11. Anokhin, A. N. The system approach to analysis and description of operator activity [Text] / A. N. Anokhin // Cybernetics and Systems. – 2008. – Vol. 1. – P. 82–87.
12. Адаменко, А. Н. Информационно-управляющие человеко-машинные системы: Исследование, проектирование, испытания [Текст]: справочник / А. Н. Адаменко, А. Т. Ашеров, И. Л. Бердников и др.; под общ. ред. А. И. Губинского, В. Г. Евграфова. – М.: Машиностроение, 1993. – 528 с.
13. Grif M. G. Methods of desingning and modeling of man–machine systems [Text] / M. G. Grif, O. Sundui, E. B. Tsoy // Proc. of International Summerworkshop Computer Science 2014, 2014. – P. 38–40.
14. Падерно, П. И. Системный администратор локальной вычислительной сети. Задачи, требования, модель, отбор [Текст] / П. И. Падерно, Ф. Э. Сатторов // Вестник академии наук Республики Таджикистан – 2009. – Т. 52, № 6. – С. 437–442.
15. Lavrov, E. Mathematical models for the distribution of functions between the operators of the computer-integrated flexible manufacturing systems [Text] / E. Lavrov, N. Pasko, A. Krybidub, A. Tolbatov // Proceedings of the XIIIth International Scientific Conference TCSET'2016, 2016. – P. 72–77.
16. Lyubchak, V. Ergonomic support of man-machine interaction. Approach to designing of operators' group activities [Text] / V. Lyubchak, E. Lavrov, N. Pasko // International Journal of Bio-Medical Soft Computing and Human Sciences. – 2011. – Vol. 17, Issue 2. – P. 53–58.
17. Lavrov, E. Planning of Group Activity of Man-Operators in Information Systems [Text] / E. Lavrov, N. Pasko // International Scientific Conference "UNITECH II". Proceedings. – 2011. – Vol. 1. – P. 371–376.

UDC 007.52
DOI: 10.15587/1729-4061.2016.66307

DEVELOPMENT OF THE METHOD FOR TESTING OF EFFICIENCY CRITERION OF MODELS OF SIMPLE TARGET OPERATIONS

I. Lutsenko
Doctor of Technical Sciences, Professor*
E-mail: delo-do@i.ua
E. Vihrova
PhD, Associate Professor
Department of Mathematics and techniques of its teaching
Krivoy Rog Pedagogical Institute
SHEE «Kryvyi Rih National University»
ave. Gagarin, 54, Krivoy Rog, Ukraine, 50086
E-mail: el-vihrova@mail.ru
E. Fomovskaya
PhD, Associate Professor, Head of Department*
E-mail: fill.fo@mail.ru
O. Serdiuk
SIHE «Kryvyi Rih National University»
XXII Partz'yizdu str., 11, Kryvyi Rih, Ukraine, 50027
E-mail: olgajs28@gmail.com
*Department of Electronic Devices
Kremenchuk Mykhailo Ostrohradskyi National University
Pervomaiskaya str., 20, Kremenchuk, Ukraine, 39600

Робота має відношення до області теорії оцінювання цілеспрямованих процесів керованих систем. Виділено класи простих цільових операцій, ефективність яких може бути визначена з використанням методу прямого оцінювання. Розроблено абсолютний показник оцінки ефективності цілеспрямованих процесів, що складаються з множини простих цільових операцій. Наведено результати тестування трьох відносних показників для визначення області їх використання в якості критерію ефективності

Ключові слова: ефективність, метод прямої оцінки ефективності, еталонні моделі простих цільових операцій

Работа относится к области теории оценивания целенаправленных процессов управляемых систем. Выделены классы простых целевых операций, эффективность которых может быть определена с использованием метода прямого оценивания. Разработан абсолютный показатель оценки эффективности целенаправленных процессов состоящих из множества простых целевых операций. Приведены результаты тестирования трех относительных показателей, для определения области их использования в качестве критерия эффективности

Ключевые слова: эффективность, метод прямой оценки эффективности, эталонные модели простых целевых операций

1. Introduction

If we request such definitions as «efficiency", and/or its analogs in the form of "KPI", "BSC" in the search box of any browser, we can get the information array which contains more than 1 billion of the most diverse responses. Whether is it possible to select the index that really can represent the result, declared in the name among the given array of various indices?

The problem is that for checking the adequacy of the efficiency criterion of goal-oriented processes, it is necessary to use objects, the efficiency of which just needs to be estimated.

As an assessment indicator, it is logical to use an absolute measure “profit” or its cybernetic analog “the added value” (target product). But, one more problem is that the “added value” index needs such restructuring as a result of which the new type of such index will be able to identify certain cybernetic processes adequately.

It is connected to the fact that the functioning of the controlled systems (CS) which generate system operations is carried out in the environment of continuously changing external conditions.

Therefore, to realize verification of indices, relating to the identification of system operations and operational processes, it is necessary to create such models of system processes which display all important characteristics of controlled systems, including prognostic estimates from the use of new investments.

Of course, this task is unsolvable in a general view. However, its successful solution for a number of special cases is quite possible.

For this purpose, it is necessary to develop a system of tests which allow identifying the offered indices regarding the claims declared in the name. Each such test, for example, can represent a couple of operations of a certain class which efficiency shall be set beforehand, based on direct methods of estimation.

Actuality of work in this direction consists that for verification of the indicators declared as the “criterion of efficiency” will be possible to define a set of couples of models of simple target operations (MSTO) of different classes, with in advance known ratio of their efficiency. Thus, it is possible to define as “operability” of this or that indicator within the class of MSTO, from the point of view of an assessment of their efficiency, and its adequacy to the criterion of efficiency in case the developed indicator adequately “works” at the whole range of classes of reference MSTO.

2. Analysis of literature data and problem statement

The class of absolute indicators which display the measure of its value added occupies a special place among the indicators characterizing the purposeful activity of the controlled system.

