estimating investment performance are incorrect. Moreover, the discounting technique does not provide any constructive basis or elements to build a more advanced methodology of estimating the effect of time.

The issue of estimating net income of capital investments calls for methodological clarity of calculating the costs of implementing a project and the time effect thereon. We believe that this clarity can be ensured by answering three questions:

1) Which method should be taken as a basis: the present or future value of cash inflows and outflows?
2) Which points on the timescale should be used for cash flow discounting or

compounding?

3) How should discount rates (reflecting the time value of money) be determined on the timescale?

Answers to the above questions, in the same order, are as follows.

The future value method should be taken as the basis. On the theoretical level, it ensures a clear interpretation of events; on the practical level – the understanding by a business owner of the real benefits of an investment project. Most importantly, the conditional amounts in the discounting formula should be replaced with real numbers.

The future value should be determined as of the date the project is put into operation, which marks the end of the investment phase. Investments in a production project lose their monetary value and liquidity as they are transformed into tangible elements of the project at the commencement of its implementation. By the time the project becomes operational, the loss-making process of investment transformation from monetary form into tangible assets ends in the creation of operating production assets, which generate cash flows, but, unlike cash, cannot be put to use on financial markets.

Table 3 (II) presents two possible models for estimating the future value of capital investments as of the date the project is put into operation (t_2), using different discount rates. Model A was commonly applied in Soviet economic practice to determine the rational allocation of capital expenditure over the plant construction period. In fact, it is based on revaluation of investments at the end of each year, which, as can easily be observed, corresponds to the estimation of future value of cash flows (see Table 1B). However, it is unable fully to estimate lost profit on tied-up capital.

Model B is supported by the following considerations. From a lender's point of view, the loan issued should generate an income of 6% p.a. at the end of each year. Accordingly, the beginning of each year is the date from which the obligations of the borrower accrue. From the point of view of companies or business owners, the cash needed to finance the implementation of the investment plan (schedule) is required by the beginning of the new year in order to pay for the purchase and delivery of metal structures, equipment, reinforced concrete, etc., to the construction site. Freedom of settlements facilitates maximum coordination in time of services provided by different contractors, to avoid any construction delays. When own (accumulated) capital is invested, losses are represented by lost interest on amounts transferred from a time deposit to a current account. However, when investments are financed with bank loans, losses in the form of loan interest become real.

The results of modeling loan principal and interest repayment also prove, in real figures, the correctness of Model B (see Table 2, column 2, line 3: the amount of loan at the beginning of Year 3 is 109.18).

When the time interval for estimating the effect of time (tying up of investments) and the date of future value and interest rates are determined, the formula for calculating net income of an investment project, adjusted for time value of money, is derived. In real figures (Table 3, II, B), it can be expressed as follows:

$$NPV_{ip}=(12.5+4.08)\times 9.898-50\times(1.124+1.06) = 54.95$$

In this formula, the decreased amount is the future value of an annuity (in our case, annual depreciation charges (12.5) and net income amounts (4.08) are constant). Since the amount of project costs increased (due to lost profit on tied up capital) to 109.2 vs. 100 used initially in estimating the future value of cash outflows, the real net present value of the investment project is reduced from 64.15 to 54.95. Now, to make the investment project profitable as financial investments, its cash flows have to be increased. That increase can be achieved only by increasing annual net income: the budgeted project costs (and, accordingly, annual depreciation charges) must remain the same, and discount rates should not change either.

Using the new method of estimating project costs (109.18) and a separate analysis of net income of financial and capital investments, when both income flows are equal, the loan obtained to finance the project will be reimbursed and repaid, as demonstrated by calculations based on the model in Table 2 above. This result supports the correctness of a new metric – NPT_{ip} (Net Profit in Time), while the common discounted indicator of investment performance (NPV) is proven to be inaccurate.

Since we have fully rejected the basis and all associated attributes of the discounting approach, we will use the term «Net Profit in Time» (NPT) to indicate the counterpart of the net present value (NPV) suggested above.

Key principles of a phased approach to time value of money. The critically important assumption underlying the new method is the choice of the point in time for estimating the future value of investments (costs) and cash flows (financial result) – the end of the investment phase and the end of the operating phase, respectively. This choice contradicts the postulate of the TVM theory that assumes a single valuation point in time and recommends setting it in the beginning of the projection period. Our recommendation is based on the only possible way to calculate inevitable financial losses in the investment phase and possible financial gains in the operating phase.

Keeping in mind the importance of this decision, we will explain its motivation once again. There can be no arguments against the suggested method for estimating the future value of cash flows from an investment project (as of the end of the projection period), since it repeats generally accepted and commonly applied procedures (albeit, for different purposes) and mathematical formulae of the future value method.

