Cost-Effectiveness Analysis (CEA) of Public Investment Projects

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Abstract:

Purpose: The aim of the article is to investigate the conditions and possibilities of wider use of methods of cost-effectiveness analysis of investment projects in the public sector, and to assess the role in decision-making in the conditions of crisis phenomena, in particular the risk of excessive budget deficit and public debt.

Design/Methodology/Approach: The concept of the article refers to the changes in the global economy and in the public finance sector in the face of the crisis. As part of the research, negative economic and social changes were observed. In 2020, many countries saw a significant decline in the value of GDP, with a simultaneous increase in the budget deficit and public debt. This resulted in changes in the financing of public tasks. Research proves that there is a need to improve the efficiency of public spending and a wider use cost-effectiveness analysis.

Findings: During the research, it was noticed that in the changing economic conditions it is justified to pay attention to increasing the efficiency of public investment projects and to a wider use of cost-effective methods of project analysis. The importance of this group of methods is related to the possibility of analyzing and evaluating projects for which it is not possible to measure the achieved effects in monetary terms. It was noticed that public investment projects, especially small ones, were not always analyzed and assessed. A broader and precise application of cost effectiveness analysis (CEA) can lead to the improvement of economic efficiency in the wider social dimension. The effects of crisis phenomena may be long-term, as indicated by the results of prospective studies.

Practical implications: The use of CEA can disseminate research methods and improve efficiency where other research is often impossible.

Originality/Value: The article is an attempt to draw attention to the need to improve the effectiveness of public funds in the conditions of crisis phenomena. The practice has not always been related to examining the effectiveness of public spending, especially those of less value.

Keywords: Public finance, public investments, economy, effectiveness.

JEL classification: H12, H43, H63, O22.

Paper type: Research article.

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1. Introduction

Public investment projects are characterized by their specificity and complexity. Correct determination of planned investment costs and subsequent annual operating costs are of great importance here. The social nature of public services makes it more difficult to assess the effectiveness of investment projects than in the case of enterprises in the private sector. Commonly used financial analysis methods for public projects cannot always be applied. It is necessary to use other methods of analysis and evaluation. For projects where the effects cannot be expressed in monetary units, the efficiency of the investment can be expressed indirectly using cost-effectiveness analysis (CEA), where the effects of the project are considered in material terms.

The assessment of conditions and the possibility of using cost-effectiveness approach for analyzing the effectiveness of public investment projects plays an important role in the decision-making process preceding the implementation of the investment. This approach is narrow, as it concerns a certain range of investment projects that have one common feature. There is no easy and unequivocal determination of the effects in monetary terms. These types of projects can absorb significant capital, which causes searching for cost-effective solutions to be entirely justified.

This is valid given the growing importance of public investments in the face of a crisis. In the 21st century, we are dealing with the effects of the 2008 global financial crisis and the socio-economic effects of the COVID-19 pandemic. We are seeing a slowdown in economic growth, a decrease in revenues, and changes in the structure of public spending. The increase in public current expenditure is related to the need to finance social services and programs (healthcare, job protection). This has a direct impact on the volume of ongoing and planned investments. The budget deficit and the related public debt become a negative consequence of the necessity of increased financing of unplanned budgetary expenses. As a result, crisis phenomena lead to long-term consequences related to the instability of the public finance sector. Therefore, it is justified to look for higher efficiency of public spending, including the improvement of investment efficiency. Crisis phenomena are a qualitatively new situation that forces increasing the efficiency of outlays. CEA is a tool here that can increase the efficiency of public spending in times of a crisis. The application of this approach can be more widely used, which can contribute to increasing the overall efficiency of management in terms of cost budgeting.

2. Theoretical Background

Cost-effectiveness analysis is used where it is difficult or impossible to estimate the effects in monetary units. Project effects are expressed in physical units and are usually determined by comparing the initial situation with that after the project implementation (e.g., improvement of the cleanliness of water reservoirs, improved air quality, reduced illiteracy rate, improved public safety). Cost-effectiveness analysis can be effectively used concerning social and environmental projects and in

some areas related to technical infrastructure (Queensland Treasury, 2015). Concerning public projects, financial analysis and evaluation methods using discounted financial flows of costs and benefits included in the NPV formula, are not always applicable. In a certain group of projects, it is difficult to apply the economic analysis of projects and evaluation with the use of economic net present value (ENPV). Therefore, from the point of view of the decision-making goal in the mentioned group of projects, cost-effectiveness analysis (CEA) can be used.

