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Methods of Economic Evaluation of Concession Project Effectiveness

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ABSTRACT

This article deals with public-private partnerships as a mechanism for financing of infrastructure projects. The purpose of the study is to offer a toolkit to substantiate the economic efficiency of the concession project for the construction of motor road using the model of its life cycle. The hypothesis is that the best method of modeling of the life cycle of a project is to use the indicator "economic acceleration", the essence of which is that it determines the intensity of changes in cash or value flow, which are the basic elements for calculating the economic efficiency of an investment project. Applying this metric, you can form a single life cycle model that covers two main stages - construction and operation. The method of substantiating the economic efficiency of the concession project, which, unlike the existing methods (net present value, internal rate of return, etc.), is based on the use of a life cycle model and determining the values of its "moments of value". The study showed that it is possible to determine the economic efficiency of a concession project, which is short and long term, using this method. The essence of this technique is that the total mass of the value expended during the period of loss-making work should be equal to the mass of the value received during the period of profit-making – this is the maximum permissible variant, or more general, when the latter must be greater than the previous one (in the period unprofitable work).

INTRODUCTION

The stable and efficient functioning of the transport infrastructure is a prerequisite for stabilization, recovery and structural restructuring of the economy, ensuring the integrity, security and defense capability of the state, improving the level and living conditions of its citizens. Transport generates interbranch services and is essentially an infrastructure infrastructure, since demand for transport services is largely dependent on demand for the output of other activities. A key factor in the functioning and development of transport infrastructure is the state of the country's transport routes. The length of highways in Ukraine is 169,5 thousand km. There are, unfortunately, very few European-level roads in Ukraine today. Almost all highways of the country pass through settlements and have restrictions on the speed of traffic; the average speed on domestic highways is 2-3 times lower than in the developed European countries. The absence of significant changes in the system of routes in the long term can lead to the exclusion of Ukraine from the list of countries attractive for transit (in particular, during the construction of the New Silk Road) and a decrease in the level of transit potential.

Almost the only way to avoid such a scenario of development is to intensify the targeted investment of this sector of economy in the short term. In such circumstances, the development of the road network in Ukraine requires a combination of public and private sector capacity, the formation of state-business partnerships, the strengthening of the role and importance of private investors and operators, the search for the most rational forms of their interaction and division of responsibilities. To conclude a concession agreement, it is necessary to justify its economic efficiency. This justification is necessary for two participants in this process: the state (concessionaire) is required to make a balanced decision on payments to be paid by the concessionaire; the user of this agreement, and the latter, to justify the expediency of such an agreement, is the efficiency of the investment of such investments. To substantiate the economic efficiency of such specific investment projects, it is practically impossible to use existing calculation methods (significant errors will occur). It is possible to solve this problem by applying new approaches to substantiating economic efficiency.

1. LITERATURE REVIEW

Long-term cycles of public and private ownership and investment in infrastructure can be seen across many European countries. Concession contracts can be traced back to the ancient Greeks, and were widely used by the Romans. They were given a modern form under the Napoleonic code, allowing most 18th and 19th century infrastructure (canals, railways, water systems etc.) to be built using private capital, frequently with implicit or explicit subsidies or other forms of government support. Many infrastructures were subsequently taken into public ownership. In the second half of the 20th century, infrastructure finance entered a new phase with privatization, new regulation models and, last but not least, new ways of cooperation under innovative legal frameworks for Public-Private Partnerships (PPPs) (Wagenvoort et al., 2010, p. 17). Rapid changes of economic reality, contradiction structures, priorities, systems and criteria values, have influenced the development of many economic thoughts (Draskovic et al., 2016, p. 37), including the development of public-private partnerships. The study of (Pirozhenko, 2016; Hang, 2017; 2019) confirms that a public–private partnership (PPP) is a cooperative arrangement between two or more public and private sectors, typically of a long-term nature. We find a similar definition of PPP in Legislation of Ukraine (2010)

A PPP can be seen as an alternative instrument for public sector intervention to alleviate a market failure and safeguard allocative efficiency in the economy. In contrast to the more traditional way of supplying infrastructure and public services whereby the public sector finances and owns the assets needed to produce them, a PPP is based on the notion that the public sector can safeguard allocative efficiency even when the assets are financed and owned by the private sector, who also provides the final services to the population (Valila, 2005, p. 115). According to Arata et al. (2016, p. 353) in the PPP acronym the most important P is the third one: Partnership. The risk analysis (Merlo et al., 2013; Pyrkova, et al., 2018) is a fundamental step in the study of a PPP project. The authors Khmel and Zhao (2016, p. 138) looked at the Implementation of projects under the conditions of Public–Private Partnership (PPP). PPP is a promising mechanism for attracting private funds is a legally executed mutually beneficial cooperation

of public bodies and authorities with business entities in respect to projects that are in the field of direct state interest and control for a certain period of time. Around the world, PPPs have become an increasingly popular means for procuring public services and infrastructure (Akintoye and Beck, 2009).

A particular attention needs to be paid to the introduction of innovations, which is possible only through legislative and investment support, which in turn will contribute to the development of entire infrastructure (Polinkevych, 2016; Davydenko et al., 2018, p. 110). According to Stec and Grzebyk (2014, pp. 17) social and economic development, which constitutes a very broad and complex problem in its character, requires various kinds of actions that may be commenced, coordinated and lead in a proper direction. Investment in infrastructure is critical to economic growth (Tkachenko et al., 2020), institutional support of a smart city, quality of life (Delmon, 2011), poverty reduction (Cwynar et al., 2019), education development (Draskovic et al., 2014; Koziuk et al., 2019), healthcare (Alyakina et al., 2017), sports (Mustafina et al., 2018), tourism (Bosovska et al., 2017; Boiko et al., 2018) and achieving many of the goals of a sustainable development economy (Khoma et al., 2018; Buzko et al., 2019, p. 10). For example, accelerating the economic growth of Poland coming from deep transformations gives a possibility to diminish the distance between particular provinces of our country and between them and other regions of the EU (Grzebyk, 2014, p. 341). The construction of new roads under PPP projects has played a significant role in this respect. However, as discussed in Gatti (2018), Project finance has emerged as an important method of financing large-scale, high-risk domestic and international business ventures. Governments and public bodies are ill-placed to fund more than a fraction of these needs in infrastructure in sectors, such as ports, bridges, roads, telecommunications networks, electric power generation and distribution facilities, airports, intra- and intercity rail networks, and water and sewerage facilities. The remainder must come from private sources, either as stand-alone projects or as public-private partnerships (PPPs). The Public-Private Partnership Development Program worked with the Government of Ukraine and community leaders to create the environment needed for PPPs to improve infrastructure and public services. P3DP assistance enabled municipalities to become more resilient to growing budget constraints by working effectively with the private sector to mobilize investment and expertise, engaging citizens early in decision making processes, and ensuring that open, fair and transparent methods were used to identify and contract the best suited partners.