Practice shows that the economic «profit» is one of the most important performance indicators of the results of management [1]. Another important indicator is the «resource efficiency», or just «efficiency».

Experts in the field of control hold continuous debates concerning what is the entity of this index and what is the ratio and/or relationship between such concepts as profitability [2], result, performance, efficiency, effect, productivity, etc.

Such discussions are in many respects connected to the fact that the index “profit” is used as a universal “tool”, without considering the features of those system processes for which assessment it is used.

Considering single-digit compliance of minimum cost to the maximum profit in a number of production operations, the issues of efficiency control are defined as the cost management [3], and optimization problems - as a search of the minimum cost or-maximum profit [4].

Nevertheless, a number of works note that efficiency is the synergy effect of profit [5] and therefore, it is necessary to consider the cumulative effect of the profit in the efficiency determination [6]. In this regard, the concept “capitalization” is actively used [7].

In the paper [5], the need of creation of the model of the controlled system for the efficiency determination by direct methods on the basis of the index “profit” is marked, in fact, the concept “supersystem” as a management company is introduced. However, the attempt of the development of the direct evaluation method of efficiency doesn`t rely on the basic cybernetic entity “operation”, but on the macroeconomic entity “enterprise”.

As a result, the indices characterizing both the material, and the parallel cash flows duplicating them, and without considering the dynamics in time are a part of the developed index of efficiency.

Now for the efficiency assessment, the independent choice of the criterion of efficiency from a packet of indices which are identified as KPI [8] and further development of this direction in the form of the system of indices BSC [9] is offered to the enterprises.

Numerous debates and publications connected to the development of efficiency criteria and the use of various indices as the criterion of efficiency point to the need for creation of a technique which use will allow resolving the issue of preliminary testing of the developed indices which are positioned as criteria of efficiency.

3. Purpose and objectives of research

The purpose of the work is the development of a method for testing of criteria of efficiency of models of simple target operations and processes.

Achieving this goal leads to solving a number of tasks such as:

– development of a method of an assessment of efficiency of simple target operations with the use of a direct method of estimation of the processes equivalent generated by them from the point of view of efficiency;

– definition of classes of models of simple target operations and definition of restrictions for these classes from the point of view of a possibility of use of couples of models of operations as an efficiency comparison standard;

– testing of the known relative indicators for the ability to identify the efficiency of a set of classes of simple target operations.

4. Development of the conceptual and axiomatic definitions of the theory of estimation of models of simple target operations

In case of creation of the theory on the basis of the postulational method, the concepts which aren’t defined within this theory which properties and the relations are described by a system of axioms and postulates are introduced.

The main (primary) undefined concepts include:

1) operation;
2) input technological product;
3) output technological product;
4) input exchange product;

5) output exchange product;
6) input information product;
7) output information product.

To formulate conclusions of the developed theory, it makes sense to use the predicate logic language, therefore, we will define the underlying sets with which we will work, and introduce the symbolic notation of the main objects (object variables) and their properties or relations (predicate variables):

M – set of the operations researched within this theory;
$\tilde{\mathbf{M}}$ – set of system processes;
$\mathbf{M}'$ – set of synchronized operations;
$\tilde{\mathbf{M}}'$ – set of synchronized processes;
$\mathbb{R}$ – set of input products of system operation;
$\mathbb{R}'$ – set of input exchange products of system operation;
$\mathbb{R}' \subset \mathbb{R}$;
$\mathbb{Z}$ – set of output products of system operation;
$\mathbb{Z}'$ – set of output exchange products of system operation;
$\mathbb{Z}' \subset \mathbb{Z}$.

Object variables for nomenclature of the basic concepts within this theory:

x – operation;
$\tilde{\mathrm{x}}$ – the system process including one or more operations of one class;
c – technological products of operation;
c' – exchange products of operation;
r – input products of operation;
p – output products of operation;
rs – expert estimation of one input product of operation;
ps – expert estimation of one output product of operation.

The predicate variables denoting the properties and the relations of objects of this theory:

$\mathrm{A}(\mathrm{x})$ – "cybernetic operation is target operation";
$\mathrm{S}(\mathrm{x})$ – "cybernetic operation is simple target operation";
$\mathrm{B}(\mathrm{x})$ – "the moment of beginning of the operation x is defined";
$\mathrm{C}(\mathrm{x})$ – "the moment of the end of the operation x is defined";
$\mathrm{D}(\mathrm{x},\mathrm{c})$ – "the product c of operation x has quantitative definition";
$\mathrm{R}(\mathrm{x},\mathrm{r})$ – "the product r is an input technological product of x operation";
$\mathrm{P}(\mathrm{x},\mathrm{p})$ –"the product p is an output technological product of x operation";
$\mathrm{R}'(\mathrm{x},\mathrm{r})$ – "the product r is an input exchange product of x operation";
$\mathrm{P}'(\mathrm{x},\mathrm{p})$ – "the product p is an output exchange product of x operation";
$\mathrm{RQ}(\mathrm{x},\mathrm{r})$ – "the operation product r at the beginning of x operation has a quantitative estimation";
$\mathrm{PQ}(\mathrm{x},\mathrm{p})$ – "the operation product p at the end of x operation has a quantitative estimation";
$\mathrm{RE}(\mathrm{x},\mathrm{r})$ – "the operation product r at the beginning of x operation has an expert estimation"; $\mathrm{RE}(\mathrm{x}) = \mathrm{rs}\cdot\mathrm{RQ}(\mathrm{x})$;
$\mathrm{PE}(\mathrm{x},\mathrm{p})$ – "the operation product p at the end of x operation has an expert estimation"; $\mathrm{PE}(\mathrm{x}) = \mathrm{ps}\cdot\mathrm{PQ}(\mathrm{x})$;
$\mathrm{K}(\mathrm{x})$ – class of operations generated by system;
$\mathrm{E}(\mathrm{x})$ – efficiency of x operation.

We will define basic concepts of this theory:

Definition 1. The operated process of transformation of products is called **cybernetic operation** or **just operation**.

