Assessment of investment projects on the basis of production efficiency

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Abstract

Methodologically, the recommended investment project (IP) selection system is distinguished from one in force by: new conception allowing for time factor; evaluating IP efficiency by eventual reproduction results, not by intermediate investment activity results (included is a generalized production efficiency indicator); separation of conditions / indicators adequate for a market economy in transition and an advanced (stable) one; allowing for differences between enterprises' (entrepreneurs') and investors' economic interests. The make-up of assessment standards was extended by tasks to be solved. An enterprise's highly competitive position after IP realization when the best analogue sales profitability is achieved was taken as the investment success criterion.

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Keywords: investment efficiency; investment project; profit; the discount rate; projection period; investment phase; operation phase; net present value (NPV); discounting cash flow (DCF); Net Profit in Time (NPT); Profitability Index in Time (PIT)

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Important Issue. The current economic challenges, including the globalization of competition, growth of mineral extraction costs driven by deteriorating geological and mining conditions and depletion concerns (for hydrocarbons), the aging of population in developed nations, growing negative environmental impact of industrial activity due to increased consumption and contamination of natural resources, can be addressed primarily with more efficient use of resources (raw materials, fuels, electric power, and labor) achievable via intensive development of science, science-intensive technologies and their product – innovations.

However, the previous half a century of experience accumulated by developed countries demonstrates that innovative reforms of production and technologies aimed at more efficient use of resources and humanization of labor involve the shift of focus from continuous intellectual and physical efforts of workers towards increasingly complicated production processes and stricter process parameters in order to manufacture high quality products with new characteristics. This trend leads to more expensive equipment and process control and management systems. Investment projects become more capital-intensive, capital investments into greenfield projects and production upgrades grow per unit. These developments have become a global trend, which collides with the fundamental provisions of generally accepted investment assessment methodology focused on preventing the increase in capital costs of investment projects (IP) and complicating the analysis of benefits from scientific and technological innovations. This situation calls for immediate solution of methodological issues related to an innovative upgrade of physical infrastructure.

In investment activity, the success of implementing a profitable investment project depends strongly on the efficiency of the project selection system and the adaptation thereof to the existing and evolving economic conditions. Decisions made on the basis of investment assessment methods have an impact both on corporate and national interests, since the complex of private decisions ultimately shapes the character and parameters of a nation's production resources. Introduction of innovations into all areas of business and plant upgrades press for improved scientific support of efficiency analysis of investments.

Based on our analysis of works on the above issue by numerous authors (in particular, books by Behrens and Hawranek 1995; Brigham and Ehrhardt 2009; Northcott 1997), we have identified the most common investment efficiency metrics applied to evaluate and select investment projects for implementation (Table 1).

The system of investment efficiency metrics can be classified into two groups: discounted (NPV, PI, and IRR) and unsophisticated (ROI and payback period). Discounted metrics are considered more important, since their projection horizon covers the total life of an investment project and allows for analyzing all possible changes in business parameters over the project life and adjusting them for the effect of time. The adoption of the new (phased) approach to estimating value in time as a basis of economic analysis of investment projects implies the liquidation of discounted metrics, as a group, and the construction of replacement (alternative) efficiency indicators based on the new approach[1].

The effect of time is associated with another investment valuation issue: the economic uncertainty typical of emerging markets (Russia, Kazakhstan, etc.), as well as underdeveloped and developing economies, and the resulting inaccuracy of forecasting investment project cash flows for a 5, 10, or 15 year horizon mean that the application of integral metrics is inappropriate in principle and moreover so, if we consider the effect of time, which multiplies the above forecast inaccuracy. The challenge is to identify valuation tools, which will be effective in such conditions, and determine the economic requirements for the application of a full or reduced set of such valuation tools.

[1] Phased Approach to Time Value of Money in Economic Analysis of Investment Projects.

The need to reconstruct the existing system is further driven by other significant weaknesses, which shall be addressed in conjunction with the implementation of a phased approach to time value of money.

The system of metrics used to select investment projects for implementation will be reliable only within adequately defined limits. The existing base of project assessment ratios is, in practice, represented by the discount rate only. As demonstrated in our previous article, the insufficiency of this ratio for project performance assessment and investment project selection, as well as the limited scope of its correct application (investment projects financed with loans) and inadequate metrics developed therefore, mean that there are virtually no limits to cut off marginal projects.

An investment decision is always a strategic one. However, the ratios used to justify this decision fail to define the position and outlook of a future project in a real economic environment, its competitive strength and ability to survive throughout the payback period and generate sufficient income. The existing theory does not provide for the comparison of investment projects with best-in-class peers to estimate the viability of the future business.

R&D and innovation companies do not have a suitable instrument for analyzing the economic performance of their products.

The general situation with the investment assessment theory raises doubts as to its ability to meet the requirements of economic development in all countries. The time has come for an overall revision and rejection of the existing set of valuation tools and ratios, and even of the very object of investment assessment.

1. The system of investment efficiency assessment

Analysis of system metrics in terms of functional adequacy. Our analysis will be based on assumptions that the existing current and future value methods are viable tools of estimating the time effect. This assumption will help to identify other weaknesses of the existing system, unrelated to methods of calculating the time value of money. We shall begin with the analysis of distinctive features and functionality of the basic discounted metric, used by the existing approach to the selection of efficient investment projects – the Net Present Value (NPV).

To facilitate the understanding of issues related to NPV, we will discus standard investment projects, which require certain initial expenditure (cash outflow) before any earnings (cash inflow) can be expected. Investments are assumed to be financed with equity rather than loans, while the return on investments consists of net income and depreciation expenses (cash flows). Accordingly, any other interim metrics, such as sales revenue, the cost of sales, tax expenses etc, are excluded from the calculations to simplify the NPV formula and its analysis. Annual cash flows will be the same throughout the whole life of the investment project.

Based on the above assumptions, NPV can be expressed as follows:

$$NPV = \sum_{t=T_c}^{T_p} \frac{P_t + a_t}{(1+r)^t} - \sum_{t=0}^{T_c} \frac{K_t}{(1+r)^t} \geq 0\,, \tag{1}$$

where P_t and a_t are the annual net income and depreciation in year t, K_t – the amount of investments; r – discount rate; T_c and T_o – construction period and the useful (service) life of the project (years); $T_o = T_{ul}$ – useful life of production assets; T_p – projection horizon.

The Net Present Value (NPV) represents the sum total of discounted annual differences between real (net of tax, interest expense etc) cash outflows and inflows over the project life. Future costs and earnings are discounted to their present value as of the proposed project commencement date.

It is generally believed that if the resulting NPV is positive, the return on investment is above the discount rate and the investment project can be considered acceptable. If NPV is zero, the return is equal to the discount rate, and the income earned will be just sufficient to cover obligations to creditors. When NPV is negative, a project shall be rejected. Naturally, the higher is NPV, the more profitable and less sensitive to risk factors is the project.

NPV is a convenient metric, since it can be applied when alternative projects are available and when a single investment project is analyzed. In the latter case, positive or zero NPV confirms that the assumed discount rate limit can be exceeded successfully, so that a positive investment decision can be made, subject to certain other factors. The above is a common understanding of NPV.

To understand, whether NPV can be acceptable as a threshold to cut off low efficiency projects, we used formula (1) to identify the amount of annual net income (and, next, the return on project assets), which corresponds to equal discounted project costs and earnings (NPV = 0), for a production upgrade project, here annual depreciation expenses depend directly on service lives of equipment, production line etc. ($a=K/T_o$), while the amount of current assets remains the same and does not have to be increased.

The required changes to the formula (1) are as follows:

$$\sum_{t=T_c}^{T_p} \frac{P_t + a_t}{(1+r)^t} \geq \sum_{t_0}^{T_c} \frac{K_t}{(1+r)^t}$$

If $\frac{1}{(1+r)^t} = \alpha_t$, $\sum_{t_0}^{T_c} \alpha_t = k_c$, $\sum_{t=T_c}^{T_p} \alpha_t = k_o$, while P_t and a_t remain the same in each year t, the expression can be further simplified as follows:

$$(P+a)k_o \geq Kk_c,\ \ Pk_o \geq Kk_c - ak_o;\ \text{if } a = \frac{K}{T_o},\ \text{then } Pk_0 \geq Kk_c - \frac{Kk_o}{T_o},$$

$$\frac{P}{K}k_o \geq k_c - \frac{k_o}{T_o},\ \text{and, finally, } \frac{P}{K} \geq \frac{k_c}{k_o} - \frac{1}{T_o} = ROI_{\min}$$

The minimum rate of return on project investments, which ensures that NPV=0 and the investment project can be accepted for implementation, can be represented by the following expression:

$$ROI_{\min} \geq \left(\frac{k_c}{k_o} - \frac{1}{T_o} \right) \times 100\%, \tag{2}$$

where k_c is the sum of discount rates for the project construction phase and k_o is the sum of discount factors applied throughout the operational phase.

The table below summarizes the minimum return on project assets, required to ensure the payback of loans raised to finance investments into production upgrade (NPV=0), according to formula (2) and assuming the discount rate in the range of (r = 2÷8%) and the useful lives of active production assets of 8 and 14 years, respectively (Table 2).