As for the effect of time on capital investments in production projects, the main issue is how to reflect it correctly. The choice is limited to estimating the value of investments at the end of the investment phase or at the end of the projection period. We believe it economically unreasonable to determine the future value of investments materialized in the form of production assets and, accordingly, no longer liquid, as of the end of the operating phase. The process of their transformation into non-liquid assets is completed on the date when the project becomes operational. Thus, this is the first point in time at which the budgeted and real project costs of the investment phase can be accurately valued. Next, the effect of time is estimated using the generally accepted method for cash flows generated in the operating phase by newly built production assets and, in this case, the point of time for cash flow valuation will be the end of the projection period.

At this stage of our study, we have grounds to say that the accepted concept and methodology of using present value metrics to estimate the time effect on the value of investment projects can be replaced with the opposite approach, which, instead of systematically depreciating nominal future cash inflows and outflows of a project, retains their real value and adds up lost profit from capital tied up in the investment phase and secondary (non-operating) income in the operating phase from the investment of free cash flows in financial markets. In this case, instead of potential losses, the resulting value reflects the real benefits from the investment project plus a rational utilization of free project cash flows. This approach helps to model the real business processes of an investment project adequately.

The proposed concept of estimating the effect of time on the value of investment projects is based on a theoretical premise, which contradicts the currently accepted practice. Obviously, a ruble of income today is worth more than a ruble in future, since its reasonable investment will generate secondary income on financial markets each year in the future. The closer the ruble is to the initial date of project operation (and further from the end of the project's useful life), the higher the income will be that it can generate. However, instead of artificial depreciation of future cash as compared to its value in the base period, the difference in time value of money should be estimated by calculating and taking into account real earnings from the investment of cash flows of the past period in bank deposits, bonds, etc. The economic indicators of the project should retain the same nominal value in each year of the projection period and differ at the valuation date only by accrued amounts of non-operating income in the operating phase and loses in the investment phase.

Our theoretical premise can be summarized as follows: time increases, rather than decreases, income from an investment project. The new method of estimating the effect of time on the value of an investment project, based on the above premise, relies on the following principal assumptions.

As a result of an investment valuation analysis, business entities should be able not only to conclude whether an investment alternative is more profitable or totally unacceptable, but also estimate the amount of additional net income (in real terms) that they can expect from project implementation, if acting reasonably. Project financials (income, margin, etc.) in any year of its lifecycle should correlate with real business results.

The results of an investment project are strongly affected by inflation rates, risks and so on. Methodological tools for estimating these factors in investment valuation have been developed and are not revised herein. To facilitate the understanding of the new approach to time factor estimation, we assume in our study the absence of any inflation and risks.

An investment project is treated as an independent and self-sufficient system functioning in a real economic environment. Benefits and losses of the system analyzed for valuation purposes should be as close as possible to actual future data and correspond to accounting principles and financial reports. Accordingly, we view the financial market as an open instrument for multiplying one’s savings, rather than a forcibly imposed alternative with mandatory discounts charged on project income. The free cash flows of an investment project will be really (not theoretically, as with the discounting method) invested in financial markets to generate additional income. Obviously, the potential ability of annual cash flows to generate secondary (non-operating) income will be different and decrease by the end of the project’s life. This assumption will determine the difference in the estimated value of cash inflows and outflows occurring at different points in time and thus create the basis for estimating the effect of time using the new approach.

The main point of the suggested approach to the effect of time on estimated investment performance is recognition of the fact that the result of an investment project is driven by two components: operating income, which depends on project profitability, and income from the investment of free project cash flows in financial markets, which depends on interest rates and the period of availability of free cash flows. Accordingly, the comparability of cash inflows and outflows occurring at different points in time is achieved by measuring the effect of their investment (failure to invest) in financial markets for income generation purposes. The value of an investment project should be based both on the amount of specific inflows and outflows and on annual changes in their financial potential throughout the projection period. The mathematical implementation of the suggested approach is summarized in Table 4.

Expression of diachronous cash inflows and outflows of an investment project using the recommended method

Based on the analysis above, the mathematical expression of key elements used to arrive at investment value estimates can be formalized as follows:

Investment flow analysis. In the investment phase, owners of an investment project have to incur, in addition to direct (budgeted) capital expenditure, losses in the form of lost profit on capital tied up in the construction project and not invested in financial markets. If debt financing is obtained, owner losses have the form of loan interest payments.

The investment phase is preceded by the pre-investment phase. For major projects, this stage, which includes the preparation of a feasibility study (investment project valuation), can take several years and involve significant expenses. We believe that this stage can be excluded from the investment period to avoid further complication of valuation procedures. Associated costs can be added to expenses of the first year in the investment phase.

