Some Statistical Solutions and Methods in Evaluation of Efficiency in Sport and Effectiveness in the Phenomenon of Sportsmen' Training

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Abstract: Problem statement: A general method for evaluation of efficiency in sport and effectiveness in the phenomenon of sportsmen's training was proposed. **Approach:** The method of four "E" was a frame method focused on communication and evaluation, where efficiency acquired an essential importance and its variation related to the initial programme, with its time or space details, respectively related to the effectiveness of coach **Results:** The practical results proved a high degree of coverage for proposed method in terms of efficiency and effectiveness in sports and training. Besides being successful in identifying regularities, generalizing the alternatives and emphasizing their fundamental contribution to majority of the results of sports organizations providing globally optimal results, due to high efficiency and lower computation time, the proposed approach could be considered an interesting candidate for easily characterization of the communication, evaluation and, finally, the decision-making processes, but especially of their aggregation in an ample process, the practical training for sportsmen phenomenon. **Conclusion:** Some conclusions of the proposed method were briefly presented for this new modern sports paradigm of modern coach and sportsmen, derived from economic thought. By comparing the alternatives of multidisciplinary analysis, considered as possible solutions of the method of four "E", regarded as a chain of logical approach of the type efficaciousness-degree of economy-efficiency-effectiveness, it was observed that statistical evaluation of indexes achieved better performances in terms of application, interpretation and the placement in hierarchical order and determination of the informational energy in terms of accuracy, using the probabilities of occurrence of effects, to the informational energy, completed and generalized the entirety.

Key words: Informational energy, team training, modern sport, efficaciousness-degree, degree of economy, sports efficiency, hierarchical order, general methodology, genetic algorithms, training programme

INTRODUCTION

The analysis of the efficiency is not a recent and exclusive concern of the economists, but even of the coaches in sports, of all managers, in general. The efficiency measurement emerges naturally from the distance between a real effect or observation and the empirical estimate of the theoretical effect. Between 1933 and 1951, economics and econometrics had revealed and quantified the economic concept of efficiency and F.H. Knight G. Debreu and T. C. Koopmans are the pioneers of scientific presentation of the results of their studies regarding the calculation of the efficiency. Kamatchi *et al*. (2009); Muralidhar *et al*. (2009); Ulrichs *et al*. (2009); Carifio and Perla (2010); Elforgani and Rahmat (2010); Eldos and Almazyad (2010); Ismail *et al*. (2010); Cage and Kluck (2010); Iskandarani (2010) and Sarabian and Lee (2010) and others have brought important contributions through their recently published materials in the study of efficiency in sports and different domains, using both parametric and non-parametric methods. There have been made numerous applications of the stochastic frontier method, using diverse specifications of the production function, stochastic or determinist ones, parametric or non-parametric ones, based on cross-section or panel data. The authors of this study try to underline the applied efficiency in sport using new solutions and methods from statistics, mathematics, physics and genetic algorithms.

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MATERIALS AND METHODS

There is neither communication between coach and sportsman without knowledge or sportive training and nor efficient results without communication and also there is no knowledge and no training without communication in sportive activity. The simplest model of representational communication is that of Karl Bühler synthesized by the first variant of the sender-message-receiver type in the next Fig. 1.

In Roman Jakobson's intermediary variant there appear three other elements, code, channel and context (referent), offering the possibility of outlining, through pluralism, a potential model with six components: Sender-code-message-channel-context-receiver, as in the next Fig. 2.

In the cybernetic model of communication of Claude Shannon and Warren Weaver the contextual component is missing, the model avoids the semantic information, in favour of the selective one and it additionally contains three new components, the transmitter, the receiver and the noise and in order to constitute itself statistically and mathematically, that is to submit its object to measurement one resorts to a special characteristic of information, the fact that it benefits from an invariance all along a series of reversible operations and for this reason it quantizes in bits (which thus became units of measurement).Warren Weaver, through a relevant question, regarding the exactness with which the symbols of communication can be transmitted, generated the next Fig. 3 of the complex/classical system of communication.