Funded by USAID and implemented by FHI360, the Program worked closely with municipal governments and the Ministry of economic development and trade in four objective areas: improving the legal and Institutional framework for PPPs; supporting the national PPP unit; increasing PPP knowledge and skills; developing pilot PPP projects (Trynchuk et al., 2014, p. 63). Project USAID P3DP worked: the municipal government of Zaporizhia to create Ukraine's first healthcare PPP, because the quality of medical services in Ukraine is low, and the medical industry needs reform (Yermoshenko and Trynchuk, 2016); the Malyn municipal heating with renewable energy PPP; improving solid waste management in Vinnytsia; the Kyiv summer sports and recreation facility PPP on Dolobetsky island; supporting the Lviv city government in developing Ukraine's first parking management PPP for a multi-level underground garage (Trynchuk et al., 2014, pp. 64-72). P3DPs' assistance benefited Ukrainian citizens through improvements in areas such as healthcare, education, solid waste management, and urban transportation. Mitigating global climate change and supporting the use of clean energy was integrated into all P3DP program activities.

There are not many publications discussing the problems of concession activity in Ukraine (Pirozhenko, 2016, pp. 41-42). In addition, a significant part of them relates to the legal side of the issues (Legislation of Ukraine, 2019). Undoubtedly, this is also a relevant and necessary area of scientific research, since without the legislative regulation of this process it is impossible to start applying concession agreements in real conditions. There are far fewer publications investigating the organizational and economic justification of concession effectiveness. This justification is relevant because, in this case, there is a need to invest heavily (in many cases, billions of dollars) over a long period (20 years or more). Therefore, the risks involved in making such a difficult decision are significant (Leschuk and Polinkevych, 2014, p. 212). The experience of many countries with different political and economic systems shows that one of the most effective ways to improve their business is through the involvement and financing of private equity on a concession basis. The main advantage of concessions is the optimal mechanisms for

creating stable and mutually beneficial relations between the state and the investor. In general, the concessionary form of public property management is used in more than 120 countries.

According to the World Bank (2005), in developing countries and countries with economies in transition, concessions account for two-thirds of government contracts in the field of transport infrastructure (railways, highways, seaports, airports). The classic form of government concession in the economic infrastructure sector is a concession based on a BOT contract – Build, Operate and Transfer (Pirozhenko, 2016, p. 44). A private entity that acts as a concessionaire builds an object (Build) operates it (Operate) and transfers it to the state after the concession (Transfer) expires. The abbreviation BOT is sometimes also understood as the construction of an object (Build), its possession over a period of time (Own) and its subsequent transfer to the state (Transfer). Also common is the formula BOOT (Build, Own, Operate and Transfer). Under such contracts, upon completion of the construction of the object, both its ownership and its operation during the concession period are carried out. However, in the area of economic infrastructure, there are many other approaches with different contractual terms and the relationship between the state and private entities (Shlafman, 2010).

The most common practice in developed countries for road construction is a scheme whereby an investor invests in the construction of a complete road complex (or road section or road infrastructure) and receives the right to its operation for at least fifty years [26 with. 40]. After the contract expires, the road is nationalized. Thus, the state gets the property into the road without investing in its construction, and the concessionaire receives a profit during the concession validity at the expense of payment by users of the fare. A variant is also widespread when the state builds a road by its own means and transfers it to a concession for maintenance in good condition, or owns part of the shares in a consortium that builds and operates a highway (Vdovenko, 2009, p. 58). In this case, the service service may be organized differently – the concessionaire may build the service facilities himself and then rent them out, or involve subconcessionaires to organize the service. According to Draskovic et al. (2017, p. 596), the conditions of production, exchange, etc. (prices regulation, investment decisions, etc.) are often crucial (specific interest) for certain groups of people. Given this fact, it is worth noting that, unfortunately, no toll roads have been built for public-private partnership projects to date.

The Verkhovna Rada adopted a new Law on Concession. This is what it should restart the state's relations with foreign investors and become a business partner for them. According to the new Law (Legislation of Ukraine, 2019), the state will choose business partners through the electronic system of public procurement. Concessions will only start in actually since autumn 2020. After all, we still need to register an algorithm for them in the ProZorro system. In the near future, four motorways up to 70 kilometers long may appear in Ukraine, namely: a bypass around Kiev, Lviv - Krakowiec; Bila Tserkva - Kyiv; detour near Odessa (Toll ..., 2019). The practice of concessionary relations in developing countries is of interest to Ukraine because of the similarity of economic development processes, in particular, the similarity of economic and social problems, the main ones being the insufficient level of development of state institutions, the use of administrative resources, and general macroeconomic instability and significant political risks. Authors, Shved et al. (2013, p. 134) perceive product life cycle is the basic model used in logistics and marketing activities to justify and study the effectiveness of an investment project or the enterprise as a whole The most significant disadvantage of virtually all models of this cycle that are cited in the economic literature is that they are described not by functional dependencies that can be used to perform quantitative analysis, but by abstract graphical images that are given for clarity and to establish the major trends in the life cycle under consideration.

Such images are characteristic for performing initial studies of any phenomenon. However, these initial stages in the economy have long since passed. Therefore, it is necessary to make the transition from abstract drawings of the product life cycle to the establishment of its real functional dependencies. However, it is not easy to make such a transition, since there is virtually one problem that hinders this – the lack of a formalized economic categorical apparatus. To put it simply, in order to investigate nonlinear dependencies, you need to know an indicator that will determine the rate of change of this linear dependence (rate of change of flow). In the natural sciences, such an indicator is called acceleration. The scientific work shows the use of the category "economic acceleration" for modeling the life cycle of products. One of the objectives of the study is the quantitative modeling and theoretical justification of the numerical values of life cycle indicators.