According to the above data, the rate of return on plant and equipment (including depreciation expense), sufficient to repay the investments into plant upgrades, hardly depends on the service life of equipment ranging from 8 to 14 years (a time interval typical of most production assets) at the most probable discount rate of 4-8% for developed economies. On the other hand, the quoted minimum rates of return on assets for production upgrade projects, which set a profitability threshold for a project and determine whether the project will be accepted or rejected, are surprisingly low, with ROI_{min} of merely 2.3-5% (at T_o = 8-14 years).

However, the practice demonstrates that the rate of return on investments in the range of 10-20% is quite common for production upgrade projects. But in the situation where actual results exceed estimated targets multifold, there are no grounds to believe that the NPV metric is an effective tool to screen out low-efficiency investment projects.

On the other hand, an economic situation typical of a future business at NPV=0 will only mean that cash inflow of an investment project is equal to its cash outflow. At the same time, it will be catastrophic from an investor's and a business owner's perspective. Thus, NPV shall be increased, but to which amount? The decision is delegated to business owners or their professional advisors and, consequently, excluded from the scope of the existing project assessment methodology, which is totally unacceptable.

The investment assessment system accepted in all developed economies, in essence, cannot be considered as such, since, instead of estimating the efficiency of an investment project, it requires a project to correspond to a lower level of return typical of debt capital (financial markets). The direct confirmation of this fact can be seen in the internal rate of return (IRR), which defines the project's individual (internal) discount rate for comparison with market rates. The rate of return on investments, and its ability to meet the manufacturer's requirements, is not even considered. Consequently, for businesses with sufficient funds, which are not interested in the creditworthiness of an investment project, the issue of investment project assessment remains unsolved.

As demonstrated by the above, NPV hardly rises to the role of the main project selection criteria in the investment assessment methodology. The existing system of investment project analysis fails to function properly: it discards only a minor part of unprofitable projects. Investments, as an economic resource, are wasted without an adequate return.

Some researches and company analysts do understand the insufficiency of requirements set for investment projects by the NPV method, if an interest rate is the only criteria of profitability, and, therefore, adjust the interest rate by premiums required to finance normal operations of a business (the payment of dividends to shareholders, innovations and business development, material incentives and social benefits for employees) in addition to common risk and inflation premiums. Indeed, this "increased discount rate" raises the required level of project profitability and brings project selection criteria to actual business requirements. However, on the theoretical level, gross problems remain.

The concept of value in time based on opportunity cost of not investing into financial markets also includes the requirement to avoid excessive opportunity costs related to business operations. In other words, NPV is expected to select investment projects capable of financing loan repayment and generating net profit sufficient for successful business operation. But if this approach to addressing the issue of a threshold NPV rate is assumed, it will be hard to understand how this approach is related to the theory of the time value of money.

The results of our analysis of the economic scope and informative value of metrics used in the existing valuation system are best demonstrated by the profitability index (PI). We developed formula (3) to arrive at a high level, simplified discounted profitability index, which, unlike NPV and IRR, truly reflects the cost effectiveness (the ratio of earnings to costs) of an investment project and is equivalent to the non-discounted ROI metric.

The resulting expression is both high-level and illustrative: it cannot be used for practical purposes, but helps to understand the true essence of the metric. Formula (3) raises serious doubts whether the theory of investment efficiency truly measures the right parameters. The discussion below will provide more details and check whether our doubts are justified.

Investments into production upgrade and reconstruction	Investments into new assets and plant expansion

$$PI = \frac{\sum_{T_c}^{T_p}(P \pm \Delta_1)}{\sum_{t=0}^{T_c}\left(K \pm \Delta_2\right)} \approx \frac{P \times T_{ul}}{a \times T_{ul}} = \frac{P}{a}; \qquad PI = \frac{P}{a + CA/T_{ul}}\ , \tag{3}$$

where P is annual net income; a – annual depreciation; CA – annual average current assets; T_{ul} – useful life of production assets; ±Δ – income from the use (no use) of net income and depreciation (Δ_1) and investments (Δ_2); $K=aT_{ul}$.

As can be seen, stripping PI of its "time value" raiment exposes its poor economic basis: it is merely a ratio of income to depreciation. If we remember that the share of depreciation in the cost structure (C) in the production sector is ~5.5% (a=0.055C), then the "stripped" PI can be quantified as follows: PI = P ⁄ 0.055C.

The return on investment can be expressed by the same formula (3), if we replace the annual income in the numerator with the total net income earned over the service life of assets (the period of utilizing the upfront costs in the denominator).

It is rather difficult to believe that the best of investment projects compared will be the project with the maximum ratio of income to depreciation. The immediate question is why in the assessment of an investment project its financial result (profit) is compared to 5.5% of total costs instead of the aggregate amount of all production assets? Is it rational to compare project profit with upfront costs (i.e., base the assessment of an investment project on ROA, or the return on assets)? Or, would it be more correct to assume that project costs are represented by the cost of production, namely, the current cash outflows, including depreciation expenses (20 times the amount of initial investments), and consider the total amount of production assets (i.e., use the return on sales as a basis for project assessment)? We believe that all these questions have to be addressed, and will discus them later.

As demonstrated above, the lack of a truly functional cutoff criteria to select production projects for implementation means that the whole group of discounted valuation metrics fails to fully meet the interests of the real production sector. This fact divides the existing system into two groups of metrics on the basis of economic interests in addition to commonly considered ability (or inability) to reflect the time value of money: discounted metrics are used by investors, while non-discounted are applied by business owners. However, there is no doubt that business owners working in the real sector also need valuation metrics reflecting the time value.

Consequently, another question emerges: why cannot the economic analysis of projects, as practiced currently, rely on the existing simpler and more accurate methods? Complex analysis of investment projects based on the system of discounted metrics represents, essentially, the assessment of the project's creditworthiness. At the same time, the preparation of a standard loan agreement with a bank (or another lending institution) includes all necessary calculation procedures and forms, which regulate loan repayment and interest payments and do not need any discounted metrics. Similarly, discounted tools have no practical value for business owners. Who and why needs the existing system of investment profitability metrics based on the present value approach?

As for non-discounted metrics used in the assessment of real production projects, their application is limited since the rates of return on investments lack theoretical justification and practice. The group of non-discounting metrics is too small and fails to cover all types of practical issues, and the role of these metrics in the economic analysis of projects appears unreasonably restricted. Generally, the existing system of investment assessment represents a collection of metrics rather than an integrated system thereof, since various metrics meet the requirements of different users and serve them poorly in all cases.

The above findings and conclusions are based on the assumption that the accepted present and future value methods can actually be used for estimating the effect of time on value.

The identified weaknesses in the application of these methods to model the movement of cash flows in time throughout the investment cycle further aggravate the inadequacy of all discounted metrics and the system in general. However, unfortunately, it is evident that the transformation of NPV and PI into NPT and PIT, respectively, under the phased approach to value in time will not be able to overcome organic weaknesses in the system of investment project valuation. Net Profit-in-Time (NPT) cannot be considered a measure of efficiency, both in structure and essence. The Profitability Index-in-Time (PIT), while becoming more accurate due to the application of a phased approach to value in time, will, similarly to PI, represent the ratio of profit to depreciation, which is an unacceptably limited metric in economic terms. Moreover, both metrics (NPT and PIT) cannot be standardized.

Thus, in addition to the improvement of the existing approach to estimating the efficiency of investment projects on the basis of the new value in time method, we also need to build an underlying system of standards virtually from scratch. Moreover, in view of doubts raised by our analysis of the informativeness of PI (3), special attention shall be paid to the reasonableness of understanding the costs in the PI formula as investments made instead of production costs of an operational plant.

Profitable project selection dilemma. To explain our doubts as to the correctness of the very approach to the assessment of investment efficiency, let us analyze the financials of two businesses manufacturing similar products (Table 3).

Our survey of dozens of dozens of plant executives and chief economic officers demonstrates that the first project enjoys an unquestionable priority. The surveyed said that in the situation of choosing between two places of employment they would prefer the first one. The motives for their preference and assessments can be summarized as follows: bigger annual income and cash flow strengthen the current financial position and the future outlook of the first project; while higher sales margin and labor productivity reflect an efficient use of resources based on innovative technology. The return on assets was perceived as an insignificant factor.

Table 4 summarizes the characteristics of a business created under two investment projects. The first project involves the replacement of an existing production line with a more advanced one, while the second project involves an upgrade of a similar production line. The useful life of both production lines is 10 years; the construction period is 2 years.

The company has available funds to finance both investment projects. The objective is to select the most efficient one. To exclude the effect of inflation, which can complicate the estimation of value in time, we shall assume the absence of any inflation.

According to the table, Project II (IP_2) demonstrates higher return on investments (19.8% vs. 10.5% for Project I (IP_1)).

However, a final decision in favor of IP_2 based on non-discounted (annual) ROI must be supported by a discounted value analysis. Additional data required include: the discount rate (cost of debt) – 0.08; useful life of equipment – 10 years; projection horizon – 12 years. In both investment projects, 50% of the CAPEX budget is spent in each year of construction.