For investment project valuation purposes, we recommend formula (1), which estimates project costs plus financial losses (future value date - T_c, Table 4), with cash outflows revalued as of the beginning of each year.

Cash flow stream. The depreciation charge and net income of each year remain available to the company for operational purposes during the year, until their full amount is accumulated, and represent the company's financial reserve.

At the end of each year, the full amount of the annual depreciation charge and net income is invested in financial markets until the end of the project's useful life (future value date - T_p, Table 4). Cash flows generated the last year of project operation cannot be invested in bank deposits due to a lack of time.

Formulae (1) - (4) represent construction blocks to build the metrics for the new system of investment performance valuation. For example, they can be used to express the real Net Profit in Time of an investment project, as follows:

$$NPT = \sum_{t=T_c}^{T_p} (P_t + a_t)(1+\beta)^{T_p - t} - \sum_{t=1}^{T_c} K_t (1+\beta)^{T_c - (t-1)} \rightarrow \max \tag{5}$$

The economic effect (the correct term to define the metric currently known as NPV) of equal amounts ($K=K_f$) invested in capital assets simultaneously with financial investments is expressed as follows:

$$E_{ip} = \left[\sum_{t=T_C}^{T_p} (P_t + a_t)(1+\beta)^{T_p - t} - \sum_{t=0}^{T_c} K_t (1+\beta)^{T_c - (t-1)} \right] - \left[\sum_{t=0}^{T_p} K_{ft} (1+\beta)^t - \sum_{t=0}^{T_c} K_{ft} \right] \tag{6}$$

Equal profitability of capital and financial investments, interpreted as their equal Net Profit in Time, can be achieved at $E_{IP}=0$.

Novelty of the theoretical and practical aspects of the recommended method. Now we will return to the question of what is NPV, its substance and reliability. Economic literature interprets the balance of investments and financial results at NPV = 0 very broadly: as the ability of a project to finance the repayment of loan obligations, as equal profitability with financial investments, and as a lack of net income and, accordingly, the minimum limit of investment performance. Let us analyze all three interpretations.

The financial insolvency of investment projects at NPV=0 has already been demonstrated above (Table 2). We have also noted the incorrectness of comparing financial and capital investments using the future value method based on an analysis of investment performance only, without adjustments for a possible difference in associated costs (Table 1 and Table 3). Assuming the insolvency of capital investments at NPV = 0 as definitely proven, we will now analyze in more detail our view on all other interpretations of NPV.

Our analysis will be based on three investment projects (IP) with zero NPV that are equally profitable (unprofitable), since, in addition to equal NPV (0), they have the same PI (0) and IRR (8%).

Underlying assumptions common for all three projects are a construction phase of 2 years, operating phase (for the active portion of production assets) of 10 years, projection period of 12 years; discount rate of 8%.

The value of the passive part of the production assets is equal for all investment projects at 500; the value of active production assets is 1,000 for IP_1 and IP_2 and 500 for IP_3 (less advanced equipment and technology). Useful lives of production assets for depreciation purposes are assumed at 25 years for passive assets and 10 years for active assets.

IP_1. Investments – 750 (1^{st} year of construction) plus 750 (2^{nd} year), for a total of 1,500; annual net income – 112.44, annual depreciation charge – 120, cash flow – 232.44.

IP_2. Investments – 500+1,000 = 1,500; annual net income – 109.45, annual depreciation charge – 120, cash flow – 229.45.

IP_3. Investments – 500+500 = 1,000; annual net income – 84.96, annual depreciation charge – 70, cash flow – 154.96.

Investment value analysis based on the suggested NPT metric results in project differentiation by performance; i.e., the projects will not be equally profitable (Table 5).

As can be seen, if our method is applied, the projects, which appeared equal in terms of profitability (zero income) under the present value method, generate income and can be ranked as follows: IP_1 is the most profitable, while IP_3 is the least profitable (with a noticeable difference). The results of our analysis demonstrate once again that the existing and proposed investment valuation tools differ in the accuracy of selecting the best investment alternative.

To obtain deeper insight into the shortcomings of the future and present value techniques, let us analyze the results of both methods in a situation where NPV=0 is interpreted as equal discounted income from financial and capital investments (discount rate – 8%). Table 6 summarizes the comparison of net income for IP_1 using the existing and proposed approaches, and for alternative financial investment on similar terms.