Definition 2. System is the object that is continuously generating certain cybernetic operations.

Definition 3. Cybernetic operation is called system operation if it includes other cybernetic operations, each of which uses the input intrasystem products and forms the output products which transformation is directed to the achievement of the one system purpose.

Definition 4. System operation, the input products of which are presented in the form of the corresponding expert estimates is called the target system operation or target operation $(\mathrm{A}(\mathrm{x}))$.

Definition 5. System target operation, the input products of which are defined in the form of total expert assessment of input products of operation (RE), and output products are defined in the form of total expert assessment of output products of operation (PE), we will determine by the concept "model of simple target operation (MSTO) $(\mathrm{S}(\mathrm{x}))$".

Definition 6. Time of the beginning of the simple target operation (t_r) is defined by the moment of registration of its input product in the form of a total expert assessment RE.

Definition 7. The end time of simple target operation (t_p) is defined by the moment of registration of its output product in the form of a total expert assessment PE.

Definition 8. The target product of the operation (AOE') is a part of an exchange product RE' the value of which is numerically equal to the added operation value $(\mathrm{AOE}' = \mathrm{AOE})$.

Definition 9. The supersystem is a class of systems the output product of which are the functioning systems of one class that transfer the target products to the supersystem (Fig. 1).

We will formulate the main statements within this theory which do not require justification in the form of postulates and axioms.

Postulate 1. For any target system operation, the moment of its beginning and the moment of its end can be defined

$$(\forall \mathrm{x} \in \mathrm{M})\left[\mathrm{A}(\mathrm{x}) \rightarrow \mathrm{B}(\mathrm{x}) \wedge \mathrm{C}(\mathrm{x})\right].$$

Postulate 2. Input and output products for any target system operation can be quantitatively defined.

$$(\forall \mathrm{x} \in \mathrm{M})(\forall \mathrm{r} \in \mathbb{R})(\forall \mathrm{p} \in \mathbb{Z})$$

$$\left[\mathrm{A}(\mathrm{x}) \wedge \mathrm{R}(\mathrm{x},\mathrm{r}) \wedge \mathrm{P}(\mathrm{x},\mathrm{p}) \rightarrow \mathrm{D}(\mathrm{r}) \wedge \mathrm{D}(\mathrm{p})\right].$$

Postulate 3. Carrying out any cybernetic operation requires the use of quite certain i input raw products R_1, R_2, R_3..., each of which can be quantitatively defined RQ_1, RQ_2, RQ_3...

$$(\forall \mathrm{x} \in \mathrm{M})\left[\mathrm{A}(\mathrm{x}) \rightarrow \exists(\mathrm{r}_\mathrm{i} \in \mathbb{R})\big(\mathrm{D}(\mathrm{r}_\mathrm{i}) = \mathrm{RQ}_\mathrm{i}\big)\right].$$

Postulate 4. The result of carrying out the cybernetic operation is a formation at the exit of the system j of output consumer products of the operation P_1, P_2, P_3 each of which can be also quantified PQ_1, PQ_2, PQ_3...

$$(\forall \mathrm{x} \in \mathrm{M})\left[\mathrm{A}(\mathrm{x}) \rightarrow \exists(\mathrm{p}_\mathrm{j} \in \mathbb{Z})\big(\mathrm{D}(\mathrm{p}_\mathrm{j}) = \mathrm{PQ}_\mathrm{j}\big)\right].$$

Postulate 5. Each amount of a raw product RQ_i and each amount of a consumer product PQ_j of the cybernetic system we can establish the corresponding exchange product with quantitative parameters RQ'_i and PQ'_j their consumer values in which are equivalent.

$$(\forall r \in \mathbb{R})(\forall p \in \mathbb{Z})\Big[\big(D(r) \to RE(r)\big) \wedge \big(D(p) \to PE(p)\big)\Big].$$

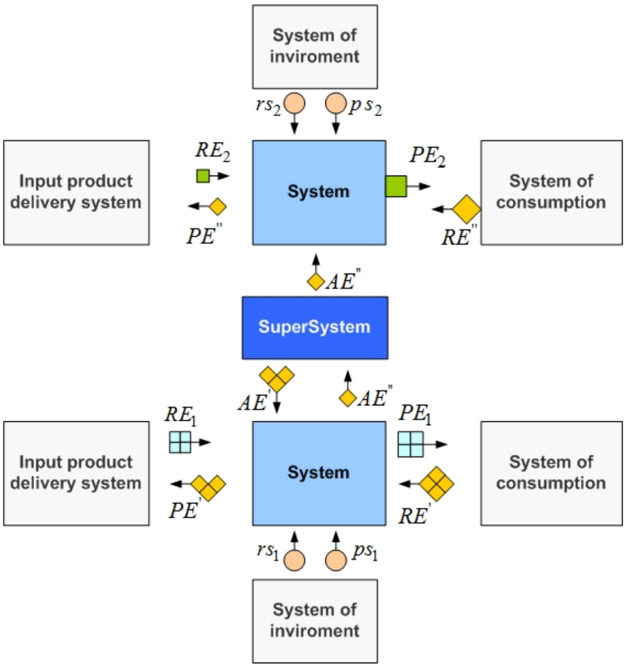

Fig. 1. Interaction of systems and supersystem

Axiom 1.

$$(\forall x \in M)(\forall r \in \mathbb{R}')(\forall p \in \mathbb{Z}')\big[A(x) \wedge \mathbb{R}'(x,r) \wedge \mathbb{Z}'(x,p) \to$$

$$\to RQ_i = RE_i \wedge PQ_j = PE_j\big]$$

Definition 10. For any target operation, it is always possible to define a cumulative expert assessment of its input and output products.