To model the product life cycle, we use a formalized categorical apparatus (Gudz and Skvortsov, 2008). Its essence lies in the fact that a priori (to the study) are given three primary categories: K – cost, N – the number of products and T – time. All secondary categories are axiomatically defined on the basis of primary ones. The main secondary categories include "productivity" and "economic acceleration". The use of this category apparatus allows to plan the numerical value of cash and value flows over a long period, which is crucial for the calculation of the product life cycle or life cycle (enterprise) of the concession project. Authors (Ma et al., 2018, p. 706) discuss the concession period of PPP (Public–Private Partnership) projects is the most essential feature in determining the time span of various rights, obligations and responsibilities between the government and concessionaire. Most traditional methods are based on the analysis of the future cash flow to determine the concession period, but either ignored the potential values or the risks that might emerge during the project life span, thus failing to find the proper concession period for the project. Cash flow research is a critical element of financial analysis (Kiselakova et al., 2018). This is explained by the fact that they substantiate the following processes and indicators of the enterprise: its market value and level of capitalization, efficiency of activity and any investment and innovation projects (Chukhray and Pator, 2001), stock price, long-term credit, etc., and this list can be continued. Unfortunately, classical economic theory has failed to answer the question of how these flows can be modeled and quantified. Cash flows at the enterprise occur when performing transactions with the external environment – other legal entities or individuals. The most common are the following two operations: payment for work or services (cost) and receipt of money for sales. One of the most important tasks of financiers in the enterprise is to achieve a balance between the money received and the expenses incurred. But to reach such a balance it is necessary to be able to forecast the amounts of such revenues and expenses. The most typical, but at the same time the most capital-intensive, are the costs of implementing an investment or innovation project, which usually require an adequate amount of construction work.

2. AIMS AND METHODS

The purpose of the study is to offer a toolkit to substantiate the economic efficiency of the concession project using the model of its life cycle and to improve the economic and mathematical model of the life cycle of the concession project. An example is the calculation of economic efficiency of concession projects on construction of roads, which is carried out by the Economic Association for the Development of Transport and Border Infrastructure "Zakhidtranskordon". To achieve the goal and solve the tasks set, the tools of scientific research methods were applied, namely:

- systematic approach, economic-mathematical modeling and comparison – to substantiate the economic evaluation of the concession project efficiency and its effectiveness created on the basis of the concession;
- statistical and comparative analysis - to analyze the main indicators;
- graphical and tabular - for visual display and effective perception of statistics and to present schematically the results of practical provisions of the study.

The methodological core of the research is the life cycle model of the concession project, which is the basis for determining its effectiveness, and, unlike the existing descriptive and qualitative ones, it is substantiated by economic and mathematical expressions, which allows to quantitatively study the investment process and to determine the predictive values of this cycle.

3. RESULTS

To establish a sound economic evaluation method for the concession project's effectiveness, two of the most important conditions must be taken into account: this method should be based on the most important and essential features of a specific concession project and, if possible, use existing approaches to this assessment. An example is the calculation of the economic efficiency of concession projects for the construction of motor roads, which is carried out by the Economic Development Association for the Development of Transport and Border Infrastructure, the Company "Westransransord". The following fea-

tures are observed, which are observed during the practical planning of concession projects for the construction of highways. The new Lviv–Rava-Ruska highway as the main variant of the connection between the largest city and the transport hub of the western part of Ukraine in Lviv and the motorway crossing on the Ukrainian–Polish border Rava-Ruska/Grebenne is considered as a component of the alternative variant of the motor transport on the section Ternopil–the state border–Lublin (Poland) as part of the European (international) transport corridor proposed by Ukraine to the Baltic Sea–Black Sea (Gdansk–Odessa) (see diagram "Direction Gdansk–Odessa in the international transport corridors", shown in Figure 1).

The necessity of new construction of the Lviv–Rava-Ruska motorway is determined by the complexity of bringing the existing highway to the category 1a parameters, as well as the need to provide promising capacity for local and distant (international) communication. Developers of the project explain the high level of uncertainty in the development of events in the distant future and the inappropriateness of forecasting for a period greater than 20-25 years. In addition, such a horizon of calculation covers the lifetime of the concession motorway before major repairs (18th year of operation), which provides a more reliable estimate of the financial efficiency of the project (Gorbova and Skvortsov, 2011). The initial conditions of the project are for indexing the maximum amount of travel fare, which allows in calculations not to take into account probable inflation rates. Calculation of investment costs, as well as gross expenses and incomes, was carried out without taking into account the value added tax, as it is subject to reimbursement (payment) in the period of occurrence of a tax credit (tax liability). The probability of arrears of VAT refunds during the investment phase of the project is considered as not having a significant effect on the cash flows of the project for the accepted degree of approximation of settlements. The emergence from the operator (concessionaire) of obligations to pay VAT in the course of exploitation of the object of the concession is fully satisfied with operating revenues from the proceeds.

Figure 1. Scheme "Direction of Gdansk–Odessa in the system of international transport corridors"
Sources: designed by the authors

The main technical and economic indicators of the project are presented in Table 1.

Table 1. Technical and economic indicators of the project

Indexes	*Value*
Road category	1a
Length of road, km	55,5
Cost of construction without VAT, ths. UAH	1 872 721,311
Normative term of construction, months	57
The expedient term of the concession, years	50

Sources: developed by the authors

The calculation of investment costs, as well as gross expenditures and income, is carried out without taking into account the value added tax, since it is subject to a refund in the period of occurrence of a tax credit. Expenditures for major repairs are evenly distributed over the period of operation and are accounted for in gross expenses. The road is put into operation by the whole object (without the allocation of individual queues), and the value of the predicted intensity of traffic in the direction adopted as the predicted values of the intensity of the motor transport on the concession road. During the project's horizon, only investment costs are foreseen. The liquidation value of assets at the end of the calculation horizon is not taken into account, since the lion's share in the value of assets is occupied by the state-owned concession facility and has a specific liquidation procedure.

The model of the financial analysis used in the project assumes that the investment cash flow (ICF) is formed only by costs during the investment phase of the project and corresponds to the cost of the work done to create the concession object. Capital repairs, which form the investment cash flow during the project's operational phase, are distributed over the period preceding capital repairs (18 years after the commissioning of the facility), and are classified as gross expenses. In addition, due to the fact that the maintenance and operation of the facility can be carried out through the operator-operator, the costs of acquiring and updating fixed assets and intangible assets at the concessionaire are not included or are included in gross expenses. The calculation of investment cash flow is based on data on the cost of constructing a toll road specified in the technical part of the feasibility study, in accordance with the calendar of the project implementation.