The valuation of investment projects under the present value method yields the following results:

$NPV_1 = 1{,}533 \times 5.753 - 4{,}300 \times 1.783 = 1{,}152$; $PI_1 = 1{,}152/(4{,}300 \times 1.783) = 0.15$

$NPV_2 = 768 \times 5.753 - 1{,}560 \times 1.783 = 1{,}637$; $PI_2 = 1{,}637/ (1{,}560 \times 1.783) = 0.59$

The Net Present Value and the discounted Profitability Index of IP_2 are significantly higher, which, in combination with a higher rate of return on investments, clearly indicates that IP_2 can be classified as more profitable and shall be selected for implementation.

As can be easily seen, Table 3 and Table 4 present the financials of the same two projects. The paradox of the situation is that in the operational phase experienced managers prefer the first project and consider it more profitable. However, investment analysts, relying on the existing system of valuation metrics, believe that IP_2 is more efficient and reject IP_1, which is more promising in the operational phase.

Calculations based on the proposed phased approach to investment valuation look as follows:

NPT_1 = 1,533×14.486 – 4,300×2.246 = 12,549; PIT_1 = 12,549/ (4,300×2.246) = 1.3.

NPT_2 = 768×14.486 – 1,560×2.246 = 7,621; PIT_2 = 7,621/ (1,560×2.246) = 2.175.

In absolute terms, the amount of profit for IP_1 will be significantly larger, but IP_2 appears much more profitable if the ratio of profit to invested capital is used. Accordingly, we have to state that it is still unclear, which project is more efficient, Table 5 (data from Tables 3 and 4).

If we consider the results of comparison under the NPT approach, IP_1 appears unquestionably the best. However, NPT, similarly to its counterpart NPV, cannot be used as a measure of financial efficiency, as it does not reflect the return on RUB 1 of costs.

Discounted profitability indices for IP_2 are higher under both approaches to value in time, while non-discounted profitability metrics are quite opposite: in terms of return on assets the leader is IP_2, in terms of return on sales – IP_1.

Under the theory of investment efficiency, IP_2 is the best, with or without the effect of time. The results of analysis discussed in this section provoke serious reflections for the following reasons.

1. Financial characteristics of investment projects compared are based on real prototypes: i.e., they are taken from actual feasibility studies.

2. The broad range of results is stunning. With the same annual production output, required investments into the innovation project IP_1 is 2.76 times higher than IP_2 requirements. Moreover, IP_1 has net income of 1,46x that of IP_2, depreciation – 4.2x, cash flow – 2x (Table 4).

3. The metrics of the existing investment assessment system demonstrate a clear superiority of IP_2: PI_2 is 3.9x PI_1, NPV_2 – 1.4 x NPV_1, ROI_2 – 1.9x ROI_1 (|Table 5). Still, managers and other business practitioners prefer the first of the two projects.

As demonstrated by the analyzed case study (Tables 3, 4 and 5), the results of efficiency analysis of investment and business operations of an investment target do not correspond. Moreover, in practice, there is a stable tendency towards contradiction between investment value based on ROA and key operating parameters of analyzed projects. Business interests justify higher capital intensity ratio, a trend opposed by the theory. This situation seriously complicates the efficiency analysis of innovation projects.

The above discussion confirms the importance of analyzing the issue of investee's production efficiency and its position in the existing system of investment efficiency measurement. Special attention shall be given to Return on Sales, which plays an important role in business valuation and is the only metric (in the existing system) demonstrating the benefits of the innovation IP_1 (Table 5).

As can be seen, the system of investment project efficiency ratios requires transformation, firstly, in connection with the new approach to value in time, the need to refine the composition of ratios and improve the understanding of their economic substance and correspondence to the category of efficiency and priorities; and secondly, as a result of a possible hypothetical change in the interpretation of costs for the purposes of project efficiency assessment.

Our approach to the issue of project selection. A correct approach to investment efficiency analysis can be based on the system theory. Therefore, we will begin with formalizing the position, interrelation and role of investment cycle phases (Figure 1).

Generally, the project life cycle is understood as an investment process period plus an operation process period, which fall under the project implementation subsystem and the project operation subsystem, respectively.

A user selecting a project in accordance with the accepted methodology of investment efficiency analysis obtains information on cash inflows and outflows throughout the project life cycle. The weakness of the approach lies in the fact that profit from the projects is compared only to the amount of investments (costs incurred in the project implementation subsystem). The scale and efficiency of labor and material resources consumed in the process of future project operation are excluded from the scope of analysis.

However, according to the system theory, resources consumed in the system shall ensure the maximum result at the output of the system (in our case, the system of production assets reproduction). The reproduction system consists of two subsystems: project implementation subsystem and project operation subsystem. Reproduction system output coincides with the operation subsystem output. Accordingly, the parameters of the operation subsystem determine the final results of the superior reproduction system. The project implementation subsystem has an output of its own, measured separately, but it represents an intermediate result with respect to the combined output of the operation subsystem and the reproduction system, and the implementation subsystem plays a secondary role as compared to the operation subsystem (Figure 1). Thus, the assessment of investment project's efficiency would be objective only if based on the analysis of operating efficiency of the project.

We do understand that the above conclusion is a principal and very important statement and will try to comment on its general economic logic without any reference to the terms and casual relationships of the system theory.

The purpose and ultimate objective of investments is the improvement of companies' operational efficiency through production upgrade, reconstruction, expansion and construction of new assets. Accordingly, the efficiency of investments as a resource is less important than the production efficiency of the investment target. However, the investment efficiency theory is based on the underlying assumption that the higher the return on each ruble invested into a project, the better. As demonstrated by our analysis, such an assumption can be true only from a lender's (bank, investor, investment fund, etc.) point of view.

Economic interests of participants in investment project implementation are quite different. For an investor, project requirements are limited to loan interest, at a market or higher rate, and a guarantee of loan repayment. Since investors sell investments, for them the transaction efficiency criterion is a guaranteed market-average return on capital invested into the project. This interest is expressed by a higher return on project assets as compared to rates of return typical of financial markets. In all situations when a project is implemented for internal business purposes (even if debt rather than equity financing is used), the above approach to the assessment of project efficiency will be incorrect.

A company and a business owner would also be interested in smaller project implementation costs and a maximum possible return on assets. However, an even more important objective is to ensure that the operation of the new project provides for the most efficient use of resources, including materials and labor in addition to production assets. The best project estimates and the selection of the most efficient project on the basis thereof imply the choice of the most rational combination of resources used and consumed by the project. Such a combination can be achieved only with the help of a general ratio of economic efficiency. The above discussion demonstrates that the existing system of investment efficiency assessment reflects the interests of investors only and fails to serve in full the interests of investment users (companies and business owners) and, ultimately, of the government.

A focus on maximizing the resulting effect (NPV) of an investment project or the return on investments would be justified if the consequences of an investment decision were limited to the investment phase, or if the only resource consumed over the operation phase would be production assets (or, rather, investments transformed into production assets when the project is put into operation). Under the existing approach, projects are selected on the basis of the only ratio – the return on assets. As a result, it is assumed that the higher is the return on assets (capital investments), the better is the operating efficiency of the future business. However, while the return on assets is an important ratio, it is only one of the three components of general business efficiency, and, without information on the other two ratios of an operating enterprise – materials to output ratio and labor productivity – which have been left out, it would be early to make a decision.

In practice, an analysis of investments into a reconstruction project can indicate that in terms of return on production assets such a project is close to, or even better than an operating business, but its labor productivity and the materials-to-output ratios are worse. In this situation, an analyst will be formally right to recommend the investment project for implementation on the basis of the existing project assessment methodology, since it demonstrates high return on assets, while concerns over the decrease in labor productivity and materials-to-output ratio cannot be quantified without a general ratio of economic efficiency.

In an opposite situation, an analyzed project can be found to have a lower return on production assets as compared to an operating business, while labor productivity and material-to-output ratio will be significantly higher (see Table 4, for example). Formally, such a project must be rejected since there is no other way to justify it in the absence of a general economic efficiency ratio.

It is very important to note that the two opposite cases discussed above are typical. The firs case describes a project based on proven and established, but often obsolete technical solutions. As a result, the project requires relatively small investments, but cannot ensure an efficient use of labor, materials and energy. The second case is typical of projects, which involve the implementation of hi-tech and automated production lines, machinery, equipment, etc. Such projects usually promote technological progress and ensure the growth of all technological and economic ratios except for return on assets. Obviously, in this situation none of the tools of the investment efficiency assessment system will be able to support a positive investment decision on a project.

We postulate that the best investment project can be selected on the basis of a general production efficiency ratio of an operating asset. Thus, we need to consider the issue of estimating production efficiency and analyze the efficiency of investments (and its measurement) as subordinate to production efficiency (and its measurement).

Production efficiency measurement. Obviously, if the initial efficiency assessment of projects proposed for implementation and their effect on the level of operating efficiency is incorrect, it would be unwise to expect high final results, and the consumption of resources by such projects could be unjustified. There are numerous efficiency ratios, which determine whether any given resource is used reasonably or whether any aspect of business is rational. However, unless these local ratios are combined into a single metric, it is impossible to see whether the situation has improved.

For example, let's assume that a company improved labor productivity by 4% over the year, while the materials-to-output ratio remained unchanged, and production profitability declined by 1%. How has the production efficiency changed?

And here is another example. In 1960-1985 (until Gorbachov's reforms, in the period of stable functioning), the economic development of the USSR was characterized by a consistent growth of labor productivity, stable material-to-output ratios and declining return on assets. In 1975, in the Communist magazine, A. Kosygin, Chairman of the USSR Council of Ministers, instructed economists to give a clear definition of the current development trend, with its opposite growth of efficiency factors – whether general economic efficiency was improving or declining.