$$(\forall x \in M)(\forall r_i \in \mathbb{R})(\forall p_j \in \mathbb{Z})$$

$$\Big[S(x) \wedge R\big(x, r_i \mid i = \overline{1,I}\big) \wedge P\big(x, p_j \mid j = \overline{1,J}\big)\Big] \to$$

$$\to \left[\left(RE = \sum_{i=1}^{I} RE_i\right) \wedge \left(PE = \sum_{j=1}^{J} PE_j\right)\right].$$

Postulate 6. The expert assessment of input products of the target operation is always more than zero, and the expert assessment of output products of the operation is higher than the expert assessment of input products of the operation.

$$(\forall r \in \mathbb{R})(\forall x \in M)\big(A(x) \wedge R(x,r)\big) \to$$

$$\to \big[(RQ > 0) \wedge (RE > 0) \wedge (PQ > 0) \wedge (PE > RE)\big].$$

Based on the D10 and P1, it is possible to define the concept of the added value of the target operation

$$(\forall x \in M)$$

$$\Big[A(x) \to \big(\exists AOE(x)\big)\Big(\big(AOE(x) > 0\big) \wedge \big(AOE = PE - RE\big)\Big)\Big]$$

and the coefficient of the added value

$$(\forall x \in M)\ \left[A(x) \to \big(\exists k(x)\big)\left(k(x) = \frac{AOE}{RE}\right)\right].$$

In this case,

$$k(x) = \frac{PE - RE}{RE} = \frac{PE}{RE} - 1 > 0\,,$$

because $(\forall x \in M)\big[A(x) \to (PE > RE)\big]$.

Thus, the added value of the operation is defined as $AOE = PE - RE$. As

$$(\forall x \in M)\Big[A(x) \to \Big(\big(B(x) = t_r\big) \wedge \big(C(x) = t_p\big)\Big)\Big],$$

it is possible to define the time of the target operation (T),

$$(\forall x \in M)\Big[A(x) \to \big(T = t_p - t_r\big)\Big].$$

Postulate 7. The model of the simple target operation can always be defined by the three parameters as follows (RE, T, PE) $(\forall x \in M)\Big[S(x) \to \Big(S(x) \leftrightarrow \big(RE, T, PE\big)\Big)\Big]$ (Fig. 2).

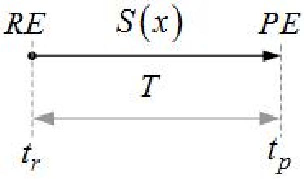

Fig. 2. The graphic model of the simple target operation

We will determine the parameters (RE, T, PE) as target signatures.

5. Multisystem process

We will consider the system operations which are carried out by different systems within a certain interval of time as a multisystem process.

Definition 11. Two MSTO x_1 and of x_2 of one class will be called parallel if: $k(x_1) = k(x_2) \wedge T(x_2) \in \big[t_r(x_1); t_p(x_1)\big]$ or $\big[T(x_2) \le T(x_1)\big]$.

Total (general, cumulative) added value of parallel MSTO within one time interval of research will be defined as the “multisystem added value (AME)”

$$\big(\forall (x_1, x_2) \in M\big)\ \big(\forall (r_1, r_2) \in \mathbb{R}\big)\ \big(\forall (p_1, p_2) \in \mathbb{Z}\big)$$

$$\Big(S(x_1) \wedge S(x_2) \wedge \big(B(x_1) = B(x_2)\big) \wedge \big(C(x_1) = C(x_2)\big) \wedge$$

$$\wedge \big(AOE(x_1) = PE(x_1) - RE(x_1)\big) \wedge$$

$$\wedge \big(AOE(x_2) = PE(x_2) - RE(x_2)\big)\Big) \to$$

$$\to\ \big[AME = AOE(x_1) + AOE(x_2)\big].$$

MSTO in which $t_{r1} = t_{r2} = \ldots$ and $t_{p1} = t_{p2} = \ldots$, will be defined as the simple target operations synchronized in time or as synchronized operations from a nonempty set of M', a set subset of M.

$$\big(\forall (x_1, x_2) \in M\big)\ \Big(S(x_1) \wedge S(x_2) \wedge \big(t_{r1} = t_{r2}\big) \wedge \big(t_{p1} = t_{p2}\big)\Big) \to$$

$$\to\ \big[x_1 \in M', x_2 \in M'\big] \text{(Fig. 3)}.$$

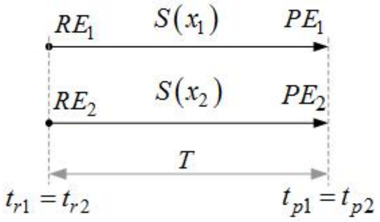

Fig. 3. Simple target synchronized operations $s(x_1)$ and (sx_2)

Comparison of efficiency of synchronized MSTO by comparison of their added value, generally, can be carried out if expert estimates of input products are equal.

$$\begin{aligned}&(\forall(y_1,y_2)\in M')[RE(y_1)=RE(y_2)\to\\&\to(AME(y_1)>AME(y_2))\oplus\\&\oplus(AME(y_2)>AME(y_1))\oplus(AME(y_1)=AME(y_2))].\end{aligned}$$

Definition 12. Two synchronized MSTO will be equivalent concerning efficiency $(E(y_1)\Leftrightarrow E(y_2))$, if

$$AME(y_1)=AME(y_2).$$

Theorem 1. Any MSTO x can be presented in the form of two or more synchronized with this operation, MSTO y_1, y_2 so that

$$RE(x)=RE(y_1)+RE(y_2),$$

$$k(x)=k(y_1)=k(y_2)=k,$$

$$PE(y_1)=(k+1)\cdot RE(y_1)$$

and

$$PE(y_2)=(k+1)\cdot RE(y_2).$$

Proof of T. 1. For MSTO x, it is possible to define

$$PE-RE=AOE=AME;$$

$$PE=(k+1)\cdot RE;$$

$$AME=(k+1)RE-RE=RE\cdot k.$$

If

$$RE(x)=RE(y_1)+RE(y_2),$$

then, considering that

$$PE(y_1)=(k+1)\cdot RE(y_1)$$

and

$$PE(y_2)=(k+1)\cdot RE(y_2),$$

we receive

$$\begin{aligned}&AOE(y_1)=PE(y_1)-RE(y_1)=\\&=(k+1)\cdot RE(y_1)-RE(y_1)=RE(y_1)k\end{aligned}$$

and

$$\begin{aligned}&AOE(y_2)=PE(y_2)-RE(y_2)=\\&=k\cdot RE(y_2)-RE(y_2)=RE(y_2)k.\end{aligned}$$