The fundamental theorem of the statistical-mathematical theory of communication, considered valid for a channel without noise and for discreet signals, refers to the channel of communication having the capacity of C bits per second, receiving symbols from a source with the entropy of H bits per second (the information communicated) and it states that, thanks to the procedures of coding adequate to the sender it is possible to transmit symbols through the channel with an average debit considered close to the maximum value C/H. This fact, based on the background of the similarity with economy (production-exchange-consumption) reduce sports communication to an exchange of messages, just as economy is an exchange of merchandise, which also allows to attach to the process of communication in sports activities one of the five methods of multidisciplinary analysis, considered as possible solutions of the method of the four "E", regarded as a chain of logical approach of the type efficaciousness-degree of economy-efficiency-effectiveness:

- Efficaciousness in the model of communication message and noise
- Degree of economy in the model of communication: the C/H relation or the limit of the resource of h type
- Efficiency in the model of communication maximization of the C/H relation for a given level of H
- Effectiveness in the model of communication monitoring/controlling the communication channel
- Statistical evaluation of indexes of procedural transformation through the law of equivalence and the dynamics of the factorial asymmetries (the index-numbers method)
- A delimitation of the informational transformation thresholds, of the maximum and minimum type, with the help of the law of the minimum and the law of the maximum (the method of the smallest squares through the use of the partial derivatives)
- A mathematical and physical interpretation of the economic relations centred upon the principle of losses, successive inequalities and of the inclinations of the slopes of effect and cause or of the angular coefficients of the $m = (Y_1-Y_2)/(X_1-X_2)$ type
- A determination of the informational energy ($S = \Sigma p_i^2$)
- A modern sports efficiency vision with the help the general methodology support from genetic algorithms

This study underlines the primacy of efficiency and efficaciousness for sports activities and the tradition of statistics in identifying new applied solutions and methods. Practically any coach will have a training programme, which efficaciousness will transcribe into a matrix of the designed effects. The announced matrix model is achieved starting from the hypothesis that the management of the sportive organization will identify, name and draw up the main effects that give content to its training policy in hierarchical order as compared to the estimated probability of their occurrence (Table 1, the sum of the probabilities being equal to 1).

The training programme as a matrix of the designed effects and placed in hierarchical order according to their occurrence probability
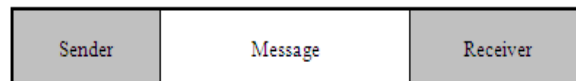
Sender	Message	Receiver

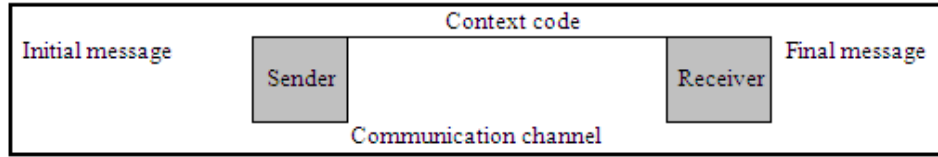Fig. 1: Karl Bühler's communication model, sender-message-receiver

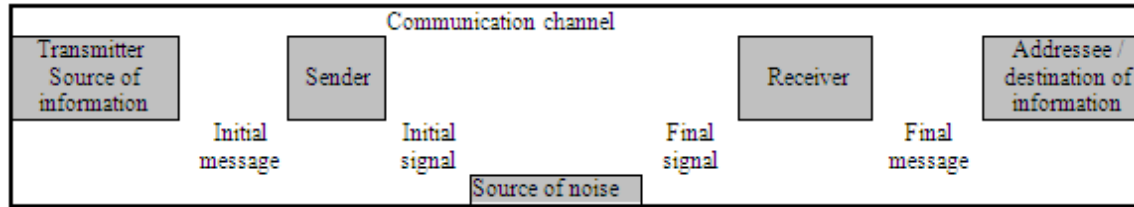Fig. 2: Reunited model of communication (Karl Bühler - Roman Jakobson)

Fig. 3: The systemic model of communication (Claude Shannon-Warren Weaver)

Table 1: The training programme as a matrix of the designed effects and placed in hierarchical order according to their occurrence probability

The designed effect and placed in hierarchical order according to the occurrence probability	U.M. (unit of measurement)	The designed level of training	The estimated occurrence probability of the effect
- A -	- B -	- 1 -	- p_a -
E_1	Km.		0,20
E_2	%		0,12
E_3	Kg.		0,10
…	…		…
E_n	hours		0,01
Total	$\Sigma\, p_a = 1,00$		

Table 2: The matrix of the prognosticated and re-placed in hierarchical order effects according to the final importance

The effect designed and re-placed in hierarchical order according to the final importance	U.M.	The designed level occurrence probability of the effect	The estimated strategic impact	The estimated	Final importance (OEp)
-A-	-B -	- 1 -	- p_a -	- p_j -	(p_a x p_j)
E_1	Km.		0,20	0,10	0,0200
E_3	Kg.		0,10	0,15	0,0150
E_2	%		0,12	0,08	0,0960
…	…		…	…	…
E_n	hours		0,01	0,01	0,0001
Total			$\Sigma\, p_a = 1,00$	$\Sigma\, p_j = 1,00$	-