The procedure of estimating the NPV of a capital project IP_1 under the present value method (Table 6, B) does not raise any questions, since the economic substance of NPV is strictly determined. However, the same procedure under the future value method (Table 6, C) brings to the fore serious deficiencies in the fundamentals of the existing approach to the estimation of time value of investments. These shortcomings have already been discussed above, but, seen in this light, give a better understanding of the theoretical and practical weakness of the generally accepted concept of time value estimation.

Cash flows from IP_1 estimated under the future value method are unquestionable; the fact of their comparison to cash flows from financial investments is unquestionable as well. But the interpretation of the difference between cash flows from capital and financial investments as net income of IP_1 is a gross theoretical mistake, since it represents the effect of capital and financial investments.

However, in our example, the net income of IP_1 can be easily determined. As a first approximation, the amount of cash flows has to be reduced for the amount of costs – 1,500 net of time effect. This methodologically incorrect procedure yields a conditional net income of IP_1:

$$NPT_{cond} = 3{,}368 - 1{,}500 = 1{,}868 \qquad (7)$$

The incorrectness of the above approach and the resulting value stems from the fact that an absolute, non-discounted amount of investments is used, i.e., the costs of IP_1 are not adjusted for the effect of time.

While recognizing that the application of the future value method to project cash flows results in an economically clear and, moreover, generally accepted interpretation of the situation, we have strong reasons to believe that the same approach will be appropriate in estimating the time value of investments. The objective decision to select the end of the investment phase as a date at which the future value is determined has been justified above and is expressed by formula (1).

The NPT of capital IP_1 calculated using a phased approach is 1,683, which is significantly less than the conditional net project value of 1, 868 calculated as the project's cash flows reduced by undiscounted costs of 1,500 (7).

The comparison of capital and financial investment performance is an important stage in selecting an investment alternative. According to Table 6, if the system of valuation is correct, the best capital investment project (IP_1) will have a lower net income (NPT_1 = 1,683) as compared to financial investments (NPT_f = 2,138). We have no reason to question the correctness of estimates for financial investments, while NPT_1, albeit calculated by an unrecognized method, has clear methodological grounds as compared to NPV definitions. The fact that all capital investment projects and the financial investment alternative are assumed to have equal profitability under both methods of estimating net present value (NPV = 0) is rather troubling, taking into account all the methodological shortcomings discussed above.

In addition to the methodological shortcomings of NPV described above, the lower net income of financial investments vs. capital investment projects is also explained by the non-comparability of the alternatives being compared, which is clearly demonstrated by future value analysis (Table 6, C). In our case, investments are made at the end of the first and second year of the project, while in practice the process of cash outflow in the investment phase begins on the first day of project implementation.

Under the existing investment valuation methods, investments are assumed to occur at year end, which is wrong, as noted above. As a rule, when the profitability of financial and capital investments is analyzed, the timing of investments should coincide. The proposed equation for calculating the economic effect of a capital investment project, as compared to financial investments, and demonstrating their equal profitability (6) meets the requirement above.

It shall be noted that the concentration of cash flows at the end of each year in the operating phase, assumed for the calculation of investment cash flows under the future value method, reduced the real cash accumulation potential of the capital investment projects. Nothing prevents a company from investing free cash in financial instruments on a monthly, or at least quarterly, basis. In this case, the discounted value would increase, but the calculations would become more time consuming and require more complicated formulae. Under the existing approach to estimating the results of a capital investment project, if its profitability is assumed to equal that of financial investments according to formula (6), the actual profitability of a capital investment will be slightly higher.

We also calculated the Net Profit in Time of IP_2 and IP_3, similarly to calculations for IP_1 presented in Table 6. The summary of results in Table 7 supports the last of our conclusions on the fairness or the strength or weakness of the existing interpretation of equal profitability of financial and capital investments at NPV = 0.

As can be seen, if compared to alternative financial investments of the same amount, duration and interest rate (8%), all three capital investment projects result in significant losses, although they are recognized as equally profitable (NPV = 0) under both existing valuation methods.

If we take the unquestionable net income of financial investments as the basis, then the measurement error of NPV calculation will be 21% for IP_1 and IP_3, and 23% for IP_2. On the other hand, the period required to compensate the lost profit of financial investments from annual net income will be 4.1 years for IP_1, 3.95 for IP_2 and 3.6 for IP_3. For projects with an operating phase of 10 years, that is clearly too long.

Summary of the analysis. Our findings support the conclusion that the balance of cash inflows and outflows of capital investment projects at NPV = 0 means neither the ability of a project to finance debt obligations (Table 2); nor equal profitability vs. alternative financial investments (Table 7); nor nullification of net income and the minimum limit of investment profitability; nor, finally, equal profitability of capital investment projects (Tables 5, 7). Moreover, the present value method fails to perform its main function of weighting cash inflows and outflows of an investment project occurring at different times. As an instrument of economic analysis of investments, this method has certain shortcomings.