Then

$$\begin{aligned}&AME(y_1,y_2)=AOE(y_1)+AOE(y_2)=\\&=RE(y_1)k+RE(y_2)k=k(RE(y_1)+RE(y_2))=\\&=kRE(x)\Rightarrow AME(x)=AME(y_1,y_2)\Rightarrow x\Leftrightarrow\{y_1,y_2\}.\end{aligned}$$

Conclusion 1 of T. 1. Two synchronized MSTO are equivalent concerning their efficiency if $k(x_1)=k(x_2)$... and $T(x_1)=T(x_2)$...

Theorem 2. When comparing two synchronized MSTO x and in which $RE(y_1)<RE(x)$, for the operation $RE(y_1)$, it is always possible to pick up such MSTO with $RE(y_2)$ as $RE(y_1)+RE(y_2)=RE(x)$ at the same time MSTO with higher AME will be more effective.

Proof of T. 2. We will consider

$$\begin{aligned}&x\in M':RE(x),PE(x),k(x):\\&PE(x)=(k+1)\cdot RE(x)\wedge AME(x)=\\&=AOE(x)=PE(x)-RE(x)=\\&=(k+1)\cdot RE(x)-RE(x)=RE(x)k(x).\end{aligned}$$

$$\begin{aligned}&y_1\in M':RE(y_1)\wedge RE(y_1)<RE(x):\\&k(y_1)\neq k(x)\wedge PE(y_1)=(k(y_1)+1)\cdot RE(y_1)\wedge AOE(y_1)=\\&=PE(y_1)-RE(y_1)=RE(y_1)\cdot(k(y_1)+1)-RE(y_1)=\\&=RE(y_1)k(y_1).\end{aligned}$$

Then

$$\begin{aligned}&\exists y_2\in M':RE(y_2):RE(y_1)+RE(y_2)=RE(x)\wedge\\&\wedge k(y_2)=k(y_1)=k(y)\wedge PE(y_2)=RE(y_2)(k(y)+1).\end{aligned}$$

$$\begin{aligned}&AOE(y_2)=PE(y_2)-RE(y_2)=\\&=RE(y_2)(k(y)+1)-RE(y_2).\end{aligned}$$

As $k(y_1)=k(y)$, then $AOE(y_1)=RE(y_1)k(y)$.

Then

$$\begin{aligned}&AOE(y_1)+AOE(y_2)=AME(y)=\\&=RE(y_1)k(y)+RE(y_2)k(y)=\\&=k(y)(RE(y_1)+RE(y_2))=RE(x)k(y).\end{aligned}$$

And consequently:

$$AME(x)=RE(x)k(x),\ AME(y)=RE(x)k(y).$$

If $k(x)>k(y),\ AME(x)>AME(y)\wedge E(x)>E(y).$

If $k(x)<k(y),\ AME(x)<AME(y)\wedge E(x)<E(y).$

If $k(x)=k(y),\ AME(x)=AME(y)\wedge E(x)=E(y).$

Conclusion of T 2.1. When comparing two synchronized MSTO x and $\left(RE(x) > RE(y^{'})\right)$, for operation $y^{'}$ with lower RE, we can always create an additional equally effective operation of the same class so that it was possible to equalize input expert estimates of the compared processes $\tilde{x}$ and $\tilde{y}$:

$$\left(\forall x, y^{'} \in M^{'}\right)\left[RE(x) > RE\left(y^{'}\right) \rightarrow\right.$$
$$\rightarrow \left[RE(\tilde{x}) = RE\left(y^{'}\right) + RE\left(y^{''}\right) = RE(\tilde{y}) \mid RE\left(y^{''}\right) =\right.$$
$$\left.\left. = RE(x) - RE\left(y^{'}\right), k\left(y^{'}\right) = k\left(y^{''}\right)\right]\right].$$

Conclusion of T 2. 2. Efficiency of synchronized MSTO x_1 and x_2 can also be compared by comparing the indexes of their added value:

$$\left(\forall x_1, x_2 \in M^{'}\right)\left[k(x_1) > k(x_2) \rightarrow\right.$$
$$\left.\rightarrow AME(x_1) > AME(x_2) \wedge E(x_1) > E(x_2)\right].$$

6. The system process

Postulate 8. Any system working in the continuous mode generates target simple operations of one class, as follows:

$$\left(\forall x_1, x_2 \in M\right)\left[x_1 \in K(x_1) \wedge x_2 \in K(x_2) \leftrightarrow\right.$$
$$\left.\leftrightarrow \left(k(x_1) = k(x_2) \wedge T(x_2) = T(x_1)\right)\right].$$

Definition 13. Two simple target operations of one class x_1 and x_2 are called consecutive if: $t_p(x_1) = t_r(x_2)$ (Fig. 4).

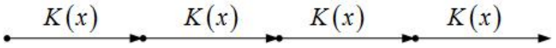

Fig. 4. The sequence of system operations of one class which are generated by one system

Within this theory for the considered classes of MSTO it is possible to introduce the concept of procedurally synchronized operations.