CEA is a tool based on the costs of the actions taken and is related to cost-benefit analysis (Lipkan *et al.,* 2018), however, thus far due attention has not always been paid to the broader use of CEA in the process of analyzing and assessing the effectiveness of public investments. Traditionally, more space was devoted to the application of this approach to healthcare (Azimi and Welch, 1998; Murray *et al.,* 2003; Storto, 2016), although, this method was initially used to evaluate military projects in the United States (Levin, 1995) and to analyze the effectiveness of alternative government programs outside the military. However, the application of the approach goes far beyond the indicated range of applications. Given that resources in any economy are scarce, CEA can be applied much more widely to diverse social projects (Lipkan *et al.,* 2018). Given the significant increase in current public spending in the social sphere, especially in healthcare, CEA may find a much wider application (Levin and McEvan, 2001) in the comparison of costs in terms of monetary units with material effects and the selection of the best variant in terms of costs.

CEA can be used as a project screening tool and as a project ranking tool for acceptable solutions. It can also be a tool helpful in making final investment decisions (cost-effectiveness as a decision tool for investment) (Lebo and Schelling, 2001). Investments in the public sector are usually financed from the budget funds of public administration units. In a balanced budget they are of a resultant character, which means allocating to investments the funds which remain as the difference between budget revenues and the current expenditure.

However, investment expenditure may be higher than it would result from keeping the principle of a balanced budget (Jarosiński, 2003). Depending on the general socio-economic situation and the level of budget revenues, the share of expenditure on the implementation of current tasks may be significantly differentiated, which has an impact on the possibilities of financing investments. This is often the result of the implementation of larger tasks and their financing within the framework of external funds of a different nature. In the long-term perspective, where apart from budget funds, returnable external funds are directed to investments, there may be negative effects in the form of a budget deficit and public debt (Jarosiński, 2020; Kamiguchia and Tamai, 2019; Arif and Hussain, 2018; Jarosiński, 2007). Therefore, from the point of view of the investment policy of public entities, it is important to test the effectiveness of the actions taken. Wider use of various methods of analysis, including cost-effectiveness analysis, may contribute to increasing the effectiveness of

management within the possessed own resources and, consequently, may lead to increased effects.

In public investment projects, a greater degree of complexity and a greater scale of diversified relations with the external environment are observed. There is a difficulty here in assessing the effectiveness of projects, especially from the point of view of the decision-making process in relation to the existence of alternative solutions (LeBel, 2011). In the sphere of public services, the priority is to obtain specific material effects (goal-oriented activities), and the costs of obtaining them are not always subject to detailed analysis and assessment. The selection of a project is determined by the criterion of achieving the assumed material and quality result of public services, while the analysis and assessment of the financial effectiveness of projects are often omitted (Drobniak, 2012). Detailed requirements for the evaluation of public projects take place in the case of projects co-financed from the budgetary resources of the European Union (Jarosiński *et al.,* 2015). This is related to the established evaluation criteria for such projects and the financial discipline established in the form of expenditure eligibility criteria.

For many public investment projects, it is not possible to obtain positive results based on financial analysis techniques. This applies to both simple techniques of assessing investment projects, as well as to complex ones using discounted cash flows. Often, in planned public projects, the cash flow analysis fails to obtain a positive NPV, which would make it possible to accept the project for implementation. As a rule, net present value lower than zero is obtained, which in terms of the selection criteria for NPV, should lead to the rejection of the project. We also have projects where the NPV calculation is not possible at all due to the lack of project revenues. However, such projects are not rejected (Beqiraj *et al.,* 2018). This is not the case as public sector investment projects are carried out due to their wider social and economic dimensions. In many cases, the project cannot be abandoned, and the project must be undertaken and completed. This applies to several projects in some sectors of critical infrastructure at the state level as well as at the regional and local levels, leading to the achievement and maintenance of the intended social effects, such as health protection, internal and external security (Andersson *et al.,* 2019).

A broader analysis, going beyond the criteria of financial efficiency, considering various economic and social factors, enabling the measurement of inputs and effects in a wider non-market dimension, is needed (Belli *et al.,* 1998; Drobniak, 2015). In the assessment of public investment projects, a broader quantitative and qualitative analysis of the planned projects is necessary (Rodriguez-Bolivar *et al.,* 2021). Economic analysis methods using economic net present value (ENPV), cost-benefit analysis (CBA), and cost-effectiveness analysis (CEA) should be considered. When many factors are affecting the project, weighted cost-effectiveness analysis (WCEA), also referred to as multi-criteria analysis (MCA) can be used (Mackie *et al.,* 2005; Dean, 2020). The main advantage of these methods is that they can be used to compare

projects with a different range of expected results. MCA is used in project analysis, where we consider only a few important criteria with fixed weights (Farrell, 1957).

The greatest difficulty is the assessment of benefits that do not exist in the form of a separate category of goods on the market. These are, for example, changes in the environment, time savings due to the use of new communication solutions, or other features constituting an unmeasurable value in social terms (Alesina and Tabellini, 1987; Mandl, 2008; Johnes, 2015). An example may also be city road construction, where certain investment outlays are incurred during the implementation of the investment, and after the completion of the investment, further costs related to the ongoing maintenance of the created infrastructure are incurred. The literature on the subject emphasizes the practical application of CEA in relation to medical services. The authors (Robinson, 1993; Garber and Phelps, 1997) point out, however, the possibility of wider application of CEA in other undertakings in the field of social and technical services.