The existing present and future value methods are the products of irrational modeling of cash flows in the investment phase of a project. As a result, indications of value estimated under these methods are inaccurate, do not fulfill their purpose and systematically underestimate the required profitability of capital investment projects. No results of cumbersome calculations of investment profitability using the present value techniques can be used (without reverse calculations) as a basis for estimating the performance of investment programs and real income growth in the course of project implementation.

If we proceed from the objective of analyzing benefits of a project rather than associates losses, integral cash flows plus non-operating income will significantly exceed original investments (these project inflows and outflows cannot be equal). Moreover, in certain cases, performance priorities of investment projects will change as well. Differences in the existing and recommended approaches to time value of money and the results thereof are illustrated by Figure 1. The real scale chart is based on the following investment project assumptions: K=100, T_c=2 years, T_{op}=10 years, T_p = 12 years, a = 7, P = 13, cash flow=20, β = 6% p.a.

Clearly, any business owner or company selecting a profitable investment project would like to know the amount of net income that can be expected from project implementation. Instead, an investment analysis based on the NPV concept and carried out to answer the question above results in an estimation of the so-called net present value, which represents the integral cash flows of the project analyzed, reduced (using an inconsistent procedure) by an amount of alternative income on a potential investment in a financial instrument. The resulting indication of net income ultimately received by the company could be relevant for an investment project financed with a loan, but it is totally unrepresentative of a situation where the company finances investments from own funds. In this case, the resulting NPV has no logical explanation.

The present value method excludes from the analysis the very idea of project cash flow accumulation, which is an integral element and a critical characteristic describing the economic potential of the capital asset reproduction process.

Discounting valuation techniques are used to estimate the solvency of investment projects instead of their profitability, which is a different notion and economic category. As a result, profitability is not measured, while solvency is only roughly estimated. However, the consequences of financing a project with borrowed capital can be estimated more fully and accurately in the process of analyzing its financial feasibility or in bank analysis of loan repayment, without any recourse to present value tools. The functional efficiency of the metrics used in the existing approach to investment performance analysis should be a subject of a separate study, but even at this stage it is obvious that further improvement of the approach should be focused mainly on the time value of money.

The phased approach to the time value of money, reflecting the specific nature of cash flows in the investment phase, can be used to build a clear and simple model of net income generated by an investment project, free from any philosophical aspects and the need to encode natural developments, as is typical of the present value method. It overcomes many theoretical inconsistencies and contradictions (e.g., that the sum of depreciation charges and net income does not compensate project investments or that the value of bank deposits increases in time while the value of investments in real projects decreases).

The resulting amounts of value in time are consistent with practical operating and accounting data. The approach and its substance can be easily understood by business owners, and the resulting definite estimates provide them with a clear answer about what benefits can be expected from project implementation.

The fundamental difference between the existing and suggested approaches to time value of money in investment valuation lies in the replacement of the basic idea underlying the valuation mechanism.

By replacing a virtual idea (analysis of an alternative to real investments) and a virtual mechanism of estimating the effect of time with real ones, we successfully overcome numerous qualitative and quantitative shortcomings of the discounting approach, namely:

- the interpretation of NPV as net income of an investment project, when in fact it represents a comparative metric (effect) – a difference between cash flows from capital and financial investments (while the difference in costs is ignored, Table 3);
- the inability of an investment project to finance loan interest payments from net income at NPV=0 (Table 2);
- the investment valuation theory has no metric for absolute Net Profit in Time of investments in a real production project or an NPT calculation methodology;
- cash inflows and outflows occurring at different points in time are valued as of the same date. This assumption ignores the transformation of investments from monetary into tangible (production) assets when the project is put into operation. This transformation prevents the use of relevant amounts as a source of interest income through the end of the projection period using the future value method. Accordingly, the estimated value of investments does not reflect the real situation due to an incorrect adjustment for the time value of money (Table 1, 3);
- the basis of discount rate application needs clarification: in the investment phase cash flows should be discounted as of the beginning of a year, and in the operating phase, at its end.

To check the efficiency of the existing and suggested approaches to the time value of money, we used a generally accepted model of analyzing bank loan reimbursement and repayment as a quantitative test to verify the correctness of the modeling of investment project cash flows (Table 2). The test confirmed the ineffectiveness of the discounting approach and the correctness of the suggested method.