Definition 14. The process $\tilde{y}$ that consists of two consecutive MSTO of one class $K(y)$, y_1 and y_2, will be called procedurally synchronized with MSTO x of the class $K(x)$, if

$$T(y_1) = T(y_2) = \frac{1}{2}T(x).$$

Then,

$$APE(y) = AOE(y_1) +$$
$$+AOE(y_2) \wedge APE(x) = AOE(x).$$

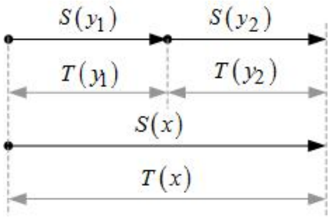

Fig. 5. The process $\tilde{y}$ is synchronized with the operation x

For two procedurally synchronized MSTO

$$APE(\tilde{y}) = AOE(y_1) + AOE(y_2).$$

Postulate 9. For any $AOE(x)$, the supersystem always generates a new system simple target operation with the parameters

$$RE(d) = AOE(x),\ k(d) = k(x),\ T(d) = T(x).$$

$$\left(\forall r_x \in \mathbb{R}^{'}\right) \rightarrow$$
$$\rightarrow \left[A_d(x) \rightarrow S_d(x) \mid RE(d) =\right.$$
$$= AOE(x), k(d) = k(x), T(d) = T(x),$$

$$\left.PE(d) = \left(k(d) + 1\right)RE(d)\right].$$

7. The developing system process

For two parallel periodic system processes, each of which is represented by the sequence of simple target operations of one class, the added value $AMPE$ is defined as $AMPE = AME + APE$.

Proceeding from the accepted activity model of systems, it follows that for two STO x and y_1 in which $t_r(x) = t_r(y_1)$ and $2T(y_1) = T(x)$, on completion of the operation y_1 the system generates the simple target operation y_2, consecutive to y_1 with identical parameters and affiliated STO as y_d, for which

$$RE(d) = AOE(y_1),\ k(y_d) = k(y_1),$$

$$T(d) = T(y_1),\ PE(d) = k(d)RE(d).$$

The set of operations y_1, y_2 and y_d on the interval $T \in \left(t_{rx}, t_{px}\right)$ is considered as the developing multisystem process (DMSP) designated as z. Then the added value of DMSP is defined by the expression

$$AME_+(\tilde{z}) = APE(\tilde{y}) + AME(\tilde{y}, \tilde{d}).$$

Theorem 3. When comparing two DMSP which generate STO of different classes $x \in K(x)$ and $y \in K(y)$ with equal $RE(x) = RE(y)$, equal $APE(\tilde{x}) = APE(\tilde{y})$ and $T(x) = 2T(y)$, the operation with higher AME_+ is more effective.

Proof of T. 3.

$$AMPE_+(\tilde{z}) = APE(\tilde{y}) + AOE(d) = AME(\tilde{y}, d).$$

As

$$AME(\tilde{x}) = APE(\tilde{x}),$$

and

$$AME(\tilde{z}) = APE(\tilde{y}) + AOE(d)$$

and

$$AOE(d) > 0 \Rightarrow AME(\tilde{z}) > AME(\tilde{x}) \rightarrow E(y) > E(x).$$

Within this theory, the algorithm of reduction of the compared MSTO of one class to the form allowing the use of the indicator AME_+ for comparison of their efficiency has been received.

8. Definition of classes of models of simple target operations as reference, for an efficiency evaluation.

Within this theory, any MSTO is defined by the three indicators RE, E, PE. Equality or an inequality of these basic indicators is important for comparison of two MSTO. From this perspective, the set of MSTO can be divided into 8 classes of MSTO presented in Table 1. The last column contains the limitations on the sample size of STO models, within the class, the operations y of which at the moment can be used as reference.

Table 1

Classification of models of simple target operations and area of restriction for selection of reference couples within a class

Classes	RE	T	PE	Selection of y from x
1	RE=const	T=const	PE=var	All
2	RE=const	T=var	PE=const	$T(y)=(1/2)T(x)$
3	RE=var	T=const	PE=const	All
4	RE=const	T=var	PE=var	No
5	RE=var	T=const	PE=var	All
6	RE=var	T=var	PE=const	No
7	RE=const	T=const	PE=const	All
8	RE=var	T=var	PE=var	$T(y)=(1/2)T(x)$

The developed theory of comparison of efficiency of MSTO with the use of the indicator AME_+ allows comparing, at the moment, all operations of the first, third, fifth and seventh classes.

For MSTO of the second class, an additional condition is the ratio of the duration of the compared operations (the time of short MSTO half the time of long MSTO). For the operations of the eighth class, the need of equality of their indicators AOE is added to this condition.

All this is presented in the last column of the table.

For other MSTO of these and the remained classes, it is necessary to continue investigations.

9. A technique of calculation of the efficiency of the developing process generated by the simple target operation

We will show an illustration of a technique of efficiency calculation with the use of the indicator AME_+ on the example of concrete MSTO x and y from MSTO of the eighth class with such parameters:

$$S(x)|RE(x)=3, T(x)=4, PE(x)=6$$

and

$$S(y)|RE(y)=1, T(y)=2, PE(y)=1.5 \text{ (Fig. 6).}$$

1) Equation of expert estimates of input products of the compared operations by the formation of additional operation y_1'' that is synchronized with the operation y_1':

$$RE(y_1'')=RE(x)-RE(y_1')=3-1=2;\ T(y_1'')=T(y_1');$$

$$PE(y_1'')=\left(\frac{AOE(y_1')}{RE(y_1')}+1\right)\cdot RE(y_1'')=3 \text{ (Fig. 7).}$$

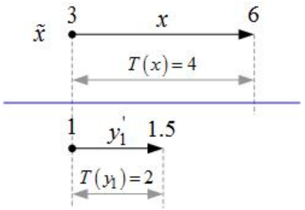

Fig. 6. Two operations (K(x)=8)that are chosen for comparison

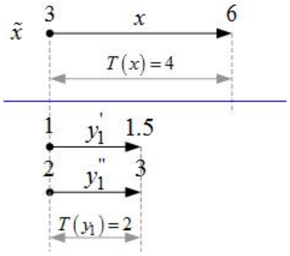

Fig. 7. Formation of the operation y_1'' that is synchronized with the operation y_1'