3. Research Methodology

Crisis phenomena in the 21st century caused serious economic and social effects in the world. The slowdown in economic development has led to difficulties in the public finance sector in many countries around the world. The decline in budget revenues with a simultaneous increase in current public expenditure resulted in the occurrence of an excessive budget deficit and public debt. There has been a clear increase in the need for external funds to finance these expenses. Although the forecasts regarding changes in the global GDP level are optimistic, the negative effects in the public finance sector will be visible for many years. One way to mitigate these effects may be to improve the efficiency of public spending. Therefore, attention was paid to the cost-effectiveness analysis as one of the methods that may contribute to the improvement of the efficiency of public investment projects.

Empirical studies were conducted based on actual data and prospective studies were carried out covering changes in the level of GDP, changes in the budget deficit and public debt in selected countries in 2010-2028. Based on the results, it was found that in the future, the budget deficit and servicing public debt may limit the scope of public investments. This applies to a huge number of projects that bring tangible effects, but do not have a fixed market price and the effects cannot be measured in monetary terms. Current changes in the economic and social environment mean that the number of such projects is growing rapidly. This leads to the increase in current budget expenditure on projects for which no efficiency analysis is carried out.

Researching the effectiveness of this group of projects is difficult, therefore a generalized approach to the efficiency study based on the CEA method was proposed. Only this analytical tool provides the basis for the assessment of cost effectiveness for this selected group of projects. On the basis of the available analytical solutions, an attempt was made to build a model approach to the research and analytical process,

assuming the division into two groups of methods: simple static methods and complex dynamic methods.

As a result, a mechanism for the application of simplified and developed methods of project analysis and evaluation based on CEA was created. The complexity of public investment projects means that, on the one hand, a separate approach to individual projects is necessary, on the other hand, it is necessary to search for a generalized system approach to specific groups of projects with common features and to apply appropriate model solutions.

In view of the ongoing changes, it was considered justified to pay attention to the wide range of applications of various tools under the CEA method in relation to projects of various sizes and complexity. This can lead to solutions to specific economic and social problems. It can also lead to savings and improvement in the efficiency of expenses and the possibility of increasing the scope of undertaken activities. The wider use of CEA gives hypothetical possibilities of obtaining additional effects with constant investment outlays. Based on the research, a generalized approach to the efficiency analysis based on the CEA criteria was proposed. In particular, attention was paid to the key solutions of static simplified analysis methods and developed dynamic analysis methods that take into account changes in the value of money over the time.

Therefore, we have the option of applying a simplified analysis without taking into account the discounted cash flows on the cost side, an analysis taking into account changes in the value of money over time and a marginal analysis of changes in the effects in relation to changes in expenses in a selected time period. The use of CEA tools leads to supporting decision-making processes in the sphere of public investments. Based on analytical solutions and input data covering all information and physical quantities characterizing the planned investment, and on the basis of output data in the form of material effects and related costs in monetary terms, a generalized model of decision making for public investment projects based on the ranking of projects may be created.

According to the model's data, the conditions for a comparative analysis of project variants and the possibility of building a project ranking from the point of view of the decision-making goal were created. As a result, it is possible to choose the best solution from among all defined solutions. The approach is therefore a pattern that is created based on real data and hypothetical data obtained during prospective research in the field of cost streams and possible material effects.

In line with the adopted methodology, the research compares acceptable analytical solutions based on CEA, which can always be used in research on the effectiveness of public spending, especially where it is not possible to express the effects in monetary form, with the results of empirical studies characterizing the current socio-economic situation in relation to emergencies caused by the COVID-19 pandemic.

The results of empirical research prove that the condition of the public finance sector has deteriorated and may continue to do so in the coming years. Paying attention in this context to the wider use of CEA methods can lead to savings in current expenditure and maintenance or even an increase in the volume of public capital expenditure.

4. Results

Based on the research, it was established that in 2018-2020, negative changes in GDP occurred in many regions of the world. Most of the countries covered by the study recorded a decline in the value of GDP in 2020 compared to 2019. Indicators calculated during the research present changes in GDP in a large number of countries. Table 1 shows the results only for selected countries that seem to be representative for European Union Member States, as well as for non-European countries. In 2010-2019, an increase in the value of GDP was recorded. This was a major achievement considering the effects of the 2008 financial crisis and the slow process of getting back on the development track. In 2020, compared to 2019, the overall GDP of the European Union Member States decreased by 5.7%.

The fall in global GDP in 2020 was catastrophic. It was related to the necessity of a rapid and significant increase in current expenditure on public health goals against the pandemic of 2020. The increase in current budget expenditure took place in the conditions of a decline in the value of GDP, and thus in a situation of a decrease in budget revenues in relation to the value of planned revenues. As a result, there was a significant increase in budget deficit and public debt in the world, in the European Union as a whole, and the individual Member States.