Discussions on the issue of production efficiency commenced in the same 1975, lasted over 10 years and had no precedent in terms of scale. Ultimately, over 100 general production efficiency ratios (GE) were put forward to express the efficiency criterion (the ratio of output to costs) in different ways. The overwhelming majority of authors agreed that the production output (the numerator in the production efficiency formula) shall be understood as the net national product on the level of national economy and production spheres, net product on industry level and net income on enterprise and production association level.

The strongest confrontation occurred on the issue of costs (the denominator in the production efficiency formula), which were understood as the amount of resources spent (current production costs) by some authors, resources used by others and the sum of resources spent and used by the third. Eventually, the third point of view prevailed and gained an increasing number of supporters. Production efficiency ratios calculated under the third model were called resource/cost-based, or combined, ratios to distinguish them from cost-based ratios in the first model and resource-based ratios in the second.

Still, even the supporters of the resource/cost model of the GE denominator (full costs) lacked unity, but all of them agreed that on the enterprise level full costs (denominator) should be understood as the annual cost of production, and the production efficiency ratio (GE) could be expressed as follows:

$$GE_t = \frac{P_t}{C_t + P_t} \tag{4}$$

For the purposes of our study, the most important is the general production efficiency ratio (4), where, according to a common opinion of Russian and foreign economists, full costs are expressed by the cost of production. In developed economies, the common business practice is to use the return on sales (ROS), which represents the ratio of net income to the cost of production. Notably, scientific works analyzing the relative significance of various profitability factors (production output, assets, labor etc.) and their effect on changes in the financial situation of companies emphasize the leading role of the return on sales (Torok, Robert M., and Patrick J. Cordon 1997).

Thus, a general production efficiency ratio (4) is equivalent to a commonly accepted ROS, where net income correlates with full costs (the cost of production).

To make formula (4) sensitive to investment costs and obtain a more clear expression suitable for investment purposes, we arrived at the following expression after a number of transformations:

$$GE_i = \frac{P_i}{C_i + ROI_S K_i} \geq GE_S \tag{5}$$

where: P_i, C_i – the amounts of annual net income and operating costs of an enterprise after the implementation of project *í*; GE_i – general production efficiency ratio of investment project *í*, GE_S – standard (target) general production efficiency ratio after project implementation; K_i – the amount of capital investments required to implement project *í*; ROI_S – standard return on investments.

The numerator in the GE_i formula is represented by net income, as appropriate for the assessment of production efficiency (ROS). The $ROI_S K_i$ component in the denominator represents a standard amount of profit for K_i investments. Accordingly, annual net income after project implementation (P_i) shall be equal or exceed ($ROI_S K_i$). As can be easily seen, the denominator

$(C_i+ROI_SK_i)$ represents the annual cost of production after project implementation calculated under the cost price model.

For the purposes of our study, all the above means that, no matter how paradoxical it may seem in the light of current views, or contradictory to the existing investment theory and practice, the efficiency of investments shall be measured by the relation of the resulting output to the future cost of production instead of the amount of investments. This approach allows for measuring the efficiency of an investment project not from an intermediate point of view (in the interests of the investment phase/investors), but from a more general position, reflecting the purpose of an investment project – in the interests of the operating efficiency and the system of reproduction. General production efficiency on enterprise level and for a stand-alone investment project is measured by the return on sales (ROS).

Let us reiterate the key idea of this section. An investment project is a model of a future enterprise or production business. When a project is implemented, the model materializes into an operating business, which realizes technical and economic parameters of the project throughout its service life. If we insist on electing the best project on the basis of its return on investment, as the most reasonable approach provided, directly and indirectly in all known methodologies, then we have to admit that total economic efficiency of any production enterprise is expressed by its return on assets only, while labor productivity and the materials-to-output ratio have no impact on general efficiency and can be used for reference only. For us, such a conclusion is apparently incorrect. On the other hand, if the total efficiency of an operating enterprise is expressed by a general efficiency ratio, it would be logical to apply the same ratio to a project (model) thereof, as investments into inefficient and non-competitive enterprises and production businesses are meaningless.

From our point of view, there is no logical explanation of how the efficiency of an investment project can be reliably measured by the ratio of its financial result to 5.5% of total production costs (amortization), as is the situation when PI (3) is used. On the contrary, we believe it logical to define the costs in the investment efficiency formula as the sum total of production assets. However, if the understanding of costs is limited to production costs only, we will fail to take into account socially necessary costs, i.e., the cost of goods sold. If we take into account the fact that investments are a factor which directly shapes the technical level of production and, accordingly, the structure and amount of costs, then we propose to calculate the net income in the denominator of the production efficiency formula (5), which used to arrive at the total cost amount in the denominator of efficiency formulas, on the basis of the ratio of capital expenditures to the total amount of the investment project, i.e., under the production model.

As can be seen, when a general efficiency ratio (GE) is used to measure the efficiency of an investment project, the higher weighting (importance) of investments is explained by the inclusion of two components into the denominator: traditional transfer of the amount of production assets to the cost of production via the mechanism of depreciation, and a rate of return to account for a positive effect of investments on the effective use of resources (this effect is currently interpreted as return on alternative investments), which depends on ROI_S and the amount of investments into a project. Finally, we can state that an assessment based on a general efficiency ratio (GE) take into account the multidirectional effect of investments on the cost of production: on the one hand, investments increase the costs via depreciation expenses, on the other hand, they reduce it via reduced consumption of labor, feedstock, materials, and energy in the production process. Inclusion of income in the estimated cost of sales (the denominator in the GE formula) on the basis of investment efficiency multiplies the weighting of investments in the efficiency analysis as compared to a formula reflecting only the utilization of investments (depreciation).

Now that we have identified a general production efficiency ratio (5) as the return on sales (ROS) and have justified its importance as the key metric in the system of investment efficiency assessment, we need to address the issue of structuring the whole system of metrics.

Development of a subsystem of non-discounted ratios. Estimates based on these ratios rely on local time intervals, usually, years. They are better adapted to dynamic changes of transitional economies and, at the same time, are an integral part of investment project selection in stable (developed) markets. Out of the three most common ratios in the group (Table 1) the return on investments is, doubtless, the backbone. Even today, it could be used as a criteria for selecting efficient investment projects should there be a reasonable methodological basis for differentiating the rate of return on investments in accordance with the objective and scope of economic analysis for the whole economy, its sectors, sub-sectors and various types of production enterprises. In Russia, this ratio is not even included into the existing methodological guidelines (Ministry of Economy of the Russian Federation and Ministry of Finance of the Russian Federation 2000).

This situation is explained by a tendency among theoreticians to diminish the capacity of non-discounted ratios as instruments of investment efficiency assessment, motivated by the inability of these ratios to reflect cash flow changes throughout the projection horizon, driven by inflation, fixed asset depreciation methods and other factors, as well as by their lack of sensitivity to time value of money and the problem of selecting a representative moment in time (year) for assessment during the operating phase. However, keeping in mind that the return on investments (for an investment project) is directly comparable to profitability of an operating enterprise, this ratio appears a very convenient and reliable valuation metric, essential for developers of new equipment and technologies, as well as in the early stages of investment project assessment.

The payback period is a less informative metric. It is estimated under a very conditional assumption that investments into a project will be repaid from net income only. In addition, it is but a reverse expression of return on investments.

Investment Payback Period (pp) determines a period in time, during which the project is operated for its own “benefit” and pays back capital expenditure incurred both from net income and depreciation expenses:

$$K = (P_1 + a_1) + (P_2 + a_2) + \ldots + (P_{Tpp} + a_{Tpp}) \quad (6)$$

where P is net income for a year; a – annual depreciation expenses; T_{pp} – the period of investment payback.

The above metric cannot measure efficiency, but is useful in analyzing and closing financial lease transactions and raising loans, since it determines the minimum period of loan repayment.

The system of market investment valuation ratios lacks a comparative efficiency ratio (annual total costs), which was used in the Soviet economy.

$$C_i + R_{TC}K_i \rightarrow \min \quad (7)$$

where C_i is annual production cost; K_i – investments into compared projects; R_{TC} – investment efficiency rate.

This ratio provides for optimum allocation of investments among competing investment opportunities. Therefore, when federal or municipal programs (or corporate programs involving large-scale implementation, i.e. introduction of grain dryers or mini meat processing factories) with limited investment amount are developed, the above ratio can be used to select the most efficient use of available funds among possible investment alternatives.

Other spheres of application for the comparative efficiency ration include environmental projects, organization of public services and amenities in the housing sector, etc. A common feature of these and similar investment projects is that they are non-profit activities with strict investment limits, which have to comply with applicable standards and technical conditions. None of ratios used in market conditions will be applicable in these situations.

An finally, it shall be noted that, as demonstrated above, none of ratios already discussed, or any other tool in the current inventory of the investment efficiency theory can satisfy the ultimate investment objectives of the real sector and reflect the degree of their achievement. The group of ratios selected by us will become a true subsystem of non-discounted ratios only after we add to it a general production efficiency ratio (5). The results of investment assessment based on this ratio determine whether an investment project meets target requirements and illustrate comparative priority of rival investment projects.