2) Reduction of synchronized operations $y_1'=y_1''$ to equivalent operation y_1, concerning their efficiency values:

$$RE(y_1)=RE(y_1')-RE(y_1'')=2+1=3;$$

$$PE(y_1)=PE(y_1')+PE(y_1'')=1.5+3=4.5 \text{ (Fig. 8).}$$

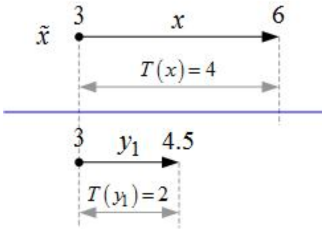

Fig. 8. Reduction of synchronized operations $y_1'=y_1''$ to equivalent operation y_1, concerning their efficiency values

3) Synchronization of process $\tilde{y}$ with operation x (Fig. 9)

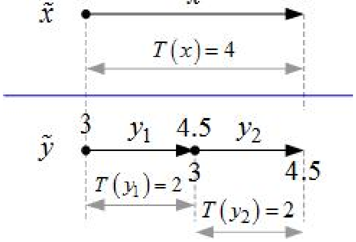

Fig. 9. The result of synchronization of the process $\tilde{y}$ with the operation x

4) Formation of the affiliated operation from the operation which has ended within the studied period:

$$\mathrm{RE}(\mathrm{d})=\mathrm{AOE}(\mathrm{y})=\mathrm{PE}(\mathrm{y})-\mathrm{RE}(\mathrm{y})=4.5-3=1.5;$$

$$\mathrm{k}(\mathrm{d})=\mathrm{k}(\mathrm{y})=1.5;$$

$$\mathrm{PE}(\mathrm{d})=\mathrm{k}(\mathrm{d})\mathrm{RE}(\mathrm{d})=1.5\cdot 1.5=2.25 \text{ (Fig. 10).}$$

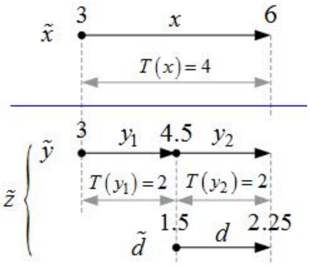

Fig. 10. Formation of the reduction developing process $\tilde{z}$ from the operation y_1

5) Calculation of AME_+ indicator for the investigated processes:

$$\mathrm{AME}_+(\mathrm{x})=\mathrm{AOE}(\mathrm{x})=3;$$

$$\mathrm{AME}_+(\mathrm{z})=\mathrm{AME}_+(\tilde{\mathrm{y}},\tilde{\mathrm{d}})=$$
$$=\mathrm{APE}(\tilde{\mathrm{y}})+\mathrm{AOE}(\mathrm{d})=3+0.75=3.75.$$

6) Conclusion about the efficiency of the compared STO, on the basis of comparison of AME_+. As

$$\mathrm{AME}_+(\mathrm{z})>\mathrm{AME}_+(\mathrm{x})\rightarrow \mathrm{E}(\mathrm{y})>\mathrm{E}(\mathrm{x}).$$

10. Testing of relative indicators which can be used for identification of efficiency of simple target operations

As an example, we consider testing of three indicators which in various sources are defined as performance indicators. It is the coefficient of the value added (profitability) (ER) [2], the growth rate of the value added (EC) [10] and the indicator (EL) [11]:

$$\mathrm{ER}=\frac{\mathrm{PE}-\mathrm{RE}}{\mathrm{RE}},\mathrm{T}=\mathrm{const};$$

$$\mathrm{EC}=\frac{\mathrm{PE}-\mathrm{RE}}{\mathrm{T}};$$

$$\mathrm{EL}=\frac{(\mathrm{PE}-\mathrm{RE})^2\mathrm{T}_1^2}{\mathrm{PE}\cdot\mathrm{RE}\cdot\mathrm{T}^2},\mathrm{T}_1=1.$$

The results of comparison of efficiency of the operations x and of y with the use of the developed method for 6 classes are given in Table 2. 3 operations of these classes were evaluated in Table 3 with the use of the tested indicators.

The comparative analysis has been carried out for couples of AME_+ indicators (Table 2) and couples of indicators ER, EC and EL (Table 3).

In the column $(1/0)$, directly following the criterion indicators, the reliability of its assessment is shown.

Table 2

Set of the STO models that can be used as efficiency assessment standards

Class	RE(x)	T(x)	PE(x)	RE(y)	T(y)	PE(y)	$AME_+(x)$	$AME_+(y)$
1	1	2	2	1	2	3	1	2
2	2	2	3	2	4	3	2.5	1
3	2	2	4	3	2	4	2	1
5	1	2	3	2	2	4	4	2
7	1	2	3	1	2	3	2	2
8	3	4	6	1	2	1.5	3	3.8

The 1 level corresponds to logical "True", the 0 level – to logical "False". So, for example, the indicator ER isn't suitable for an assessment of 2 and of 8 STO classes. The indicator EC estimates the classes 5 and 8 inadequately. The indicator EL provides an adequate efficiency assessment of all classes of STO given in Table 2 without restriction.

Table 3

Results of testing of three indicators ER, EC, EL regarding a possibility of an assessment of classes of operations (Table 1)

Class	ER(x)	ER(y)	(1/0)	EC(x)	EC(y)	(1/0)	EL(x)	EL(y)	(1/0)
1	1	2	1	0.5	1	1	0.125	0.333	1
2	0.5	0.5	0	0.5	0.25	1	0.0417	0.01	1
3	1	0.3	1	1	0.5	1	0.125	0.021	1
5	2	1	1	1	1	0	0.3333	0.125	1
7	2	2	1	1	1	1	0.3333	0.333	1
8	1	0.5	0	0.75	0.25	0	0.031	0.042	1

11. Discussion of the results of the research that is connected with testing of identification indicators of simple target operations

The researches carried out within this work have shown a basic possibility of verification of indicators with the use of reference operations, which efficiency is calculated by the use of methods and indicators of the developed theory.