Table 1. *Balance of total government revenue and government expenditure in selected countries in 2018-2020 and the projection for 2021-2022 (in Mrd EUR)*

Specification	2017	2018	2019	2020	2021	2022
European Union	-103.35	-54.45	-74.32	-1109.01	-850.08	-658.64
Ireland Euro area	-104.25	-53.51	-74.09	-981.71	-761.21	-580.94
Belgium	-3.05	-3.65	-9.28	-49.74	-33.20	-31.15
Bulgaria	0.58	1.11	1.18	-1.75	-1.87	-0.89
Czechia	2.91	1.93	0.59	-12.88	-10.04	-8.50
Denmark	5.27	2.09	11.82	-12.76	-7.87	-6.27
Germany	44.40	61.65	52.47	-199.54	-140.63	-90.56
Ireland	-0.96	0.38	1.85	-23.63	-21.28	-9.36
Greece	1.29	1.84	2.80	-11.32	-10.92	-6.16
Spain	-35.14	-29.90	-35.64	-134.45	-111.87	-106.76
France	-67.96	-54.08	-73.01	-236.47	-198.59	-152.89
Italy	-42.34	-39.00	-28.65	-176.16	-133.11	-106.83
Hungary	-3.09	-2.88	-3.03	-11.20	-7.51	-6.50
Netherlands	9.30	10.61	13.93	-55.93	-46.11	-31.93
Austria	-3.01	0.68	2.67	-36.27	-25.76	-15.37
Poland	-6.95	-1.20	-3.70	-45.45	-22.22	-16.79
Portugal	-5.79	-0.72	0.18	-14.41	-9.42	-6.57

Romania	-4.96	-6.00	-9.74	-21.90	-25.53	-29.99
Slovakia	-0.79	-0.89	-1.27	-8.57	-7.44	-6.06
Finland	-1.47	-2.01	-2.31	-17.86	-11.81	-8.75
Sweden	6.73	3.89	2.43	-18.19	-12.38	-7.03
United Kingdom	-57.16	-54.46	-58.35	-311.07	-208.01	-180.93
Serbia	0.43	0.27	-0.09	-4.14	-1.47	-1.32
Turkey	-21.17	-18.43	-20.67	-36.74	-35.38	-35.86
Iceland	0.13	0.17	-0.33	-1.71	-1.70	-0.98
Norway	17.67	28.83	22.45	10.06	26.11	29.61
Switzerland	7.38	8.31	-0.98	-25.60	-10.03	-3.21
Japan	-125.17	-95.74	-151.69	-598.59	-243.08	-154.61
United States	-736.33	-1149.83	-1369.23	-2775.55	-1276.03	-909.14

Source: https://www.ec.europa.eu/economy_finance/ameco_old/user/serie/ ResultSerie.cfm.

The results of the research indicate that the situation regarding the changes in the level of GDP in Europe was varied. In some countries, the decline in GDP was significant, ranging from 19.0% in Mexico, 14.2% in Montenegro, 11.2% in Spain, 10.6 in Norway; in the second group of countries it was already lower and, for example, in Sweden, it amounted to 1.2%, in Switzerland 1.5%, in Ireland, 1.9%, in Poland, 3.5%. The graphic illustration for selected countries is presented in Chart 1.

Chart 1. *Changes in gross domestic product (GDP) in selected countries in 2018-2020 and the projection for 2021-2022 (in %)*
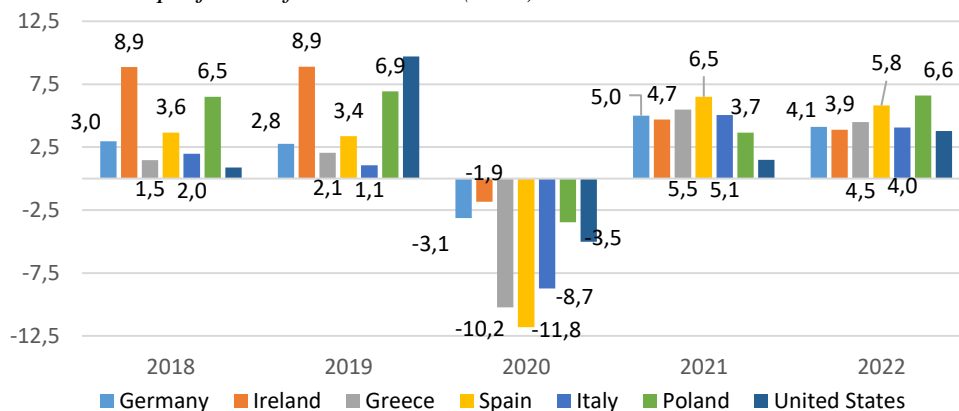
Source: https://www.ec.europa.eu/economy_finance/ameco_old/user/serie/ ResultSerie.cfm.