Table 3: The evaluation of the average coefficients given by the members of the coaches for the selection of the optimum variant of team training

Number of coaches	Coefficients given by the members of the coaches for the training of the team / effect			
E_1	E_2	E_j…	E_n	
Variant I = k_1	E_{11}	E_{21}	E_{j1}	E_{n1}
Variant II = k_2	E_{12}	E_{22}	E_{j2}	E_{n2}
…	…	…	…	…
Variant "i" = k_i	E_{1i}	E_{2i}	E_{ji}	E_{ni}
…	…	…	…	…
Variant "n" = k_n	E_{1n}	E_{2n}	E_{jn}	E_{nn}
Average coefficient $Em_{ji}=(\Sigma E_{ji}k_i)/(\Sigma k_i)$	$Em_1=(\Sigma E_{1i}k_i)/(\Sigma k_i)$	$Em_2=(\Sigma E_{2i}k_i)/(\Sigma k_i)$	$Em_j=(\Sigma E_{ji}k_i)/(\Sigma k_i)$	$Em_n=(\Sigma E_{ni}k_i)/(\Sigma k_i)$
Hierarchy of effects	It is established according to the final relationship ">" or"<" type among all Em_{ji}			

Table 4: The matrix of the efforts (consumptions) necessary according to the risk of non-degree of economy (competitiveness) of the effort

The designed effect and re-placed in hierarchical order	U.M.	The designed level	The necessary effort (consumption)	U.M.	The necessary level of effort	The risk of non-degree of economy of the effort
- A -	- B -	- 1 -	- Cnj-	- D -	- 2 -	- pC_{nj} -
E_1	Km.		C_{11}	Km.		0,08
			C_{12}	Km.		0,06
			C_{13}	Km.		0,04
			C_{14}	Km.		0,02
E_2	%		C_{21}	%		0,10
…	…		…	….		…
E_n	hours		C_{n1}	hours		0,01
		Total				$\Sigma\, pC_{nj} = 1,00$

Table 5: The matrix of the prognosticated effects and of the necessary efforts (consumptions of resources) re-placed in hierarchical order according to the final importance

The designed effect replaced in hierarchical order	U.M.	The designed level	The necessary effort (consumption of resources)	U.M	The necessary level of effort	The risk of non- degree of economy of the effort	The estimated strategic impact	The final importance (OCp)
- A -	- B -	- 1 -	- C-	- D -	- 2 -	- pC_{nj} -	- pj -	- $pC_{nj} \times p_j$ -
E_1	Kg.		C_{11}	Kg.		0,08	0,04	0,0032
			C_{12}	Kg.		0,06	0,03	0,0018
			C_{13}	Kg.		0,04	0,02	0,0008
			C_{14}	Kg.		0,02	0,01	0,0002
E_2	%		C_{21}	%		0,10	0,15	0,0150
…	…		…	…		…	…	…
E_n	hours		C_{n1}	Hours		0,01	0,01	0,0001
		Total				$\Sigma\, pC_{nj}= 1,00$	$\Sigma\, p_j= 1,00$	-

The specificity and originality of the training strategy finds its expression in a second matrix or Table 2, which multiplies the estimated occurrence probability of the effect with its impact as such and generates a new hierarchy of the effects according to the explanatory factors. The solution for measuring the degree of economy (competitiveness) resumes the procedure already mentioned and presented, including here a larger spectrum of analysis of the efficaciousness and the degree of economy or competitiveness (than the usual one in the classic training, where the efficiency and effectiveness of the training its management are reference points of the whole in the efficaciousness of sportive organization, Table 3 and 4), inventorying the efforts, in direct dependence on the effects already designed with specific units of measurement, but also potentially detailed or multiplied as compared to the effects placed in hierarchical order as estimated occurrence probability, according to the following matrix.

The matrix instrument identifies in an associated way the main efforts (consumptions of resources, Table 5) in parallel with the effects re-placed in hierarchical order. The value of the aggregate of the risks of all effort (consumption of resouces) components, reunited on the level of distinct category of designed effort, coincides with the estimated occurrence probability of the category of effort:

$pC_{11}+pC_{12}+pC_{13}+pC_{14}=p_a$ for E_1 and pC_{11}

$+pC_{12}+pC_{13}+…+pC_{nj}= \Sigma p_a=1,000$

The managerial strategy in the field of efforts (consumptions of resources) is to be found still in a matrix capitalizing the multiplication of the risk of non-degree of economy with its impact and without generating a new hierarchy of the effects, but only a re-placing in hierarchical order of efforts within the classes of effort afferent to a distinct category of effect, as in the next table 6 and 7.