It should be noted that the research results of were limited to a set of models of simple target operations. At the same time, the received results don`t cover all classes of these models, and in two cases subclasses of classes as well.

It means that subjects of further investigations in this direction will concern the expansion of classes and subclasses of MSTO within which sets of reference MSTO can be received. It causes practical interest of expansion of a set of reference couples or sets of operations for the entire class of target operations.

The offered method of verification of indicators of identification of target operations provides the objective choice of the criterion of efficiency according to the requirement of the practical solution of optimization problems. At the same time, the solution of the problems of the eighth class with the specified restriction is possible only in that case when parameters of affiliated MSTO are well known.

The results of the research can be used by experts who are engaged in the development of the theory of estimation, development of performance indicators, design of control process automation subsystems and other optimization problems.

The work is a continuation of earlier research [11, 12].

12. Conclusions

1. Bases of the theory of estimation of models of target operations and the processes generated by them have been designed. It is proved that any MSTO can be transformed into two or more synchronized MSTO of one class. At the same time, it is proved that at equality of coefficients of the value added, the initial and the transformed MSTO are equally effective. The technique of creation of the generated MSTO of processes is offered. A feature of the generated processes is their comparability according to the values of the indicator of efficiency. Within the theory, the absolute predictive value added measure of the developing process is formulated.

2. The method of calculation of efficiency of simple target operations is developed. The essence of the method is that, in case of need, the initial MSTO in the beginning should be transformed into equally efficient MSTO with equal input expert estimates of MSTO. Then, if necessary, the synchronization of the process duration of short MSTO with MSTO, having a greater duration is made. In case of duration synchronization, the affiliated operation from the first short process operation is formed at the last stage. By means of the developed absolute predictive measure AME_+ , the comparative assessment of efficiency of the processes generated from initial operations is made. Based on the received assessment, the judgment of the relation of initial operations efficiency is expressed.

3. Eight classes of MSTO are defined, the MSTO couples of which can be used for testing of the indicators that are offered as criteria for efficiency evaluation of MSTO. Restrictions for creation of couples of reference MSTO within each class are defined.

4. Testing of three known indicators regarding the possibility of their use as the efficiency criterion is held. It is shown that only one of the three indicators adequately estimates couples of all classes of reference MSTO within which such standards can be created for today.

References

1. Golovin, A. A. Faktory formirovanija pribyli v APK [Text] / A. A. Golovin, I. I. Kurasova, A. Ju. Chzhan-Sen // Agrarnyj vestnik Urala. – 2014. – Vol. 1 (119). – P. 80–83.
2. Demchuk, O. V. Pribyl' i rentabel'nost' predprijatija: sushhnost', pokazateli i puti povyshenija [Text] / O. V. Demchuk, S. G. Aref'eva // Problemy jekonomiki i menedzhmenta. – 2015. – Vol. 8 (48). – P. 6–9.
3. Ghiani, G. Operations research in solid waste management: A survey of strategic and tactical issues [Text] / G. Ghiani, D. Laganà, E. Manni, R. Musmanno, D. Vigo // Computers & Operations Research. – 2014. – Vol. 44. – P. 22–32. doi: 10.1016/j.cor.2013.10.006
4. Zheng, Y.-J. Ecogeography–based optimization: Enhancing biogeography–based optimization with ecogeogrephic barriers and differentiations [Text] / Y.-J. Zheng, H.-F. Ling, J.-Y. Xue // Computers & Operations Research. – 2014. – Vol. 50. – P. 115–127. doi: 10.1016/j.cor.2014.04.013
5. Makarevich, O. A. Modeli ocenki jekonomicheskoj jeffektivnosti i sistemnogo (sinergicheskogo) jeffekta tehnologicheski integrirovannoj proizvodstvennoj sistemy [Text] / O. A. Makarevich // Politematicheskij setevoj jelektronnyj nauchnyj zhurnal Kubanskogo gosudarstvennogo agrarnogo universiteta. – 2012. – Vol. 75. – P. 1–21.
6. Baholdina, I. V. Pribyl' na akciju kak instrument ocenki jeffektivnosti delovoj aktivnosti jekonomicheskogo sub'ekta [Text] / I. V. Baholdina, Ju. V. Shherbinina // Upravlenie jekonomicheskimi sistemami. – 2013. – Vol. 11 (59).
7. Kisel'nikov, E. A. Ocenka strategii povyshenija jeffektivnosti funkcionirovanija predprijatij mashinostroenija na osnove kapitalizacii pribyli [Text] / E. A. Kisel'nikov, A. N. Sorochajkin, N. M. Tjukavkin. // Vestnik Samarskogo gosudarstvennogo universiteta. – 2013. – Vol. 4 (105). – P. 34–42.
8. Maiju, V. Development of key performance indicators and impact assessment for SHOKs [Text] / V. Maiju, A. Lonnqvis, G. Schiuma // Publication of the Ministry of Employment and the Economy Innovation . – 2014. – Vol. 27. – P. 47.
9. Sun, Y. A new management model of university scientific research funds based on the BSC [Text] / Y. Sun // Education Management and Management Science. – 2015. – P. 303–306.
10. Cirlin, A. M. Optimal'noe upravlenie tehnologicheskimi processami [Text] / A. M. Cirlin. – Jenergoatomizdat, 1986. – 400 p.
11. Lutsenko, I. Identification of target system operations. Development of global efficiency criterion of target operations [Text] / I. Lutsenko // Eastern-European Journal of Enterprise Technologies. – 2015. – Vol. 2, Issue 2 (74). – P. 35–40. doi: 10.15587/1729–4061.2015.38963
12. Lutsenko, I. Identification of target system operations. 2. Determination of the value of the complex costs of the target operation [Text] / I. Lutsenko // Eastern-European Journal of Enterprise Technologies. – 2015. – Vol. 1, Issue 2 (73). – P. 31–36. doi: 10.15587/1729-4061.2015.35950