All other metrics in the subsystem characterize separate aspects of efficient use of investments as a local but scarce resource, as shown above.

Development of a subsystem of valuation metrics reflecting value in time. In previous sections we have already demonstrated that NPV and IRR do not reflect the efficiency of real investments (capital expenditure), mainly, because their structure does not correspond to a classical expression of efficiency as the relation of project income to initial costs (investments), but also because these ratios assess, albeit incorrectly, only the ability of an investment project to meet the requirements of the financial market and help to prove that an analyzed project will ensure the repayment of invested capital plus interest thereon at market interest rates. As a result, these metrics cannot be applied as a tool of selecting acceptable investment projects in the real production sector. From investors' point of view, the issue of analyzing creditworthiness of an investment project can be addressed with more reliable and proven methods, which do not involve any assessment based on discounted ratios. To a certain degree, the system of investment efficiency assessment proposed by us will not serve as a basis for project selection by investors, but the quality and financial potential of investment proposals will improve significantly as a result of higher efficiency and competitiveness.

Thus, the new approach to investment project selection on the basis of production efficiency in the operating phase and a new concept of estimating value in time both necessitate and make possible the development of a new group of valuation metrics for investment efficiency assessment adjusted for the effect of time. The system of metrics relies on elements (income and costs) modeled under the proposed phased method of estimating the time value of money[2].

Net Profit in Time (NPT). Let's start with the definition of Net Profit in Time (net income of an investment project adjusted for the effect of time), which, in addition to being a core element of investment analysis, contains the components used in other ratios:

$$NPT = \sum_{t=T_c}^{T_p} (P_t + a_t)(1+\beta)^{T_p - t} - \sum_{t=1}^{T_c} K_t (1+\beta)^{T_c - (t-1)} \rightarrow \max \tag{8}$$

Structurally, this ratio is similar to Net Present Value. However, unlike NPV, NPT provides a real picture of income flows and amounts by years in the implementation and operation phase of a project. NPT estimates for each year in the investment cycle serve as a basis for planning business operations and formulating business development programs.

Under the phased approach, the adjustment for the "freezing" of funds in the investment phase of real production projects decreases the estimated project income, while increasing the income from alternative financial investments. Accordingly, the analysis of production projects must include their comparison to benefits from equal financial investments (9). This fact was taken into account, when we included NPT in the system of valuation metrics.

The economic effect E (a correct definition of the currently applied NPV) from a simultaneous investment of equal amounts into production projects vs. financial investments ($K=K_f$) is expressed as follows:

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[2] Phased Approach to Time Value of Money in Economic Analysis of Investment Projects.

$$E_{ip} = \left[\sum_{t=T_C}^{T_p} (P_t + a_t)(1+\beta)^{T_p - t} - \sum_{t=0}^{T_c} K_t (1+\beta)^{T_c - (t-1)} \right] - \left[\sum_{t=0}^{T_p} K_{ft} (1+\beta)^t - \sum_{t=0}^{T_c} K_{ft} \right] \qquad (9)$$

Equal benefit from material and financial investments defined as equal net income, adjusted for the effect of time, is obtained at E_{ip}=0.

Profitability Index-in-Time (PIT) is a ratio of investments to Net Profit-in-Time, as adjusted for the effect of time:

$$PIT = \frac{\sum_{t=T_C}^{T_P} (P_t + a_t)(1+\beta)^{T_p - t}}{\sum_{t=1}^{T_C} K_t (1+\beta)^{T_C - (t-1)}} - 1 \to \max \qquad (10)$$

PIT helps to rank investment projects by the efficiency of investments only, rather than the total amount of resources spent and used. This raking is secondary and less meaningful than the ranking based on the general production efficiency ratio. NPT and PIT provide investors (owners of invested resources) important information on investment projects.

General production efficiency ratio (GET) can be expressed as follows, using the original formula for annual measurement (5) and a denominator transformed from (C+ ROI_SK) into NC + (*a*+ROI_SK):

$$GET = \frac{NPT}{\sum_{t=T_C}^{T_P} NC_t + \sum_{t=T_C}^{T_p} (a_t + ROI_S K_t)(1+\beta)^{T_p - t}} \geq GET_S \qquad (11)$$

where NC_t – annual operating costs net of depreciation expenses.

General production efficiency ratio (GET) is the core element of the system, because it reflects cumulative results of using and spending all production resources involver, rather than investments only, covers the whole project life cycle instead of any local time interval and takes into account the time value of money. Changes in this ratio indicate whether an investment project is acceptable. It has no counterpart in the existing system of ratios.

The numerator of the expression is the time value of the total amount of net income for all years of project operation – see formula (8). The denominator is the present value of total annual cash flows plus annual production costs (net of depreciation expenses). Net operating costs are not discounted to present value since they represent funds withdrawn from the system of asset reproduction and cannot be accumulated or used to generate additional income in financial markets.

Methods of calculating planned (target) GET_S and GE_S will be discussed in the nest section.

The group of value-in-time metrics consists of three ratios: GET, NPT, PIT. The abbreviations represent key notions in the full definition of ratios, while the last T indicates value in time.

2. Assessment of investment efficiency in emerging markets and underdeveloped economies

As for the problems typical of transition to a developed market economy and their impact on the subject of our study, the following can be stated using Russia as an example.

Low living standards and low profitability of the real sector combined with a large proportion of loss-making businesses hinder the domestic market development. It is difficult to forecast demand and sales volumes. Customs duties are volatile. Prices of goods and services for public consumption grow. Fuel, power and transportation prices also increase steadily. Antiinflationary measures are ineffective, and it is virtually impossible to forecast the rates of inflation and the possible timing of curbing the price growth.

Internal factors, which promise future economic stability but promote current significant changes in the historical economic proportions and indicators, include the ongoing reform of the tax system; an active process of import substitution; the alignment of regional social and economic conditions; volatile prices for certain product groups preceding the stabilization of price system across the country; changes in the policy of fixed asset depreciation; declining deficit of financial resources and the reduction of commercial loan interest rates; renovation of production assets and improved rates of return on asses, etc. All these factors characterize the economic environment in the transitional period as very dynamic and highly uncertain, which is objective, since this situation is the result of economic reforms focused on accelerating the transition and creating a stable market economy.

At the current economic development stage and in the mid term, the application of valuation metrics reflecting differences in the value of cash inflows and outflows occurring at different moments in time (in line with common practice for developed (stable) markets) is impracticable because cash flows cannot be projected reliably for a 10+ year period – a typical projection horizon for an investment project.

Information needed to analyze the efficiency of an investment project using value-in-time ratios (these include any and all integral metrics) includes the following: projected pricing of finished goods and inflationary changes in the cost of materials, fuel, services etc. throughout the project lifetime; projected changes in the exchange rate; taxation details, including tax bases and tax rates applied at different budget levels; projected changes in production volumes and structure, feedstock consumption rates, personnel numbers, stock levels, etc.; the impact of fixed assets wear and tear and the replacement of core production equipment on the production program and the projected growth in operating costs; changes in macroeconomic indicators (Central Bank refinancing rate, discount rate, the rates of taxes, duties and excise taxes, minimum monthly wage, etc.). The required amount of input information for the purposes of estimating investment efficiency in time appears unrealistic for two reasons.

Firstly, because small and medium enterprises have no access to such information, which is not available to public.

Secondly, such information, even if obtained, will be inaccurate and unreliable. For example, in recent years inflation rates in Russia exceed the projections in the federal budget prepared by leading Russian economists. If the discrepancy (the term “error” would be incorrect due to a high level of economic uncertainty, as mentioned above) between budget projections and actual data occurs even in projections for one (and, moreover, the next) year, what can be expected of forecasts for 5, 10 or more years?

The problem has another, equally important aspect. Who will develop multi-scenario feasibility studies of investment projects (such scenarios are necessary when time value of money is considered)? How much will such investment efficiency analysis cost and, mainly, how closely will actual results match the projections? An attempt to use estimated data can lead to a gross misstatement of investment efficiency.

Although our phased approach does improve the estimation of value in time for the purposes of investment efficiency analysis in transitional economies and helps to overcome certain weaknesses of the present value method (in particular, its inability to acknowledge the efficiency of innovation projects), still, it would be unreasonable to recommend it for practical application now. Risks typical of transitional economies and an uncertain economic environment, which affects the accuracy of any cash flow projections in a 5, 10, or 15-year interval, make it impossible, in principal, to apply any integral ratios for the assessment of investment efficiency. As for ratios reflecting value-in-time, they further redouble the inaccuracy of cash flow projections.

An obvious question is raised: what conditions will indicate the end of a transitional stage and the emergence of a stable market economy and, consequently, the ability to apply a system of globally accepted valuation metrics for investment efficiency assessment, including a group of integral ratios reflecting value in time? We do have a definite answer based on Russian experience.