A natural consequence of the decline in the volume of GDP is the decline in budget revenues. Due to the pandemic, the budget deficit has become widespread and is associated with the need to finance unplanned increased current expenses with funds from loans and borrowings.

In the conditions of a pandemic, these expenditures are mainly the financing of the health service, social support programs for families, and programs related to

maintaining jobs. These programs depended on the adopted national solutions, but the general rule was to consider such expenditure as necessary and priority.

Excessive public debt in the future may pose a threat to development in the coming years. The projection for 2021-2022 indicates that the budget deficit will gradually decrease, however, comparing the values from 2020 and the forecast values, we see that the deficit will not be able to be eliminated quickly. By 2019, many countries managed to stabilize and improve their government deficit situation, and consequently to improve the public debt situation.

In 2020, however, there was a drastic deterioration of this circumstance and it should be assumed that until stability in terms of public health is achieved, it will not be possible to reduce or eliminate the deficit. There are many examples of such a change here. In Poland, in 2020 it was planned to achieve a balance in the sphere of the state budget; data indicate that the state budget deficit, without local government units, amounted to EUR 24 billion (Ministry of Finance, 2019). Changes in the budget deficit in selected countries are presented graphically in Chart 2.

Chart 2. *Balance of total government revenue and government expenditure in selected countries in 2018-2020 and the projection for 2021-2022 (in Mrd EUR)*
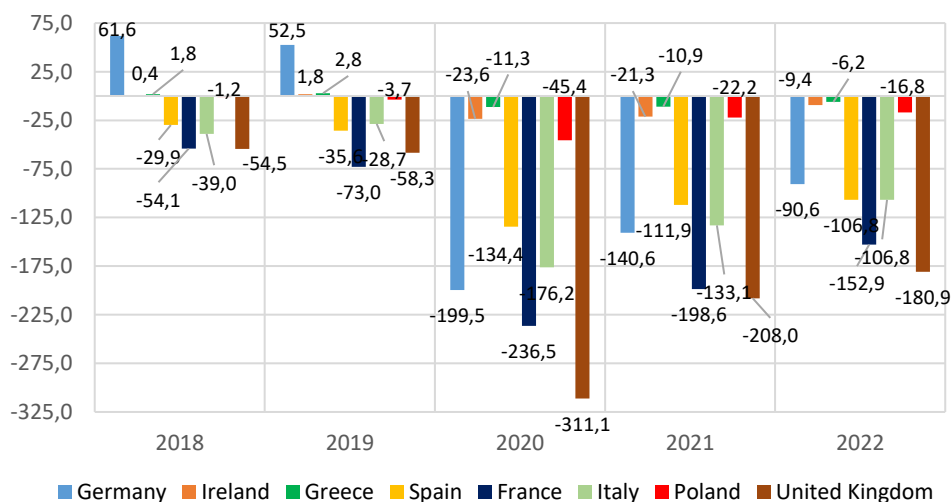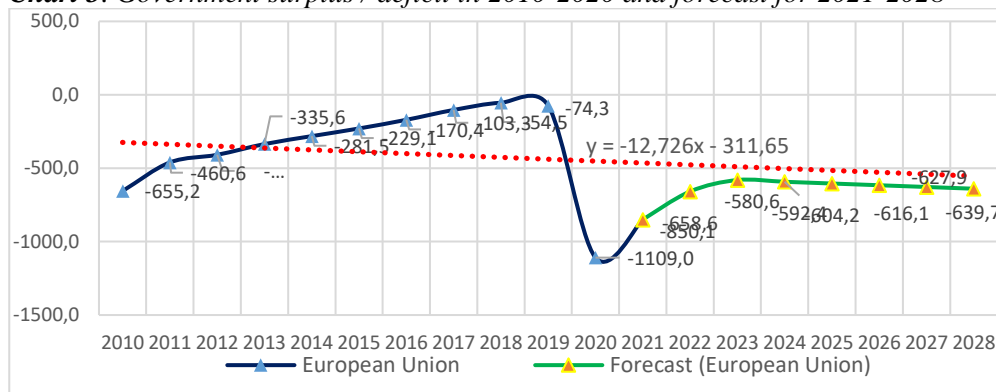

Source: Own study based on the AMECO database of European Commission, accessed on 15/04/2021.

The budget deficit will have negative consequences, especially in terms of the implementation of planned investment projects. Therefore, it is important to pay attention to the possibilities of increasing the efficiency of using public resources in small enterprises, as well as in medium and large projects. Thus, attention is paid to the wider use of cost-effectiveness project evaluation methods due to the significant increase in their number and value in health and social services.

Research shows that an increase in the value of GDP can be expected in the coming years, but with regard to the budget deficit it will not be possible to reduce the value of deficits. Due to the pandemic, there was a significant and uncontrolled increase in current expenditure, which affected the condition of public finances. The conducted research shows that in the European Union the budget deficit of the Member States in general will not significantly decrease in the coming years. Chart 3 presents the results of prospective research on the budget deficit.