The presented risks and probabilities can be determined analogously, starting either from the same subjective or objective criteria, recorded in the case of efficaciousness or from a generalized Fishbein-Rosenberg scale of report.

RESULTS

The two results of the products between the occurrence probability of the effects and their impact and between the risk of non-degree of economy of the efforts and their impact defined as informational energy of the designed effect (OEp) and informational energy of the designed effort (OCp), through analogy with the Onicescu informational energy defined as product of probabilities can be considered as essential indicators in the analysis of efficiency and effectiveness in the general plan of the organization and, especially, in the organizational managerial plan.

Table 6: The determination of the efficiency of activity in economy

--------------------------Direct method (Effect / Effort)--------------------				-----------------------Indirect method (Effort/Effect)--------------------			
Effort Effect	E_1	E_2	…	E_n	Effort Effect	C_{1j}	C_{2j}	…	C_{nj}
C_{1j}					E_1				
C_{2j},					E_2,				
…		$e = (E_n / C_{nj}) \times 100$			…		$e = (C_{nj} / E_n) \times 100$		
C_{nj}					E_n				

The conclusion of the degree of economy (competitiveness) brings along a rendering relative of the importance of the effect and an emphasis of the significance of the balance between results and resources or between effects and consumptions $(E > C)$, as well as of the absolute change $(\Delta = E\text{-}C$ or $\Delta = \Sigma E - \Sigma C)$. One can thus appreciate that the degree of economy of an activity, exclusively in the situation in which there appear economies determined as positive difference between effects and efforts $(E - C > 0)$. The analysis of the relationship effect-effort or consumption-result practically defines the essence of the coach of the team in the sportive organization. The coach is bound to analyze which is the minimum combination of efforts (inputs), for a designed level of the effect (the output), or, disposing of some limited efforts or fixed inputs, which is the maximum output, the one that can be obtained through their use:

The training programs that apply this analysis permanently are obviously called expressions of the efficient thinking of a modern coach. A more profound level of thinking thus starts from efficaciousness and degree of economy (competitiveness) and evolves towards a paradigm based on the principles that correctly delimitate their existential environment and the real relational one of the effect-effort or consumption-result effect. This approach based on principles is founded on the new thinking of the sportive organization's efficiency and its management. The efficiency expresses the relationship between efforts and effects, through specific indicators resulted from abstracted and evaluated associations, such as the association of the efforts (consumptions) of the resources as designed and accomplished level, in parallel with the association between the level of the designed and accomplished effects, the temporal (chronological) association or the spatial one of the effort/effect or effect/effort type. In practice two criteria of efficiency are attached: the criterion of saving through the relation to effort and the criterion of intensification, through correlation with the effect.

Approached from an applicable point of view, efficiency is defined through two methods, respectively through the direct one as relationship between any of the values of the effects or of the results $(E_1, E_2,…, E_n)$ and any of the values of the efforts or consumptions $(C_{n1}, C_{n2},…,C_{nj})$, or through the indirect method, respectively described as relationship between efforts or consumptions $(C_{n1}, C_{n2},…, C_{nj})$ and effects or results $(E_1, E_2,…, E_n)$.

The determination of the efficiency of activity in economy: No matter how modelling and methodical, the thinking of efficiency still remains a static and purely observing one. At this stage one can appreciate that the whole defines a new method, simply called the method of the four "E" that will impose the final appreciation of the training for the sportive organization.

By comparing the alternatives of multidisciplinary analysis, considered as possible solutions of the method of the four "E", regarded as a chain of logical approach of the type efficaciousness-degree of economy-efficiency-effectiveness, it is observed that statistical evaluation of indexes achieved better performances in terms of application, interpretation and the placement in hierarchical order and the determination of the informational energy in terms of accuracy, using the probabilities of occurrence of the effects, to the informational energy, complete and generalize the entirety. Some practical results of the method, from the training of the team in the sportive organization of the Faculty of Physical Education and Sports, underline the importance and allow the selection of the modern coach and sportsmen, derived from economic thought and based on the effects achieved or better performances in terms of the estimated occurrence probability of the effect and of the risk of non-degree of economy of the effort. From the five teams involved in the evaluation of efficiency in sport and effectiveness in the phenomenon of sportsmen' training using the method of four "E" one needs a better communication between coach and sportsmen, especially of the designed level of training estimated occurrence correlated with probability of the effect and two need a better estimation of the strategic impact and of the risk of non-degree of economy of the effort.