The real money flows (RMF) of the project reflect cash inflows and payments that are related both to the creation (investment cash flow – ICF) and to the operation of the object (operating cash flow – OCF), and to the financing of investments (financial cash flow – FCF). The operating cash flow (OCF) is defined as the actual amount of cash remaining at the disposal of the concessionaire after covering all the gross expenses and payment of the income tax. In the calculation of operating cash flow, the tax on profit is determined at the rate – 25%, and the period of transfer of losses of past periods is unlimited. The calculation of OCF and FCF is shown in Table 2 and Tabl. 3, and the calculation of the break-even point in Figure 2. Net income is the indicator of the total income of the investor during the estimated horizon. Net income at the end of 25 year is UAH 274,602 thousand (see Table 3), which is a small amount taking into account the calculation horizon and the size of the investment. This explains the fact that the payback period of the project is 22.8 years (see Figure 2). Thus, under accepted conditions, the project is characterized by long (remote) payback and generally low internal characteristics of financial efficiency.

Since in our case the payback period of the project approaches the calculation horizon, and the choice of the discount rate in the current macroeconomic situation is difficult, calculation of indicators of financial return on the method of discounting is not appropriate. In particular, for the adopted horizon, the net balance of net income (NDI) will be negative, and the internal rate of return (IRR) is about 1.03, which is much lower than the market interest rates for long-term financial resources. The calculation confirms that the long payback of investments, as well as high returns in the long run, is a specific feature of infrastructure projects. Formation of attractive values of indicators of financial efficiency of the project for the chosen calculation horizon is problematic. The project is characterized by a high degree of sensitivity to the cost of capital, with the principal and determining for the successful implementation of the project under the conditions accepted is the concessionaire's involvement of budget financing as a partial co-financing of works under a concession contract. However, the project has the potential to significantly improve its internal financial efficiency, in particular due to an increase in the calculation peri-

od, due to optimization of the conditions of implementation compared with the accepted initial terms of calculation and provided more favorable dynamics of the parameters of the project, determining its future benefits (intensity of motor transport on the concession motorway, solvency of users, etc.). Optimization of the conditions of the project implementation in comparison with the accepted initial conditions of calculation can be carried out according to the following main directions:

- Optimization of the scheme of financial support of the project;
- Reduction of the duration of the investment phase of the project by introducing modern methods of organizational and technological support for the construction of the concession facility;
- Organization of construction and commissioning of the concession facility in queues;
- Optimization and detailing of the investment plan in time;
- Optimization of terms and expenses for repair works taking into account the high quality of designing and construction of buildings within the concession facility;
- Reduction of the tax burden on the cash flow of the project;
- More detailed elaboration of the revenue part of the project as part of the concession services related services.

Table 2. Calculation of operational cash flow of the project

Indexes	*Value of indicators by years, ths. UAH*																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Gross revenues	135842	140738	145635	150541	155437	160334	165231	170127	175033	179929	184826	189723	194628	199525	204422	209318	214224	219121	224017	228914
Gross expenses	64235	64235	64235	64235	64235	64235	64235	64235	64235	64235	64235	64235	64235	64235	64235	64235	64235	64235	64235	64235
Depreciation deductions	145383	134096	123686	114084	105228	97059	89524	82574	76164	70251	64797	59767	55127	50847	46900	43259	39901	36803	33946	31311
Adjusted gross income	-73776	-57593	-42286	-27779	-14026	-960	11472	23318	34634	45443	55794	65721	75266	84442	93287	101824	110088	118082	125836	133368
Losses of past periods		-73776	-131370	-173656	-201435	-215461	-216421	-204949	-181631	-146997	-101554	-45760								
Profit before income tax deduction	-73776	-131370	-173656	-201435	-215461	-216421	-204949	-181631	-146997	-101554	-45760	19961	75266	84442	93287	101824	110088	118082	125836	133368
Profit tax												4990	18817	21111	23322	25456	27522	29521	31459	33342
Net profit (loss)	-73776	-131370	-173656	-201435	-215461	-216421	-204949	-181631	-146997	-101554	-45760	14971	56450	63332	69965	76368	82566	88562	94377	100026
Balance of operating cash flow	71606	76503	81400	86305	91202	96099	100995	105892	110798	115694	120591	120498	111577	114179	116865	119627	122467	125365	128323	131337

Sources: calculated by the authors

Table 3. Calculation of financial cash flow of the project

Indexes	Value of indicators by years, ths. UAH																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Balance of investment cash flow (ICF)	-337090	-507513	-447575	-299635	-280908																				
Operating cash flow balance (ICF)						71606	76503	81400	86305	91202	96099	100995	105892	110798	115694	120591	120498	111577	114179	116865	119627	122467	125365	128323	131337
The flow of money	-337090	-507513	-447575	-299635	-280908	71606	76503	81400	86305	91202	96099	100995	105892	110798	115694	120591	120498	111577	114179	116865	119627	122467	125365	128323	131337
The flow of real money to the project is a growing sum	-337090	-844603	-1292178	-1591813	-1872721	-1801115	-1724612	-1643212	-1556907	-1465705	-1369606	-1268611	-1162718	-1051921	-936227	-815636	-695138	-583561	-469382	-352517	-232890	-110423	14942	143265	274602
Balance FCF	337090	507513	447575	299635	280908																				
The balance of real money						71606	76503	81400	86305	91202	96099	100995	105892	110798	115694	120591	120498	111577	114179	116865	119627	122467	125365	128323	131337
The balance of real money is an incremental outcome						71606	148110	229509	315815	407017	503115	604111	710003	820800	936495	1057086	1177583	1289160	1403339	1520204	1639831	1762298	1887663	2015986	2147323