Chart 3. *Government surplus / deficit in 2010-2020 and forecast for 2021-2028*

Source: *Own study based on the AMECO database of European Commission, accessed on 15/04/2021.*

Due to the large increase in the budget deficit in the Member States of the European Union, the difficulties related to the deficit may persist for many years. Public debt is a fairly common phenomenon in the world; it reflects the financial incompatibility of budget expenditures to the own ability to collect budget revenues at the state level, as well as regional and local levels.

Public debt is a consequence of the accumulation of liabilities from previous years, which were not financed from their budget funds. There can be many reasons for this problem, which is a separate research issue. From the point of view of the aim of the article, crises of various origins may lead to an uncontrolled increase in public debt, which may have far-reaching economic and social consequences in the future. During the research, changes in the volume of public debt for the analyzed countries in 2018-2020 were determined and the forecast values for 2021-2022 were established. On their basis, indicators of changes in the level of public debt in 2018-2022 were calculated.

Public debt may have long-term negative effects in the private sector and the public finance sector. The main threat is the reduction in the ability to finance public investment due to the increase in debt service obligations. In the European Union, this problem is monitored in detail, and in the conditions of exceeding the permissible level of debt in relation to GDP, procedures related to the creation of the so-called

excessive budget deficit are applied. For these reasons, it is necessary to launch efficiency mechanisms that will allow for better use of the existing budget resources.

5. Instruments for the Cost-Effectiveness Analysis of Public Investment

CEA applied to investment efficiency in the public sector, regardless of the complexity of the analytical methods, comes down to selecting the most advantageous solution option based on the costs of implementation and subsequent operation of the investment. Therefore, the basis for making an investment decision is the balance of future needs and the scale of necessary investment outlays related to the expansion of production capacity. Although often the aim is to use diversified discounted flow methods as widely as possible, considering cash outflows and inflows, CEA is often the only one that allows for project evaluation.

In CEA, homogeneous material effects and costs in monetary terms should be taken as a measure of the project result. As mentioned, it is possible to apply diversified variants of CEA. However, the aim is always to develop a project ranking based on the costs and to select the solution with the lowest unit cost compared to alternative variants. This creates a decision criterion for planned investments (Queensland Treasury, 2015). All project variants must be identified and compared in terms of their benefits. The benefits in kind should be similar in terms of quantity. In this approach, it is possible to rank projects in terms of the total amount of expenditure and indicate the least costly option to achieve the set result (Queensland Treasury, 2015). Cost-effectiveness analysis requires the determination of the values of indicators that are the relation of total costs to the generated benefits of individual project variants.

For CEA purposes, the costs should be compiled by the classification of costs by nature: basically, there are three categories of the costs, namely: labor cost, material cost, and expenses. These elements can be further classified in detail. A separate category of costs is the depreciation of tangible and intangible assets. Depreciation is a registered cost, which means that it may be an element of costs, but it does not generate negative cash flows. For these reasons, it is often classified as costs in accounting terms and reduces the amount of income, while in the efficiency calculation it may be ignored due to the separate consideration of capital expenditure as a separate component of CEA costs. The annual total costs are therefore calculated using the formula below.

$$C = M_t + L_c + E_c + D_c, \tag{1}$$

where:
C – annual total cost,
M_t – material cost,
L_c – labor cost,
E_c – expense cost,
D_c – depreciation cost.

The final decision criterion for selecting the project variant will be the lowest ratio of costs to the planned results. For smaller projects, it can be useful to implement a simplified CEA method where efficiency is tested on an annual basis. The scope of application of the method may be wide where there are expenses for the implementation of small projects or tasks financed under current budget expenses. In the case of large, complex investment projects, fully developed methods of cost-effectiveness analysis are applied, considering the existence of several investment variants.

In addition, technical variants of CEA can be used depending on the type of project, scale, duration of the project, amount of expenditure, and investment implementation time. As mentioned, the use of CEA methods requires the collection of input data with varying degrees of detail. The extent of the data and its detail depend on the size, complexity and characteristics of the project, as well as the intended use of the available analytical tools. Research should determine future project expected values. On this basis, the analytical method can be selected and the method variant adjusted to the actual situation of the project and its environment. Simple static methods can be used relatively widely. The simplified method is described in the formula below.

$$e = \frac{I(r+s)+C}{P} \tag{2}$$

where:
e – CEA investment cost-effectiveness index,
I – total investment expenditure,
C – total costs in a given year (without depreciation),
P – project effect in material terms per year,
r – capital interest rate,
s – depreciation rate.