The main features of the recommended phased approach to estimating the Net Profit in Time of investment projects, differentiating it from the discounted, or present, value, are:

- depreciation of nominal cash flows of an investment project over the projection period is replaced with their increase through investments in financial markets;
- discount rates are replaced with interest rates reflecting the additional income (costs) in financial markets;
- in the operating phase, the economic potential of a project will decrease on an annual basis; however, the total amount of income will grow steadily and attain its maximum level upon expiration of the project life (T_p – the point in time at which the future value of project cash flows is determined);
- capital tied up in the investment phase means losses for the company. The longer the period from the investment date to the date of putting the project into operation is (T_c – the point in time at which the future value of investments is determined), the larger the amount of losses is;
- introduction of new rates to adjust the value of an investment project for the effect of time: β – annual interest rate for temporarily free project cash flows invested in financial markets (the discount rate is not applied).

The recommended innovations will facilitate practical implementation of the new method of estimating cash inflows and outflows occurring at different points in time for investment project valuation purposes. However, we are faced with the issue of developing a new subsystem of metrics associated with net profit in time of investment projects, which cannot be analyzed within the limits of this article. This issue will be discussed in subsequent publications.

Table 1

NPV of an investment project estimated according to present value (PV) and future value (FV) methods

Phases of the life cycle		Investment		Operation ($t_3 \div t_{10}$)								TOTAL	NPV
Years of the projection period		t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}		
A. Discounting method (PV)	Discount rates (r=0.06), a_t	0.943	0.89	0.84	0.792	0.747	0.705	0.665	0.627	0.592	0.558		
	Investments (50+50=100)	47.15 (50x 0.943)	44.5	-	-	-	-	-	-	-	-	-91.65	0
	Cash flow (16.58)	-	-	13.93	13.13	12.39	11.69	11.03	10.4	9.82	9.25	91.65	
B. Compounding method (FV)	Discount rates (r=0.06)	1.689	1.594	1.504	1.419	1.338	1.262	1.191	1.124	1.06	1		
	Investments (50+50=100)	84.45 (50x 1.689)	79.7	-	-	-	-	-	-	-	-	-164.15	0
	Cash flow (16.58)	-	-	24.9	23.5	23.18	20.9	19.75	18.6	17.57	16.58	164.15	

Table 2

Loan and interest repayment model for an investment project with NPV=0

(all amounts are absolute and denominated in conditional currency units)

Year of projection period	Opening loan balance	Repayment at year end (amortization)	Interest due at year end (6% p.a.)	Net income at year end	Interest repaid at year end	Capitalized overdue interest (-), Accumulated cash (+)
1	50	0	3 (50x0.06)	0	0	-3 (0-3)
2	103 (53+50)	0	6.18 (103x0.06)	0	0	-6.18 (0-6.18)
3	109.18 (103+6.18)	12.5	6.55 (109.18x0.06)	4.08	4.08	-2.47 (4.08-6.55)
4	99.15 (109.18-12.5+2.47)	12.5	5.95 (99.15x0.06)	4.08	4.08	-1.87 (4.08-5.95)
5	88.52 (99.15-12.5+1.87)	12.5	5.31 (88.52x0.06)	4.08	4.08	-1.23 (4.08-5.31)
6	77.25 (88.52-12.5+1.23)	12.5	4.64 (77.25x0.06)	4.08	4.08	-0.56 (4.08-3.92)
7	65.31 (77.25-12.5+0.56)	12.5	3.92 (65.31x0.06)	4.08	3.92	+0.16 (4.08-3.92)
8	52.65 (65.31-12.5-0.16)	12.5	3.16 (52.56x0.06)	4.08	3.16	+0.92 (4.08-3.16)
9	39.23 (52.65-12.5-0.92)	12.5	2.35 (39.23x0.06)	4.08	2.35	+1.73 (4.08-2.35)
10	25 (39.23-12.5-1.73)	12.5	1.5 (25x0.06)	4.08	1.5	+2.58 (4.08-1.5)
Outstanding loan principal	9.92 (25-12.5-2.58)		42.56	32.64		

Table 3

Cash flow model of an investment project using the future value method and in real terms

Time scale		T_b T_c T_p t_0 t_1 t_2 t_3 t_4 t_9 t_{10}	Net income, adjusted for the time value of money (NPV)
I. Cash flows and costs of an investment project modeled under the FV method (I)	Cash flows	a Fixed assets = 100 К=0 *FV of project cash flows* *16.58×9.898 = 164.15*	NPV_{pa} = 164.15 – (12.5×8) = 64.15
	Costs (two bank deposits implied)	К=50 50×1.698 = 84.45 b К=50 50×1.594 = 79.7 FV of costs: 84,45 + 79,7 = 164,15	NPV_f = 164.15 – 50×2 = 64.15
II. Real cash flow model (II)		FV of investments 103 A 1,06 50 50 FV of investments – 109,2 *FV of cash flows - 164.15* B 1.124 1.06 50 50	NPV_{ip} = 164.15 – 103 = 61.15 NPV_{ip} = 164.15 – 109.20 = 54.95

Legend: ⊗ - future value date; ● - investment date; - - - period without investments; NPV_{pa}, NPV_f, NPV_{ip} – net income from existing fixed assets, financial investments, and investments in a production project, respectively, as adjusted for the time value of money.