Sources: calculated by the authors

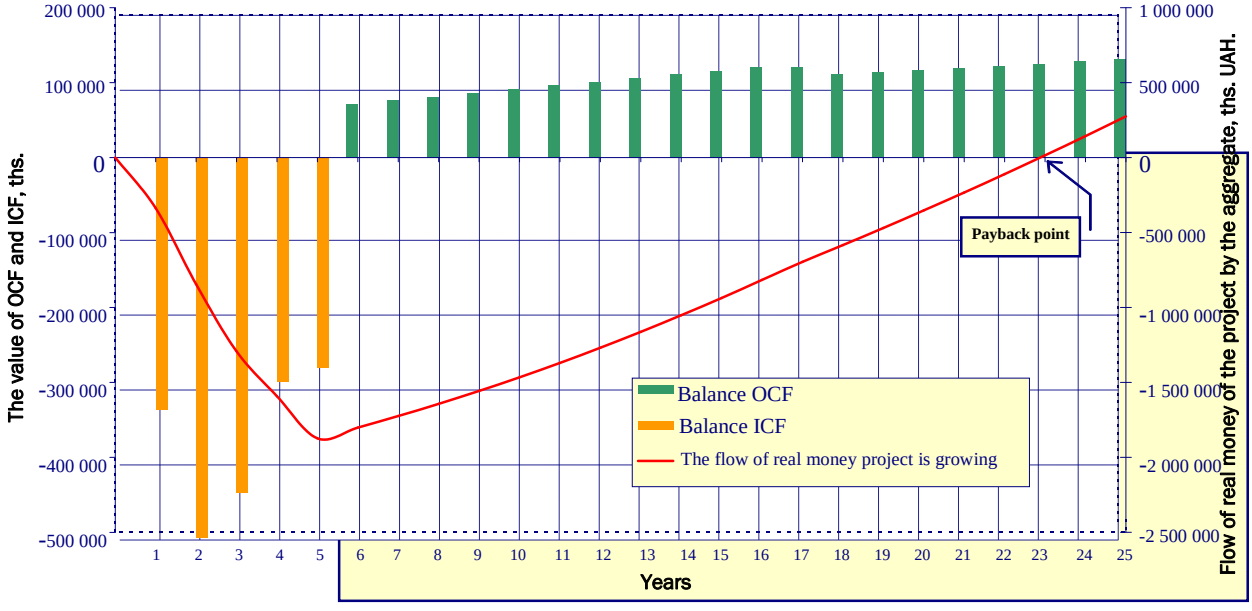


Figure 2. Calculation of the project payback point

Sources: developed by the authors

Based on the performed research, from the analysis of the reasons for low economic efficiency of this project, the following conclusions were made:

The main reason for the lack of efficiency of this project is the non-compliance with economic conditions, which are summarized by the concept of "scale effect";

The proposed length of the 55.5 km route, which is to be transferred to the concession, is not sufficient to create an effective project. This is explained by the fact that in order to carry out construction work it is necessary to create the appropriate infrastructure (concrete and asphalt plants, warehouses, etc.) that form specific "constants" costs of construction. Therefore, the smaller the volume of construction works, the greater their cost and, conversely, the larger the volume – the lower the cost;

Performed calculations show that if the concession pass the route Rava-Ruska–Ternopil, then the payback period is reduced by 7 years, and if Rava-Ruska–Uman, it is reduced by almost 20 years.

To continue the study, it is necessary to emphasize again the main features of concession projects, which will be taken into account as much as possible in the proposed methodology. There are the following main features of concession projects:

- The life cycle of this project consists of two main stages: the design and construction;
- Unlike the usual enterprises, the term of functioning of which is theoretically unlimited, concession-based enterprises have a clearly established term for termination of the agreement (termination of operation);
- The construction period must be included in the life cycle of the project, since this period is included in the term of the concession agreement, that is, by increasing the duration of construction, the concession recipient actually reduces the period of exploitation of this concession facility.

In the proposed model of the life cycle of a concession project, most of these features are taken into account. Such a model of the life cycle of a concession project is considered as the basis (see Figure 3):

a) Project Life Cycle Model (LCP) of the current values that corresponds to the expression

$$P_t = \begin{cases} -R_{c0} \cdot t + \frac{1}{2} \cdot \frac{R_{c0}}{T_{m1}} \cdot t^2, & 0 \le t \le T_c; \\ R_{o0} \cdot (t - T_c) - \frac{1}{2} \cdot \frac{R_{o0}}{(T_{m2} - T_c)} \cdot (t - T_c)^2 + S_1, & T_c \le t \le T_s, \end{cases} \quad (1)$$

where, R_{c0} and R_{o0} – the initial value of economic acceleration during the construction period (c) of the enterprise and its operation (o);

T_c and T_s – duration of the construction period and the estimated operating period;
T_{m1} and T_{m2} – time when the maximum investment costs during the construction period and the maximum profit during the exploitation period are reached;
S_1 and S_2 – steel integration, which is determined from the initial conditions;

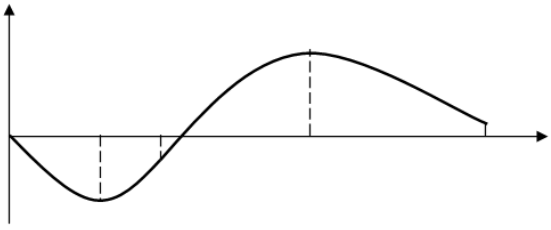
b) The basic model of the cycle, on the basis of which we will note the effectiveness of the concession project (Skvortsov, 2003)

$$K_t = \begin{cases} -\frac{1}{2} \cdot R_{c0} \cdot t^2 + \frac{1}{6} \cdot \frac{R_{c0}}{T_{m1}} \cdot t^3, & 0 \le t \le T_c; \\ S_1 \cdot (t - T_c) + \frac{1}{2} \cdot R_{o0} \cdot (t - T_c)^2 - \frac{1}{6} \cdot \frac{R_{o0}}{(T_{m2} - T_c)} \cdot (t - T_c)^3 + S_2, & T_c \le t \le T_s. \end{cases} \quad (2)$$

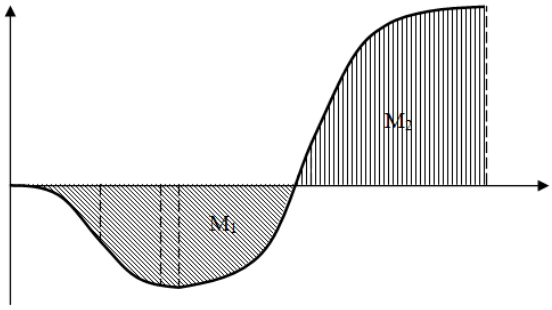
The effectiveness of certain concession projects, the implementation of which is insignificant (up to 15 years old), can be determined by the expression (2). However, the effectiveness of most concession projects, which are over 40 years old and which are risky, it is more appropriate to rely on another approach.