Table 7: Walsh indices used for effects or efforts on the impact, on the occurrence probability or on the risk of economy's non-degree

Walsh index used for effects with emphasis on the		Walsh index used for efforts with emphasis on the	
$\dfrac{\sum\limits_{i=1}^{n} p_{j1}\sqrt{p_{a1}\times p_{a0}}}{\sum\limits_{i=1}^{n} p_{j0}\sqrt{p_{a1}\times p_{a0}}}$	$\dfrac{\sum\limits_{i=1}^{n} p_{a1}\sqrt{p_{j1}\times p_{j0}}}{\sum\limits_{i=1}^{n} p_{a0}\sqrt{p_{j1}\times p_{j0}}}$	$\dfrac{\sum\limits_{i=1}^{n} p_{j1}\sqrt{(p_{Cn})_{j1}\times(p_{Cn})_{j0}}}{\sum\limits_{i=1}^{n} p_{j0}\sqrt{(p_{Cn})_{j1}\times(p_{Cn})_{j0}}}$	$\dfrac{\sum\limits_{i=1}^{n} (p_{Cn})_{j1}\sqrt{p_{j1}\times p_{j0}}}{\sum\limits_{i=1}^{n} (p_{Cn})_{j0}\sqrt{p_{j1}\times p_{j0}}}$
Impact	occurrence probability	impact	risk of economy's non-degree

DISCUSSION

The thinking of effectiveness detaches from the thinking of efficiency, re-interpreting it in time, in relation to the level of the effect and of the effort, both designed and effective. The effectiveness of communication and of negotiation as bilateral or multilateral type of communication successful and accomplished through common agreement becomes instrument of appreciation of the whole sportive preparation and training of the team in the sportive organization. The statement according to which the decision of a team of coaches is much more effective has more chances of being correct in relation to the idea that the individual coach's decision is the expression of the maximization of the same effectiveness. Communication at the level of the team of coaches does not generate totally new information, although it could be possible to identify in the communicated message a series of knowledge that initially has not been taken into consideration. In the team of coaches through double communication, specific to the negotiation within the variants of design of the effects and efforts, a better selection can be made between the examined alternative projections, but it is also possible to have a loss of information and precision as well (it is true, not as high as the loss in case of a unique point of decision presented and accepted). But according to the observations from the statistics of the teams of coaches there are quite enough cases (approximately a third), in which the team's final decision is weaker than the best variant of the top coach's unique initial decision (thus individual). This takes place only in the hypothesis in which the knowledge is fragile and there are many pieces of erroneous information (the difference between the designed and the effective informational energies being much above the 5%, limit frequently accepted in the economic decision), the decisional communication of the team of coaches having high chances to lead to cognitive performances inferior to the individual ones.

CONCLUSION

Among the five methods of analysis, considered as possible solutions of the method of the four "E," only four are the result of the direct contribution of statistics:

- The statistical evaluation of the procedural transformation indexes through the law of equivalence and the dynamics of the factorial asymmetries, respectively through the method of indexes which has the Walsh index as adequate solution, applied to effects and to efforts both in their temporal evolution and in relation to the initial managerial plan
- The delimitation of the informational transformation thresholds, of maximum and minimum type, with the contribution of the law of the minimum and of the law of the maximum (the method of the smallest squares by using the partial differentials)
- The statistical interpretation of the differences of slope of the effect and effort ramps or of the different angular coefficients of $m = (Y_1-Y_2)/(X_1-X_2)$ type
- The determination of the informational energy, but not in the classical formula ($S = \Sigma p_i^2$), but either as informational energy of the designed effect ($OEp_0 = \Sigma p_{a0}\times p_{j0}$), compared to the informational energy of the achieved effect ($OEp_1 = \Sigma p_{a1}\times p_{j1}$) or as informational energy of the designed effort ($OCp_0 = \Sigma pC_{nj0}\times p_{j0}$) compared to the informational energy of the achieved effort ($OCp_1 = \Sigma pC_{nj1}\times p_{j1}$). The differences higher than 5% become relevant to the analysis of the effectiveness (effective value being below 95% of the projected one)
- The determination of a modern sports efficiency vision with the help the general methodology support from genetic algorithms

In essence an effectiveness measured this way can be detailed on three degrees of importance: 1st degree

effectiveness, which will compare the efficaciousness (the effects), 2nd degree effectiveness, which will compare the degree of economy (effects and efforts, but also the difference between them) and 3rd degree effectiveness which will compare the efficiency.

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