Table 4

Formulae used to determine the time value of elements used in investment valuation

<table>
<tr><td colspan="2">Projection period</td><td colspan="3">Investment phase
T_b</td><td colspan="6">Operating phase
T_c ⊗ … T_p ⊗</td></tr>
<tr><td colspan="2">Time scale</td><td colspan="3">t_0 t_1 t_2</td><td colspan="6">t_3 t_4 t_5 t_{10} t_{11} t_{12} t_{13}</td></tr>
<tr><td colspan="2">Time factor, k_t</td><td>$(1+\beta)^3$</td><td>$(1+\beta)^2$</td><td>$(1+\beta)^1$</td><td>$(1+\beta)^9$</td><td>$(1+\beta)^8$</td><td>…</td><td>$(1+\beta)^2$</td><td>$(1+\beta)^1$</td><td>$(1+\beta)^0$</td></tr>
<tr><td rowspan="4">Valuation metrics equations</td><td>Investments, I</td><td colspan="3">$I=\sum_{t=1}^{T_c} K_t (1+\beta)^{T_c-(t-1)}$ (1)</td><td colspan="6"></td></tr>
<tr><td>Depreciation charges, D</td><td colspan="3"></td><td colspan="6">$D = \sum_{t=T_c}^{T_p} a_t (1+\beta)^{T_p - t}$ (2)</td></tr>
<tr><td>Net Income (discounted) NI</td><td colspan="3"></td><td colspan="6">$NI = \sum_{t=T_c}^{T_p} P_t (1+\beta)^{T_p - t}$ (3)</td></tr>
<tr><td>Cash flows, CF</td><td colspan="3"></td><td colspan="6">$CF = \sum_{t=T_c}^{T_p} (P_t + a_t)(1+\beta)^{T_p - t}$ (4)</td></tr>
</table>

Legend: T_b – beginning of the projection period, T_c, T_p – end of the construction stage and the projection period, respectively; β – annual interest on a loan or bank deposit; ⊗ - dates of future value estimation for investments (Tc) and cash flows (Tp)

Table 5

Investment projects ranked by NPV and NPT (by PI and IRR, when NPV of IP1-3 is equal)

IP No.	Valuation approach				
	Existing			Proposed	
	NPV	PI	IRR, %	NPT	Rank
1	0	0	8	1,683	1
2	0	0	8	1,661	2
3	0	0	8	1,122	3

Table 6

Net value (profit) of a capital investment project vs. financial investment alternative

	Time scale	T_b t_0 · t_1 · T_c t_2 · t_3 · t_{10} · t_{11} · T_p t_{12}	Net value (profit) in time
A	Net profit from financial investments as an alternative to IP-1 (NPT_f)	$K_t' = K_0(1+\beta)^t = 750(1+0.08)^{10} = 1{,}889$ -750 $K_t'' = 750(1+0.08)^9 = 1{,}749$ -750	$NPT_f = 1{,}889 + 1{,}749 - 750 \cdot 2 =$ $= 3{,}638 - 1{,}500 = 2{,}138$
B	NPV of a capital investment project (IP-1) under the present value method	$NPV_1 = 232.44(0.794 + ... + 0.397) -$ $- 750(0.926 + 0.857)$ -750 -750 232.44 232.44 232.44	$NPV_1 = 232.44 \cdot 5.753 -$ $- 750 \cdot 1.783 = 0$
C	NPV of a capital investment project (IP-1) under the future value method	Cash flow from IP $232.44(1.199 + \ldots + 1) = 3368$ 232.44 232.44 232.44 IP costs (cash flow from financial investments) $K_t' = 750(1+0.08)^9 = 1{,}749$ -750 $K_t'' = 750(1+0.08)^8 = 1{,}619$ -750	$NPV_1(E') = 3368 - 1{,}749 -$ $-1{,}619 = 0$
D	NPT of a capital investment project (IP-1) under the phased approach	$NPT_1 = 232.44(1.199 + \ldots + 1) -$ $-750(1.166 + 1.08)$ -750 -750 232.44 232.44 232.44	$NPT_1 = 232.44 \cdot 14.486 -$ $- 750 \cdot 2.246 =$ $= 3368 - 1{,}685 = 1{,}683$