Characteristics of a mature and stable market economy include:

a) Low inflation: Japan – 1.2%, the USA +(1.5-2.5%), EU +1.9%, Russia (2007) +11.9%. This issue requires considerable efforts.

b) Affordable credit. Annual London Interbank Offered Rate (LIBOR), an interest rate at which prime banks in the London interbank market can borrow loans from each other in different currencies and for different maturities, as well as an interest rate applied to annual Eurocredits, is 4-6% (net of inflation adjustments). In Russia, in 2007 (before the crisis), the Central Bank refinancing rate, which serves as a benchmark for loan interest rates was 10.5-11%. We do not expect any improvement in this area soon.

c) Minimization of investment risks. An effective system of investment risk insurance must be created, including the risks of foreign investors.

d) Development of a strong financial system. Today, the combined financial resources of all Russian commercial banks are less than the capital of a Top 3-5 commercial bank in Japan, USA, or Germany.

When all of the above issues are addressed, the economic environment will stabilize, and the economy will be predictable and foreseeable. It's hard to tell how much time is required. The process will strongly depend on favorable or unfavorable dynamics of domestic and external macroeconomic factors, as well as on the political landscape in Russia and globally.

Economic conditions characterizing the current stage of Russia' development and brought about by the country's transition to market economy are typical of many underdeveloped economies and emerging markets. Healthy economies also can find themselves in a similar situation as a result of an economic or political crisis. In other words, the situation in Russia is not exceptional; it is a typical stage in the development of an emerging or recovering market economy. Therefore, instruments for the assessment of investment efficiency should differ for economies with different degrees of stability (Table 6).

3. Standard ratios for estimating the efficiency of investment project

General provisions. In the theory of the time value of money the key ratio of investment efficiency (the discount rate) is based on an average available cost of funds (%). In other words, it represents the rate of return on financial investments. No mention is made of any methods to analyze the efficiency of material investments (ROI_S). As for the rate of return on sales (ROS) seen in a new role, as a basic criterion for the selection of investment projects for implementation, this issue has never been raised, although ROS is the ratio which determines both the efficiency of an investment project and a financial stability of a new enterprise joining other operating manufacturers, since, generally, the rate of return in financial markets has an equal impact on cash flows of all enterprises. For a specific investment project, the rate of return on financial investments is uncontrollable (exogenous), while its own rate of return on sales is essential for successful competition with other production enterprises and determines potential advantages of its positioning in financial markets. In this context, the need for identifying a benchmark ROS for investment projects is obvious.

If we assume a rate of return on the level of an actual industry average ROS according to government statistics, it will not have a motivation function: for prosperous companies such ROS will be too low, for low-profit or loss-making enterprises it would set an intermediary target insufficient to support future competitiveness. Therefore, a standard rate of return shall be benchmarked against the rates achieved by leading enterprises. In Russia, the publications and official editions of the State Statistics Service (Rosstat) still do not contain any information on ratios achieved by leading comparable companies. The information blockade of achievements demonstrated by the best Russian companies in the commercial and non-commercial sector has been overcome by Interfax – Corporate Information Agency with the support of Hansabank. The agency performs a comparative analysis (production structure and growth, profitability and cost efficiency) of over 1 million public and private companies and compiles an annual Top100 list of the largest companies (by revenue) across key sectors of economy. Information on actual ROS and ROA achieved by large companies has a direct relevance for the selection of efficient investment projects and can serve as a basis for selecting efficiency ratio benchmarks.

According to Interfax-AKI, the best rates of return demonstrated by Top100 companies in various sectors of economy are several (sometimes dozens) times above average statistics. Production efficiency ratios of leading enterprises prove that the potential for efficiency improvement in all sectors is huge. The realization of thereof at this stage of economic development will be possible only through the application of progressive efficiency benchmarks in a large scale innovative reconstruction of production assets, which will solve the issue of social and economic improvements and also make high rates of production assets development both permanent and based on the implementation of an effective asset reproduction process by all manufacturers, instead of separate, albeit large scale, projects and campaigns.

On the other hand, the analysis of statistics of real enterprises answers the question whether benchmark rates of the return on sales (ROS) and investments (ROI) can be based on their maximum levels, which are usually achieved by different, rather than the same companies in each industry. In most industries, companies with the highest ROS have a significant lead vs. companies with the best ROI, but their ROI is much lower. We can explain this situation as follows:

When equipment and technologies are replaced after the expiration of their useful lives, two opposite strategies are possible. The first strategy involves the use of proven equipment and technologies and results in relatively low capital intensity, high return on assets and the unchanged resource-to-output ratio and production costs. The second (innovation) strategy involves the implementation of the most advanced (and capital-intensive) equipment and results in overall reduction of operating costs (potentially lower cost of production) with a simultaneous decline in ROA. In view of this, maximum rates of both ROS and ROI in one investment project appear unlikely. Accordingly, the selection of benchmark ratios shall be focused on an investment project with the highest ROS, as a priority ratio, and a ROI that supports such a maximum ROS.

In our attempt to develop a base of standard ratios for the assessment of investment efficiency, as an element of (attachment to) our Methodological Guidelines On Investment Efficiency Assessment, we were confronted with objective difficulties. Firstly, broad differentiation of ROS across industries is further widened within each industry, as production programs (product structure and mix) differ by enterprise. Secondly, the list of industry leaders and their ratios can change over time due to highly uncertain external economic environment and a possible implementation of new equipment and technologies by other peer companies.

In view of the above (an extreme bulkiness of such a base due to a great variety of production types, quick deterioration of data, etc.) we have found it impracticable to develop a fixed base of standard ratios for the Guidelines and chosen to recommend a practical approach to necessary data collection, which can be summarized as follows.

The purpose of an information request prepared by a company (investor) considering an investment project is to identify several peer companies (with a truly comparable production program) with maximum ROS_s and corresponding ROAs for the last 2-3 years. The analysis of data obtained, which shall serve as benchmarks, will help to identify target rates of return on sales (GE_s) and investments (ROI_s), which will become the minimum thresholds to be exceeded by investment projects considered.

At the next step, required to finalize target GE_s and ROI_S, peer companies shall be contacted and site visits arranged to get familiar with specific production processes and analyze separately the contribution of technology improvements, process engineering and market factors into high performance ratios. Naturally, the application of this approach depends on legal protection of commercial secrets and specific arrangements.

The final step includes contacts and cooperation with an engineering firm, which developed the benchmark project for a peer company.

Capital investments can have four forms: production upgrade, reconstruction, expansion and greenfield projects. The amount of capital investments per unit of capacity increases, while ROI decreases, respectively, in the same order. Accordingly, the rates of return (ROS and ROI), expected from a greenfield project or an operating company, have to be adjusted upward to the maximum level typical of upgrade projects. There are no universal efficiency ratios for upgrade and reconstruction projects, unlike greenfield (and, to a lesser extent, expansion) projects.

In general, an investment efficiency ratio for all forms of capital investments is calculated as follows:

$$ROI_{Sfo} = k_{fo}\, ROI_{sc}, \tag{12}$$

where:

k_{fo} – ROI_{sc} increase rate.

ROI_{Sc} is based on a benchmark for a guideline company (an industry leader), describes the return on the sum total of it assets and meets the requirements for a greenfield project ($k_{fo} = 1$). Index *fo* indicates the dependence of k, and ROI as well, on the form of a capital investment project and shall be transformed into specific indices: *ex* – for expansion, *rc* – for reconstruction, *pu* – for production upgrade. For a technical upgrade project, for example, formula (12) after a proper adjustment will look as follows: $ROI_{Spu}=k_{pu}ROI_{Sc}$, while the size of the ratios will change in accordance with the following pattern: $ROI_{Sc}<ROI_{Sex}<ROI_{Src}<ROI_{Spu.}$

A coefficient, which reflects the increase of ROI for the other three types of investment projects vs. greenfield construction, is expressed by the following formula:

$$k_f = A_c / K, \tag{13}$$

where A_c is the amount of assets of the guideline company (the sum of the book (historical) cost of fixed and current assets);

K – capital investments into new equipment and technologies (fixed assets in use), the adaptation of buildings and facilities for the use of new assets and the increase in working capital (if necessary) for the analyzed investment project.

The reliance on benchmark ratios is convenient at early stages of pre-investment analysis. Only at a final stage of a feasibility study (or business plan) development for an investment project, when a project implementation budget and information on the cost of production, future profit and investments into renovations and business development are available, an investor can estimate the expected ROI and ROA of the project. For reconstruction and production upgrade projects, ROA is expressed as follows:

$$\mathrm{ROA} = \mathrm{P} / (\mathrm{FA_u} + \mathrm{K}), \tag{14}$$

where K – the budgeted cost of replacement, renovation or reconstruction of fixed assets and the replenishment of working capital of the project; FA_u – the cost of fixed assets in continued use (initial FA less disposed, or $FA_u = FA_{base} – FA_{disp}$).

The project ROA shall be compared to a benchmark ROA to assess and improve the quality of the project.

Target general production efficiency ratio (GE_S). Target (planned) return on sales is expressed by the following formula:

$$GE_S = \frac{ROI_S K}{C_P + ROI_S K} \rightarrow ROS_S \tag{15}$$

where: K – the amount of planned phased or upfront investments; ROI_S– investment efficiency ratio calculated in accordance with methodology discussed above; C_P – planned annual operating costs after project implementation, based on unit cost of production for a leading guideline company (production line, etc.) or project. We recommend setting target ROI_S on the level of ROI demonstrated by guideline companies (project lines, etc.) with the highest ROS.

In the above expression $ROI_S K$ represents a target amount of net income for the year, if the amount of invested funds is K. The denominator $C_P+ROI_S K$ represents planned annual cost of production after investment project implementation.