It is important to determine the amount of the depreciation rate that reflects the annual depreciation write-offs (s) and the interest rate on capital (r). As a rule, an average depreciation rate based on the grouping of inputs by type, assigning them specific weights, and determining the weighted average value of the depreciation rate is used (Dziembowski, 1983). The second difficulty may be determining the amount of interest rate on capital. The situation may vary depending on the source of capital. It is often only equity for which the social interest rate can be applied, or we may have to determine the weighted average cost of capital (WACC), which would reflect the actual costs of using capital from various sources (Carluccio and Mazet-Sonilhac, 2018; Manikowski and Tarapata, 2001). The social discount rate (SDR) should reflect the long-term social preferences of using capital to implement public investments. The social discount rate (Zhuang *et al.*, 2007) is therefore intended to reflect the social point of view on the assessment of current and future costs and benefits. There are significant variations in public discount rate policies practiced by countries around the world, with developing countries in general applying higher SDRs (8% –15%) than

developed countries (3%–7%) (Asian Development Bank, 2013). The general formula is presented below.

$$e_k = \frac{I_{k_1} + \sum_{t=2}^{n} \frac{C_{kt}}{(1+r_s)^t}}{\sum_{t=2}^{n} B_{kt}} \tag{3}$$

where:
e_k – investment cost-effectiveness index for project k,
k – consecutive number of the project from the set of projects tested from 1 to k,
I_{k_1} – total capital expenditure of project k, for projects with a one-year cycle of expenditure t_1,
C_k – total costs (excluding depreciation) generated in individual years of the project,
B_{kt} – the size of the project result in material terms in the next year of project operation,
r_s – social discount rate
t – subsequent years of the project implementation.

If there are large projects where the investment process takes more than one year, it is also necessary to discount the negative cash flows spent on that investment. Therefore, the planned investment outlays should be discounted depending on the duration of the construction of facilities and equipment. The general formula is presented below.

$$e_k = \frac{\sum_{t=1}^{h} \frac{Ik}{(1+r)^h}}{\sum_{t=1}^{h} B_{kt}} + \frac{\sum_{t=h+1}^{n} \frac{C_{kt}}{(1+r)^t}}{\sum_{t=h+1}^{n} B_{kt}} \tag{4}$$

where:
h – period of investment outlays calculated in years,
other markings as above.

Project effectiveness analysis may be performed on a marginal basis. Due to the necessity to expand and increase the existing economic potential, development investments are being carried out. In such conditions, it may be necessary to make additional investment outlays to obtain additional material effects of the project. The CEA efficiency calculation will then concern the increase in investment outlays in relation to the already operated project and the study of the increase in effects related to this increase in outlays. The general formula is presented below.

$$MCEA_k = \frac{C_{k_{tp}} - C_{k_{t0}}}{B_{k_{tp}} - B_{k_{t0}}} = \frac{\Delta C_k}{\Delta B_k} \tag{5}$$

$MCEA_k$ – marginal cost-effectivity analysis,
$C_{k_{t0}}$ – project cost level k at t_0,
$C_{k_{tp}}$ – project cost level k at t_p,

$B_{k_{t0}}$ – the level of the project effects k at the point t_0,
$B_{k_{tp}}$ – the level of the project effects k at the point t_p,
$\Delta C_k = C_{k_{tp}} - C_{k_{t0}}$,
$\Delta B_k = B_{k_{tp}} - B_{k_{t0}}$,
ΔC_k – increase in investment costs from the initial t_0 level to the t_p level,
ΔB_k – an increase of benefits from the initial t_0 level to the t_p level,
k – consecutive number of the project from the set of projects tested.

The above formulas make it possible to conduct an analysis and cost-effectiveness assessment of public investment projects, regardless of the degree of their complexity. Therefore, based on the proposed solutions, small projects, using the simplified methodology, as well as complex projects, can be examined and assessed. Formula (4) is the more commonly used methodology. It involves the need to prepare the input data for the final calculations. The most important factor in this analysis is the total cost category. Determining the volume of total costs in the prospective analysis is a complex task, especially in the face of a crisis. On the one hand, it is based on actual data known at the time of project implementation, on the other hand, it must reflect estimates for future periods, including the mutual relations of prices of components that make up the total costs.

Cost forecasting may be burdened with a large influence of random factors. The forecast error depends on the strength of their impact. In crisis conditions with high dynamics and the scale of economic changes, random factors may, in the short term, cause a significant deviation of the forecasted values from the actual values recorded later. An example is the planned budget deficit in Poland in 2020. According to the forecast, this deficit was supposed to amount to 0.0%, but due to the crisis caused by the COVID-19 pandemic, it amounted to 20.2% (https://www.bankier.pl, 2021) in real terms.

The most favorable situation concerning research on project effectiveness is the socio-economic stability, which gives grounds for achieving greater consistency of forecast data with actual data in the future. The use of cost-effectiveness analysis, similarly to other methods that use forecasting future cash flows, requires the development and application of methods to limit the impact of the random component in forecasting. The most beneficial situation in relation to studies on the effectiveness of projects is social and economic stability, which gives grounds to achieving a better congruence between the forecast data and the real data in the future.