Legend: ⊗ cash flow discounting date
● investment date

Table 7

Comparative analysis of Net Present Value of financial investments and capital investment projects (IP1-3) with a projection period of 12 years

IP No.	Net income of financial investments, NPT_f	Net income of capital IP		Effect of financial vs. capital investments			Ranking of capital IP by NPT (phased approach)
		NPT	Annual net income (no discount)	Proposed method, E	Present and future value, NPV	Loss recovery from net income, years	
1	2,138	1,683	112	-455	0	4.10	1
2	2,091	1,661	109	-490	0	3.95	2
3	1,425	1,122	85	-303	0	3.60	3

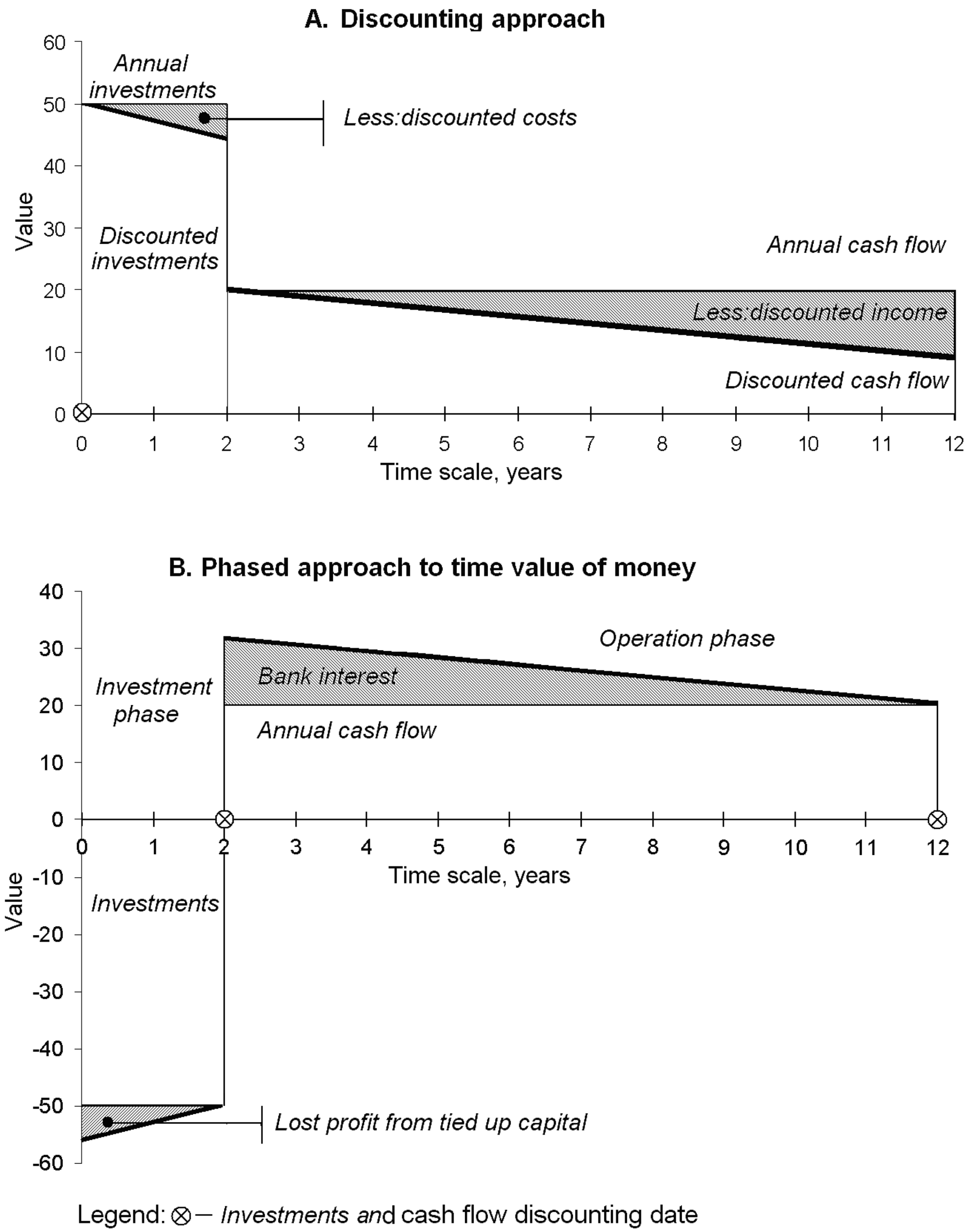

Figure 1. Investment project costs and cash flow to time value of money

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