Now we have to answer a logical question: why are both target GE and target ROI required at the same time? If the ultimate objective of investments is the achievement by the future project of a required return on sales, and the rate of return (GE_S) is quantified, why do we need a target investment efficiency ratio (ROI_S)? Would it not be enough to estimate investment efficiency using formula (16), which excludes ROI?

$$GE_i = \frac{P_i}{C_i + P_i} \geq GE_s \tag{16}$$

Let us assume that we have 2 greenfield investment projects (IP) with ROS on the level of the leading guideline company. The comparison of project parameters with the guideline company is summarized below:

	Net income	Revenue	Investments	$GE_н$	ROI
Operating company	200	1,000	1,300	0.2	0.154
IP_1	200	1,000	1,600	0.2	0.125
IP_2	200	1,000	1,450	0.2	0.138

In terms of return on sales (ROS=0.2) both investment projects match the guideline company. However, the return on investments of the two projects (0.125 and 0,138) is below ROI of the operating guideline company (0.154). Accordingly, the cost of investments into project implementation is higher (IP_1 – 1,600, IP_2 – 1,450) as compared to the operating guideline company (IP_{oc} – 1,300). As can be seen, formula (16) does not reflect the investment efficiency of subject investment projects, which is below the ROI of the operating company in both cases. As a result, the best IP_2 requires much more investments (1,450) than the guideline industry leader (1,300).

The implementation of the two investment projects will be justified at the actual ROI=0.154, which supports GE > 0.2, if the projects can demonstrate the following levels of GE:

$$GE_1 = \frac{0.154 \cdot 1{,}600}{(1{,}000 - 200) + 0.154 \cdot 1{,}600} = 0.235; \quad GE_2 = \frac{0.154 \cdot 1{,}450}{(1{,}000 - 200) + 0.154 \cdot 1{,}450} = 0.218$$

Thus, if the target ROI is achieved, the return on sales shall be 0.235 (IP_1) and 0.218 (IP_2), but both projects fail to support the target levels. This conclusion implies, primarily, the need to look for reasons of excessive capital expenditure and possible ways to cut down the cost in order to bring the amount of required investments down to the level of the guideline company. However, if additional investments are explained by innovations, it will be necessary to find means of raising the return on sales to the above GE_1 and GE_2 estimates to justify the proposed innovations.

Generally, the need to specify target levels of both ROS and ROI confirms our understanding that the required income growth of RUB 100 million can be achieved with investments of RUB 1,000 million at ROI_S=0.1 and RUB 2,000 million at ROI_S=0.05.

Please note that the importance of identifying target efficiency ratios is especially high in the situation of investment deficit typical of emerging markets and of Russia at its current stage of development. In developed markets (USA, Japan, Germany and others) with strong financial systems and low interest rates, the trend shifts towards lower importance of ROI and greater focus on maximizing the return on sales. In all cases, the repayment of investments is guaranteed by depreciation expenses.

Thus, an investment project is acceptable for implementation, if the following interval is achieved:

$$ROS_{av} < GE \leq GE_S, \tag{17}$$

where ROS_{av} is an average rate of return on sales for the type of production being considered.

Investment efficiency ratio as component of annual total costs (R_{Tc}). As demonstrated above, the main sphere of application for this ratio is the assessment of non-profit investment projects (labor safety, environmental protection, etc). The lower is a target investment efficiency ratio depending on annual total costs, the more chances have the initiators of an investment project to select a more capital-intensive and, consequently, long-lasting, reliable and effectively operated solution.

To satisfy the above requirements, we need the lowest accumulation rate β in investment practice. The final choice will be made by the future project owner, but a reasonable estimated rate shall be in the following interval:

$$\beta \leq R_{Tc} \leq ROI_S \tag{18}$$

Target GET – the target general production efficiency ratio of an investment project, adjusted for the effect of time, shall be identified by sensitivity analysis of cash inflows and outflows of a benchmark modeled on the basis of guideline company (industry leader) ratios over a projection period (usually, the useful life of fixed assets in use). Sensitivity tests shall be run within the limits of target rates (*β, ROI_S, C_P* etc.). Cost-performance ratios of an investment project selected for implementation shall meet the following requirement: GET→ GET_s. In this case, the return on sales of the new or renovated project will match the levels of its key competitors.

$$GET_s = \frac{\sum_{t=T_c}^{T_P} \left(P_p + a\right)_t (1+\beta)^{T_P - t} - \sum_{t=0}^{T_p} K_t (1+\beta)^{T_C-(t-1)}}{\sum_{t=T_C}^{T_P} NC_t + \sum_{t=T_C}^{T_P} (ROI_s K_t + a_t)(1+\beta)^{T_p - t}}, \tag{19}$$

where NC_P - planned annual operating costs net of depreciation, estimated on the basis of product unit costs of the guideline company (industry leader); P_P– planned net income for the year ($P_P = ROI_S K$). Target ROI_S will vary for different types of capital investment projects, the methodology of their calculation has been discussed above (12-14). Annual changes in P_P and NC_P over the period of benchmark project operation are assumed to be equal to the dynamics of a competing investment project.

The assumed annual changes in total assets (K_t) in the operating phase can be driven, among other factors, by the increase or decrease of current assets.

Target accumulation rate (β). If recommended investment efficiency ratios adjusted for the effect of time are to be applied before a potential user (owner) of an investment project is identified, it is useful to introduce a target (common) interest rate for income from the investment of temporary available (accumulated) funds (depreciation expenses and net income) in financial markets. A bank deposit appears to be the most universal, easily accessible and guaranteed, albeit less profitable, investment. A potential investment project owner will use for calculations the accumulation rate β based on available financial instruments. Thus, lending of temporarily available funds at high interest rates is open only to financial and industrial groups and certain large corporations. Taking into account the uncertainty and high risks typical of financial markets, the volatility of annual income, which can, nevertheless, significantly exceed income on bank deposits, and high requirements to expertise and experience of financial market players, the use of a market rate of return as a common basis for the analysis of investment efficiency in terms of value in time appears unreasonable.

Information on interest rates paid by commercial banks on deposits is publicly available.

A future project owner will determine the ultimate rates of GE_S, GET_S, ROI_S and β to support the selection of an investment project for implementation on the basis of general efficiency ratios, while NPT can be used to estimate all project cash flows and net income both by year and for the whole project life cycle.

Conclusion

1. Only two ratios out of six, which form the existing system of investment project assessment (Table 1), are included in the recommended system (Table 6) – Return on Investment (ROI) and Payback period (pp). Meanwhile, the composition of the efficiency assessment system has been expanded to include seven ratios instead of six.

The system has the following classification criteria: investment efficiency assessment with or without the effect of time, emerging and developed markets, general production efficiency ratios and investment efficiency ratios.

In general, on the methodological level, the difference between project assessment ratios in the recommended system and the existing ratios is not limited to a new approach to time value of money. New efficiency ratios are focused on the final outcome of the reproduction process instead of intermediary results of the investment activity (both groups include a general production efficiency ratio with relevant modifications). Other differentiating features include the differentiation of economic conditions and adequate ratios between emerging and developed (stable) markets; reflection of different economic interests of companies (business owners) and investors in the selection of investment projects and the associated focus of assessment ratios on the requirements of the real production sector.

2. Practical application of the recommended system of ratios (Table 6) will require the introduction of new efficiency ratios into the investment analysis practice, such as ROS_S, ROI_S, R_{TC}, GET_S, GE_S and β, used in estimates supporting the selection of investment projects. The structure of efficiency ratios has been significantly expanded in line with specific nature and requirements of issues addressed, while the discount rate, the core (and only) ratio used in the economic analysis of investments has been totally excluded. Unlike its prototype (the discount rate), the accumulation rate β plays a modest role of income replication, only indirectly linked to the competitive position of a new or upgraded enterprise. The key success factor is a high competitive strength of an enterprise as a result of investment project implementation, characterized by the return on sales matching the levels demonstrated by leading peers.

3. The proof of the pudding is in the eating. And where the results of investment practice (increasing capital intensity of production assets and declining return on investments) contradict the theoretical framework, it is high time to identify weaknesses of the existing theory and improve it. These weaknesses can be summarized as follows:

a) The approach to time value of money in investment efficiency analysis is unviable.

b) The system of investment project selection is based on their commercial feasibility and nothing to do with the assessment of investment efficiency. Project efficiency and project creditworthiness are two different and, as a rule, opposite characteristics. The economic analysis of investments includes a financial feasibility study, which, among other issues, provides a detailed and well-founded conclusion on the ability of a project to finance the repayment of debt and on the future financial position of a potential project owner.

This conclusion, similarly to a conclusion of a loan institution, which protects the interests of an investor, does not apply investment assessment ratios and relies on a different, more accurate system of analytical tools.

In fact, the existing efficiency assessment system duplicates the tasks covered by other components of the economic analysis of investments. Notably, the system fails to perform its function (to assess the economic potential and efficiency of projects). Moreover, it does more harm than good.

Decisions on project benefits are based on the assumption of total investment deficit, which is untypical of developed markets. Investments rationed for each project in accordance with the laws of famine are insufficient for innovative transformation of economy.