The essence of the proposed methodology is that it involves taking into account the two most important factors: firstly, the significant duration of this project, which is conditioned by objective factors – low profitability of the project, which is typical for toll roads, and therefore a long period of payback or significant risks.

To calculate such risky and long-term concession projects, it is proposed to apply the following method: the total weight of value spent during a period of loss-making should be equal to the mass of value that will be received during a period of gainful employment.



a) Differential graph of the LCP – the schedule of "cost streams"



b) Integral chart of LCP – schedule "cost stocks"

Figure 3. Graphic representation of the stages of the calculation of the life cycle of the project (LCP) and the method of substantiating its effectiveness

Sources: developed by the authors

If we skip some mathematical proofs, it is simplistic to say that the following conditions must be met to justify efficiency:

$M1 \le M2$, (3)

where M1 and M2 are "moments of value" of unprofitable and profitable periods, the economic and mathematical content of these indicators is that their value corresponds to the area of shaded figures that are under the schedule of the product life cycle function (Figure 3 b). Or equivalent expression:

$M2 - M1 \ge 0$. (4)

This, it would seem, simple principle in real terms is not so easy to implement. This is due to the fact that in such a case, the correctness of calculating the life cycle of the concession project and determining the areas (value points) of the figures obtained has a significant effect on the result obtained. But the proposed method allows this problem to be resolved positively. The definition of the change in the "value point" (M) can be performed with the expression (Skvortsov, 2003, p. 76-77):

$$M = \int_a^b K_t dt \quad , \qquad (5)$$

where Kt – change of the cost of the considered process during the change of time from the value "a" and to the value "b".

This possibility of the expression (5) is explained by the fact that the mathematical content of a definite integral is precisely that it defines the area of the figure, which is between the values of the function change and the axis abscis (xx). Therefore, to determine this area of the figure (change of values of the moment of value), which is depicted in Fig. 3 b, it is necessary to integrate the expression (2). As a result of this integration, you can get an expression:

$$M_t = \begin{cases} -\frac{1}{6} \cdot R_{c0} \cdot t^3 + \frac{1}{24} \cdot \frac{R_{c0}}{T_{m1}} \cdot t^4, & 0 \le t \le T_c; \\ S_2 \cdot (t - T_c) + \frac{1}{2} S_1 \cdot (t - T_c)^2 + \frac{1}{6} \cdot R_{o0} \cdot (t - T_c)^3 - \frac{1}{24} \cdot \frac{R_{o0} \cdot (t - T_c)^4}{(T_{m2} - T_c)} + S_3, & T_c \le t \le T_s, \end{cases} \qquad (6)$$

where S_3 is the stable integration, which is determined from the initial conditions.

To determine what the proposed methodology for calculating the efficiency of the investment (concession) project, which corresponds to the expression (6), differs from the existing one, which corresponds to expression (2), we will consider the numerical example. If you use the source data shown in the table 4, then you can calculate the effectiveness of this project in two methods. Method 1 (Existing). A characteristic feature of this method is what takes into account, according to Expression (2), actually two indicators – the initial value of fixed assets (Kfa), which, in economic terms, coincides with the indicator "total investment" in the project, and the total profit (Kpm), which will be received during the settlement period (or the term of the concession agreement) (Zagoretska et al., 2011).

Table 4. Output data of investment project indicators

Indicator	*Marking*	*Unit of measurement*	*Value*
Initial economic acceleration during construction	R_{c0}	m/y2	2
Initial economic acceleration during operation	R_{o0}	m/y2	1,5
Construction term	T_c	years	4
Estimated period	T_s	years	14
Extreme point 1	T_{m1}	years	2,2
Extreme point 2	T_{m2}	years	9,4

Sources: developed by the authors

The total value of investments K_{fa} and the total value of profit K_{pm} can be determined if the expression (7) substitute the values taken from the initial data (see Table 4) in expression (7).

$$y = N(P_i \cdot t - \frac{1}{2} R_b \cdot t^2)_5 \qquad (7)$$

where, P_i – initial marginal productivity (intensity) of development of capital investments;
R_b – the limiting value of the change of this intensity (economic acceleration). According to the concluded agreement, the work performed will be paid every five months. Only in this case, in order to determine the total profit value, the schedule of the investment cycle function should begin from zero, but not to continue from the amount of capital invested. To do this, the integration of S_2 must be constant equal to zero. As a result, we obtain the following analytic expression of this function:

$$K_t = \begin{cases} -\frac{1}{2} \cdot R_{c0} \cdot t^2 + \frac{1}{6} \cdot \frac{R_{c0}}{T_{m1}} \cdot t^3, & 0 \le t \le T_c; \\ S_1 \cdot (t - T_c) + \frac{1}{2} \cdot R_{o0} \cdot (t - T_c)^2 - \frac{1}{6} \cdot \frac{R_{o0}}{(T_{m2} - T_c)} \cdot (t - T_c)^3, & T_c \le t \le T_s, \end{cases} \qquad (8)$$

and the numeric value of this function is:

$$K_t = \begin{cases} -\frac{1}{2} \cdot 2 \cdot t^2 + \frac{1}{6} \cdot \frac{2}{2{,}2} \cdot t^3, & 0 \le t \le 4; \\ 0{,}73 \cdot (t - 4) + \frac{1}{2} \cdot 1{,}5 \cdot (t - 4)^2 - \frac{1}{6} \cdot \frac{1{,}5}{(9{,}4 - 4)} \cdot (t - 4)^3, & 4 \le t \le 14. \end{cases} \qquad (9)$$

The graph of this dependence is shown in Figure 4.