6. Discussion

Empirical research conducted in 2020-2021 shows that unfavorable changes are taking place in the global economy due to the COVID-19 pandemic. The economic and social effects are so deep that it is difficult to predict changes in the social and economic situation in the coming years. Currently, governments are trying to limit the

spread of the COVID-19 pandemic by all possible means, without paying much attention to the costs associated with it. Conducting detailed analyses of the running costs of fighting the pandemic is not a priority, it is only about obtaining the desired health outcomes. However, the economic calculation shows that, regardless of the results of the fight against the pandemic, the effects on the economic dimension are visible, and can be far-reaching and felt for many years to come. As a result of the crisis caused by the pandemic, the budget imbalance has deepened, which, due to the need to finance social programs, combined with limited fiscal revenues, leads to further and uncontrolled deterioration of public finances and has negative effects in the sphere of enterprises.

The scale of the impact of a global crisis is huge and causes a rapid and significant increase in current public expenditure, which leads to a change in the structure of budgetary expenditure of public administration at the state, regional and local levels. Increasing the current public expenditure leads to a reduction in the available financial resources within the budget, which could be allocated to investments. Restrictions have a direct impact on the investment volume and lead to a reduction in related public expenditure.

The results of the research indicate that in the years 2012-2020, a diversified situation was observed in terms of the budget deficit and public debt. In many countries, it was possible to stabilize public debt and even reduce its size. This was due to the launch of savings programs by governments, as well as the launch of sustainable financing of current liabilities with loans and funds. The situation changed significantly in 2020 with the need to take steps to counteract the effects of the COVID-19 pandemic. Two opposing directions of changes emerged: budget expenditure on healthcare began to grow rapidly, social programs for the population were launched as well as support programs for businesses.

As a result, there has been a marked increase in current public spending, with falling tax revenues as a result of excluding certain sectors of the economy to limit the transmission of infections. Starting from the first quarter of 2020, there was an increase in public expenditure for social and protective purposes in the economy, which increased the budget deficit. The global economy and individual countries found themselves in the realm of new priorities and hierarchy of goals. The negative effect was the reduction of public spending on investments.

This means the need to look for other investment financing opportunities. One of the lines of action is to look for opportunities to increase efficiency where it is still possible. This applies to all projects where economic efficiency analysis can be applied, taking into account the social costs that society would be willing to bear in access to services, and the effects determined in monetary or material terms. One of the possibilities of the analysis is CEA, which allows one to analyze the effectiveness of projects where it is not possible to monetarily determine the benefits obtained. CEA

enables the verification and ranking of planned investment projects in many research areas.

Although the analysis has so far been of great practical importance in the field of health protection, as evidenced by the extensive literature on the subject, applications should be sought in other types of public services. The literature on the subject highlights the range of possible applications in the field of public services at the level of local and regional public administration. This type of performance analysis can be used more widely in social and technical services.

The formulas provided should be applied to various investment projects in the public sector. These formulas can be applied to simple projects as well as to more complex ones, where there is a need to take into account changes in the value of money over the time. A common feature of projects for which the CEA variants can be applied is the inability to express the effects of projects in monetary terms. By using the CEA, it is possible to improve the overall efficiency level of public spending.

7. Summary and Conclusions

According to the results of the conducted research, it should be stated that CEA may contribute to the improvement of efficiency in the social dimension and, as a result, additional funds for financing public investments may appear. The analysis of investment effectiveness has always played an important role in the process of preparing and implementing an investment. The demand to pay attention to the wider use of CEA in the public sector may lead to the mitigation of the negative effects of the pandemic, which can be considered a transition period until the elimination of economic and social constraints. The proposed methodology of CEA refers to various situations that may occur in the economic practice of the public sector.

Considering the differentiation of investment projects that may be the subject of implementation, a different methodological approach to the analysis of project effectiveness was proposed. The main division is made up of two groups of projects: small projects, where simplified analysis and evaluation methods can be applied, and large projects with a complex internal structure, for which a research methodology based on developed dynamic evaluation methods should be applied. In each of the proposed approaches, the focal point of the analysis are the costs related to the implementation of investments and the operational phase of the projects. Costs are the main point of reference in CEA – they are the primary measurable expression of the inputs necessary to achieve specific final material results.

In a nutshell, CEA is an analytical approach that can only be applied to public tasks. It is only there that a legitimate search for methods of analysis going beyond standard financial analysis or broader economic analysis exists. The use of CEA results mainly from the specificity of public services and the specificity of the process of providing these services. Most often, a preliminary economic calculation conducted based on

the financial criteria of project evaluation causes its rejection. In practice, however, public investment projects are aimed at satisfying social needs, the dimension of which cannot always be considered. Therefore, in such cases, it is possible to carry out an indirect CEA. The results of the analysis will never give a positive result in the financial aspect of effectiveness but may facilitate the decision-making process concerning several project variants that may show a different level of capital commitment with the same results or may show a different material volume of services with the same capital commitment.

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