On the other hand, the existing efficiency assessment system is founded on an incorrect assumption that all projects will be financed with debt capital, as all companies are poor and lack investment resources of their own. In real situations, when projects are financed from accumulated funds a comparison to an alternative investment into a bank deposit results in misstated estimates, as demonstrated above, while the approach, in itself, contradicts altogether reasonable plans to invest available funds into high-yield transactions in financial markets.

c) The material discussed in this article provides a new content for the project

assessment/selection theory.

Firstly, a new objective is proposed for ranking projects by efficiency: ROS → max. Secondly, a well-founded system of project efficiency ratios and norms is developed.

Target norms are based on real ratios achieved by leading companies in terms of investments and innovations, instead of loan interest rates charged by investors.

4. Our study identifies very serious weaknesses in the key areas of the investment efficiency theory (the approach to value in time, the system of investment efficiency assessment and efficiency ratios), resulting in inaccurate assessment results and, moreover, in non-systemic approach to issues addressed. The search for possible ways to overcome the above weaknesses resulted in the development of new methods of phased approach to the time value of money and the assessment of investment projects on the basis of production efficiency. The new efficiency assessment system is illustrated by Table 6. As the conceptual framework of the new approach to the selection of investment projects, including all its key components (the approach to value in time, the system of ratios and norms) differs radically from commonly accepted methods, we need to determine, whether the existing investment efficiency theory truly meets the requirements of economic development.

Our view on this issue can be discussed in the next article.

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Table 1

System of investment performance metrics

DISCOUNTED METRICS
1. Net Present Value (NPV) $$NPV = \sum_{t=T_C}^{Tp} \frac{P_t + a_t}{(1+r)^t} - \sum_{t=0}^{Tp} \frac{K_t}{(1+r)^t} \geq 0$$
2. Profitability index (PI) $$PI = \frac{NPV}{\sum_{t=0}^{Tp} \frac{K_t}{(1+r)^t}} \to \max$$
3. Internal rate of return (IRR = $r_в$) $$\sum_{t=T_C}^{Tp} \frac{P_t + a_t}{(1+r_в)^t} = \sum_{t=0}^{Tp} \frac{K_t}{(1+r_в)^t}$$
NON-DISCOUNTED CASH FLOW METHOD (UNSOPHISTICATED)
4. Return On Investment (ROI): $$ROI = \frac{P}{K} 100\%$$
5. Payback period (by profit, p): T_p= K/P, years
6. Payback period (by cash flow, pp): $$T_{pp} = \frac{K}{P+a}, \text{ years}$$

Legend: T_c – project completion time, T_o – service (useful) life, (T_c+T_o) – projection horizon (T_p), in years; P_t – profit in year t; a_t – depreciation expenses in year t; r – discount rate in relative units; $r_в$ – IRR of the project; C – annual operating costs; К – CAPEX in year t; ROI – return on

Table 2

Minimum return on investments resulting in equal discounted cash outflows and inflows (NPV=0)

Discount rate (r), %	2	4	6	8
Minimum return on investment (ROI_{min}), required to pay back the costs, %: at T_c=1 and T_o=8 years	1.15	2.3	3.5	4.9
at T_c=1 and T_o=14 years	1.12	2.33	3.6	5

Table 3

Financial characteristics of two operating projects

Item	Amount, RUBm	
	Project I	Project II
Annual sales	5,450.00	5,450.00
Annual operating costs	4,324.00	4,678.00
Annual operating income	1,126.00	772.00
Net income	901.00	618.00
Annual cash flow	1,533.00	768.00
Return on assets (ROA), %	10.50	19.80
Return on sales (ROS), %	16.50	11.30
Labor productivity, %	120.00	100.00

Table 4

Characteristics of two mutually excluding investment projects

Item	Financial data of projects compared, RUBm		Ratio of IP_1 to IP_2, %
	Project I (innovation)	Project II (traditional)	
Annual sales	5,450.00	5,450.00	100
Net income	901.00	618.00	146
Investments	8,600.00	3,120.00	276
Annual depreciation	632.00	150.00	420
Annual cash flow	1,533.00	768.00	200
Return on investments (ROI), %	10.50	19.80	53
Return on sales (ROS), %	16.50	11.30	146

Table 5

Profitability ratios of the two investment projects

Ratio	IP1	IP2
1. Non-discounted		
Return on investments (ROI), %	10.5	19.8
Return on sales (ROS), %	16.5	11.3
2. Discounted, under the present value method		
Net Present Value (NPV), RUBm	1,152.0	1,637.0
Profitability Index (PI), %	15.0	59.0
3. Under the phased approach to value in time		
Net Profit-in-Time (NPT), RUBm	12,549.0	7,621.0
Profitability Index in Time (PIT), %	130.0	217.5

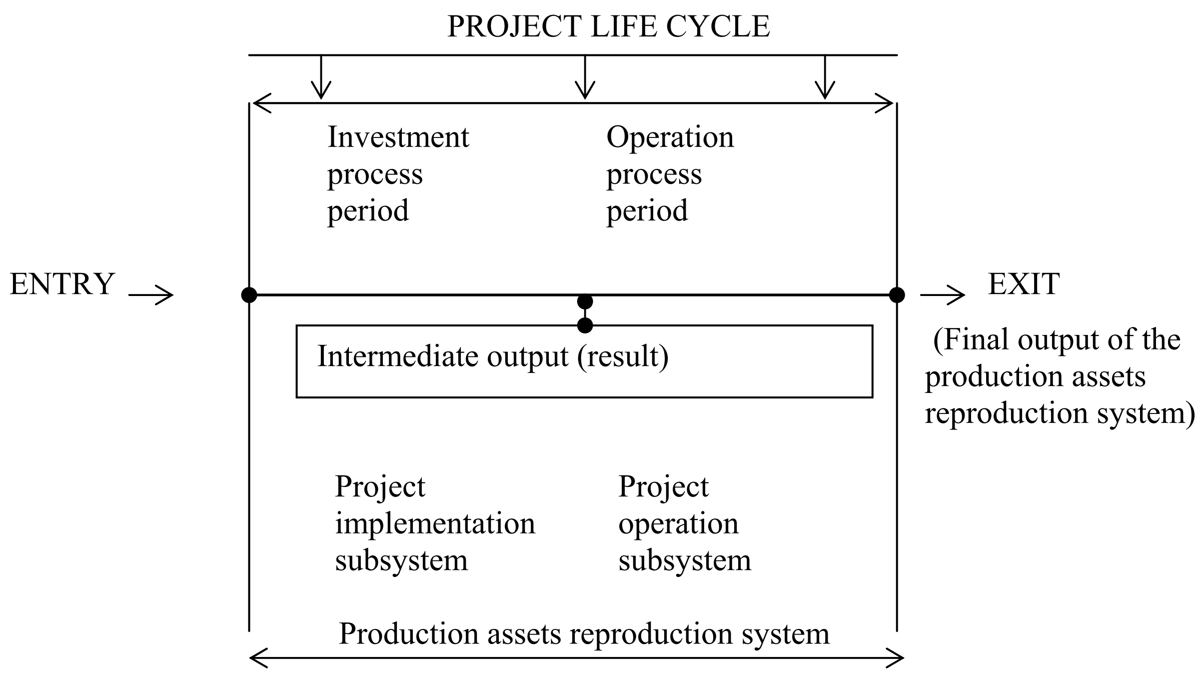

Figure 1. Structure of the production assets reproduction system

Table 6

Recommended system of efficiency assessment ratios for investment projects

Efficiency ratios	For emerging markets	For developed (stable) market economies
I. RATIOS ADJUSTED FOR VALUE IN TIME		
1. General production efficiency ratio: $GET = \frac{\sum_{t=T_c}^{T_P}(P_t + a_t)(1+\beta)^{T_P-t} - \sum_{t=0}^{T_C} K_t(1+\beta)^{T_C-(t-1)}}{\sum_{t=T_C}^{T_P} NC_t + \sum_{t=T_C}^{T_P}(ROI_S K_t + a_t)(1+\beta)^{T_P-t}} \ge GET_S$	Application is impracticable	+
2. Net Profit-in-Time: $NPT = \sum_{t=T_C}^{T_P}(P_t + a_t)(1+\beta)^{T_P-t} - \sum_{t=0}^{T_c} K_t(1+\beta)^{T_C-(t-1)} \to \max$		+
3. Profitability Index-in-Time: $PIT = \frac{\sum_{t=T_c}^{T_p}(P_t + a_t)(1+\beta)^{T_p-t}}{\sum_{t=1}^{T_c} K_t(1+\beta)^{T_c-(t-1)}} - 1 \to \max$		+
II. NON-DISCOUNTED RATIOS		
4. General production efficiency ratio: $GE = \frac{P}{C + ROI_S K} \ge GE_S$	+	+
5. Return on Investment (ROI): $ROI = \frac{P}{K} 100\% \ge ROI_s$	+	+
6. Payback period (by cash flow, pp), years $\sum_{t=1}^{T_{pp}}(P_t + a_t) = K$	+	+
7. Annual total costs: $C + R_{TC}K \to min$	+	+

Legend: T_c – construction period, T_p – projection horizon, Π_t and a_t – net income and depreciation expenses for the year, β – accumulation rate, K_t – capital investments, C_t – annual operating costs, NC_t – annual operating costs net of depreciation, ROI_s- return on investments; R_{TC} – return on capital investments, as component of total costs.