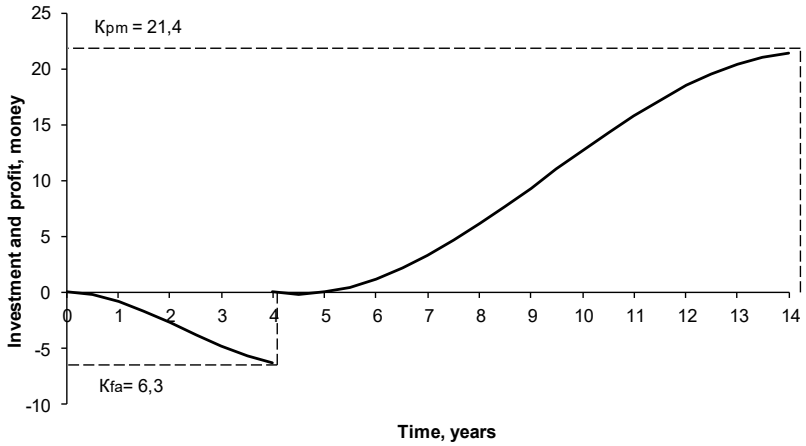


Figure 4. The schedule of the investment cycle function, which consists of two parts – the period of construction and operation of the enterprise

Sources: developed by the authors

When the expression (9) substitutes t=14 years, then you can determine the value of K_{pm}. Then the effectiveness of the project can be checked by the formula:

$$N_{pe} = \frac{K_{pm}}{K_{fa}} = \frac{21,4}{6,3} = 3,4 >> 1,5 \qquad (10)$$

That is, the estimated value of the investment norm of profit, which is 3.4, significantly exceeds the normative value of this indicator 1.5 more than twice, which indicates the high efficiency of this project. However, this conclusion would be correct, if it were for the ordinary enterprise, the term of operation of which is unlimited (theoretically it goes to infinity). The importance of this observation is that any period of construction (actually it's 5-10 years, and sometimes and more), compared to infinity, can be neglected (not taken into account), which is carried out in this method. But for a concession-based company, this can not be neglected, as this factor will directly affect the effectiveness of such a project. To confirm this assertion, one can assume that there is a project in which all the endpoints (investments of K_{fa} and the earned K_{pm}) correspond to the preceding case (see Table 4). But the construction period of this project (enterprise) is twice the size of the previous case. Changing the term of construction will cause such a change in the basic indicators (see Table 5).

Table 5. Output indicators of the changed investment project

Indicator	*Marking*	*Unit of measurement*	*Value*
Initial economic acceleration during construction	R_{c0}	m/y2	0,5
Initial economic acceleration during operation	R_{o0}	m/y2	2,28
Construction term	T_c	years	8
Estimated period	T_s	years	14
Extreme point 1	T_{m1}	years	4,4
Extreme point 2	T_{m2}	years	13,4

Sources: developed by the authors

As a result, the function of the investment cycle will change:

$$K_t = \begin{cases} -\frac{1}{2}\cdot 0,5\cdot t^2 + \frac{1}{6}\cdot\frac{0,5}{4,4}\cdot t^3, & 0 \le t \le 8; \\ 0,73\cdot(t-8) + \frac{1}{2}\cdot 2,28\cdot(t-8)^2 - \frac{1}{6}\cdot\frac{2,28}{(13,4-8)}\cdot(t-8)^3, & 8 \le t \le 14. \end{cases} \qquad (11)$$

The graphic representation of this function is shown in Figure 5.

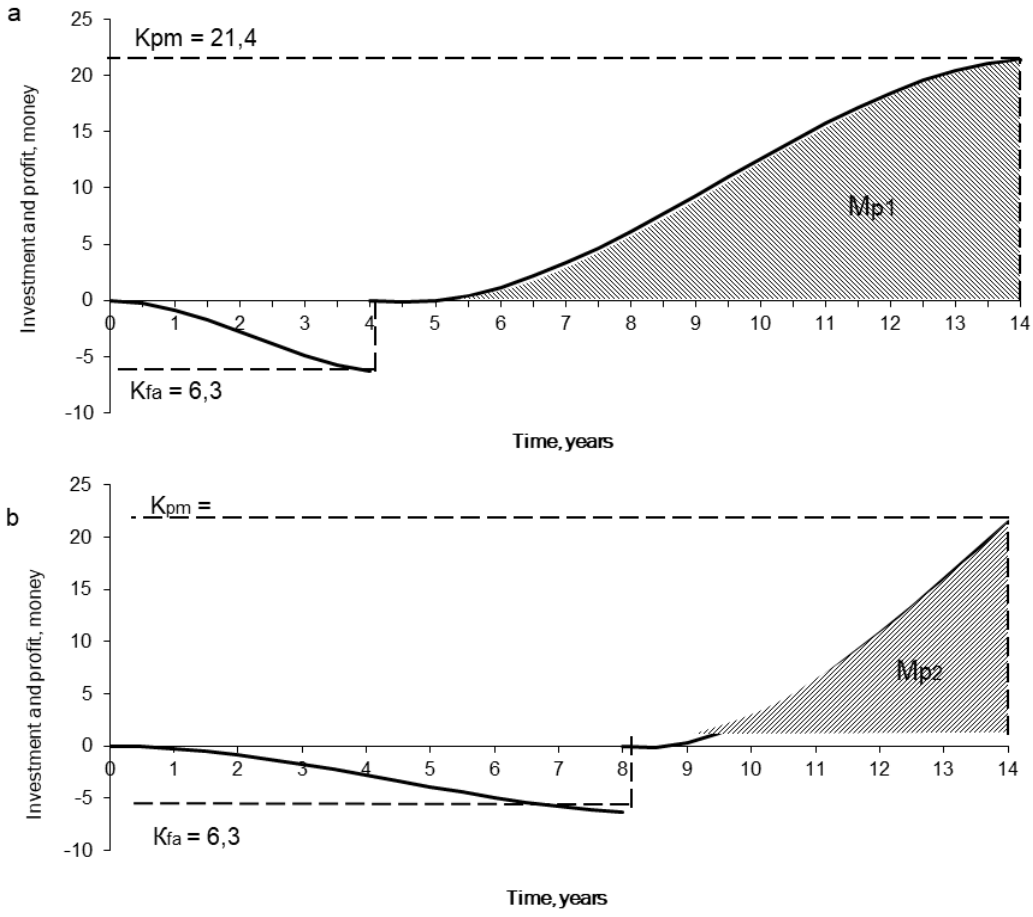


Figure 5. Comparison of the effectiveness of a concession project provided that the period of its construction is changing

Sources: developed by the authors

If you use the indicators of the existing method – the expression (10), then the effectiveness of these two projects, as shown in Figure 6a and Figure 6b will be the same, since the values of the K_{pm} and K_{fa} indices are the same. But this does not correspond to the obvious facts – the mass of profit, which will be obtained in the first case (the shaded area of M_{p1}), significantly exceeds the value of this indicator for the second case (M_{p2}). Therefore, the prior assertion that the expression (8) can not be used to substantiate the effectiveness of concession projects in most cases is correct, as this technique is adapted for other cases.

Method 2 (suggested). If we calculate the effectiveness of the first investment project by the expression (6), then it can be established that this project is effective, since the total value of the moment of value at the end of the considered period (14 years) is greater than zero (Figure 6 a).

However, when calculating the efficiency of the second variant of the investment (concession) project, it can be established that this variant is really not effective, since the total value of the value of the moment is significantly less than zero (Figure 6 b).

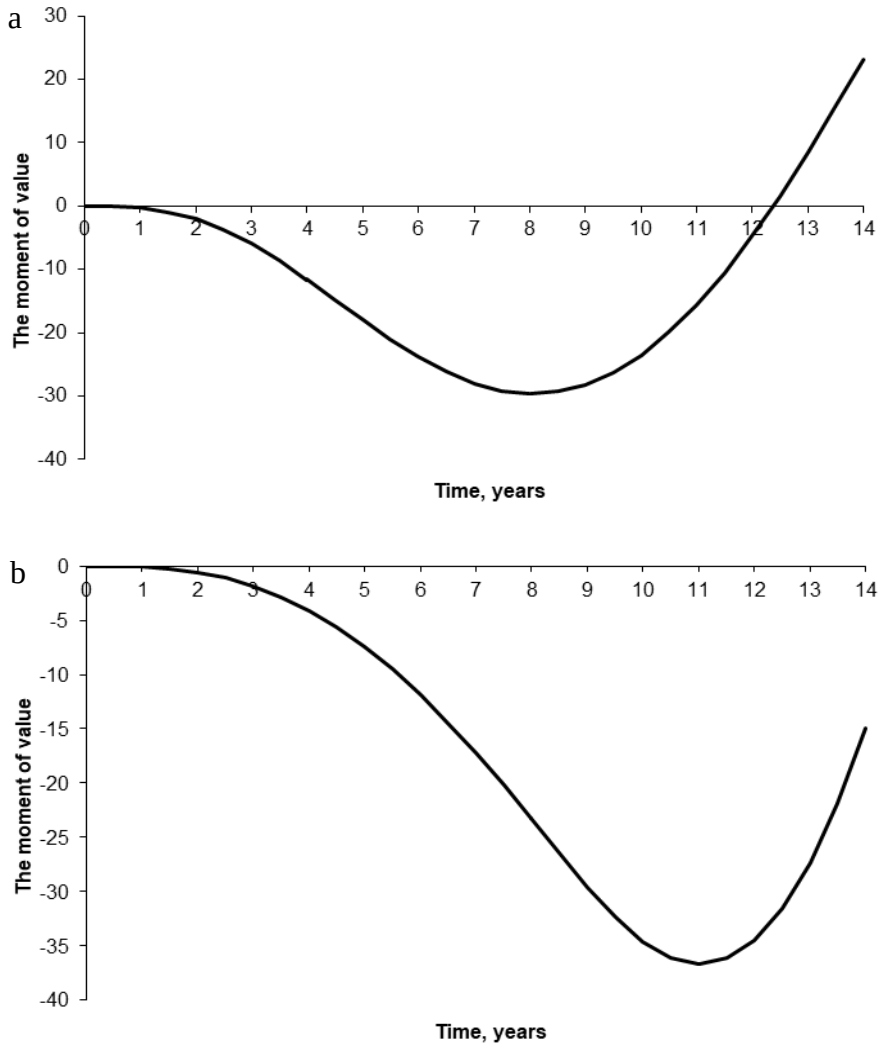


Figure 6. Graphical calculation of the effectiveness of the investment project using the moment of value

Sources: developed by the authors

4. DISCUSSION

It is possible to conclude that the proposed method of substantiating the effectiveness of a concession project based on the application of value points, more objectively justifies it in comparison with existing methods. In addition, the proposed method for substantiating the effectiveness of an investment (concession) project differs from the traditional one, and focuses not on the substantiation of the values of discount rates (discount rates and maturity dates, etc.), but on the direct modeling of this process. That is, efficiency is defined as a logical study of the constructed model. Undoubtedly, for the application of this technique in different industries, it is necessary to take into account their peculiarities which should be laid down in the basic model of the product life cycle.

This methodology can also be applied to other concession projects, which initially involve the execution of construction work and subsequently the stage of operation. Such objects can be: road, sea and airports, separate enterprises.

CONCLUSIONS

On the basis of the performed research we can draw the following one general conclusion: if the construction works (in the general case of investment) of any project make up a fourth part of its settlement period and more, then the effectiveness of such investment project should be checked according to the proposed method of determining the areas of "moments of value". It is also important that such projects are most characteristic of concession agreements.

It is established that cash flows have significant features – they are modeled with the use of special non-elementary mathematical functions, the relationship between cash flow and stock is made not through integration and differentiation operations, but through summation and separation (diffraction graph). All this leads to the fact that calculating the numerical value of cash flows is much more complicated than the value flows. The proposed methods for calculating and modeling cash flows are only the first steps in such research that need to be continued to cover all their diversity.

It is substantiated that a special methodology is required to determine the economic efficiency of concession projects. This is due to the fact that these projects have significant features, among the most important of which are: limited duration of the project; the considerable length of the construction period relative to the limited period of operation; as a rule, the long duration of such projects, which is due to objective factors, is the low profitability of the project, which is characteristic of toll roads, and therefore a long payback period or significant risks.

The main feature of the proposed method of substantiating the economic efficiency of the concession project is:

- modeling of the project life cycle is based on the technological features of the specific project implementation;
- construction and operation periods are modeled as a function of the investment cycle on the basis of calendar schedules of these works, which forms a real basis for substantiating the economic efficiency of the project;
- the combination of these two investment cycles - the period of construction (investment) and operation (sales and profit) – forms the life cycle of the project;
- the efficiency of the project life cycle is determined by the method of "moments of value", the essence of which is the excess of the "mass of value", which they will receive in the period of profitable work (after the payback point), over the "mass of cost", which they spend in the period of construction and return of invested funds.

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