

## The Research of the Factors Influence the Diffusion of Enterprise Innovational Activity Results

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**Summary.** The paper presents the results of the research and evaluation of the factors influence the diffusion of the enterprise innovation activity results. The author singled out: market volume of the diffusion object, market diversity, the level of market competence, the character of the object of diffusion, the quality and price of the object of diffusion, the level of development of market communications, the level of development of the management system of the enterprise-diffuser, the level of information safety development, the level of enterprise-diffuser creativity. The application of expert method (the method of the immediate evaluation and the method of pairwise comparisons) we have evaluated the validity and dimension of these factors influence on the process of diffusion. The results were statistically analysed using the program Statistica 8.0. Taking into account processed data of expert evaluations we have built a classification of the above mentioned factors influence the diffusion of the results of enterprise innovational activity according to the characteristics of the influence power, the environment of appearance, character and the ability to regulate.

**Key words:** diffusions of the enterprise innovational activity results, the factors of influence, expert method, the classification of the factors.

### INTRODUCTION

To solve particular issues, including functional models of innovations spread, we consider at first determine the factors influence the diffusion of the enterprise innovation activity results.

To reveal the possibility to successfully apply and manage the diffusion of the innovations of modern managerial technologies it is necessary to analyze theoretically the factors influence the diffusion of enterprise innovational activity.

Among the researches done by prominent scientists who investigated the entity of innovations diffusion, the

following works are worth attention. These are the works by R. Byers, G. Emrik, G. Pope, E. Rogers [16], V. Ruttan, J.-G. Tarde [20], Y. Shumpeter [19]. The issues of innovations diffusion predictions were investigated by F. Bass [3], N. Chuhray [6], H. Shamota [18]. A sociological aspect of diffusion was investigated by S. Baran and K. Dennis [2], J. Coleman [8], B. Ryan and N. Gross [17], E. Kats, P. Lazerfeld [10], B. Ryann [17]. In their turn, Yu. Anisimov, I. Borisenko [1], Geoffrey A. Moore [13], R. Peres, V. Mahadgan, E. Muller [14], P. Maslyak, Ya. Oliynik [12] considered innovation diffusion from the point of view of communicative and marketing approaches.

The factors influence the diffusion of innovation are not fully studied, and some recent results in this area can be found in studies [4, 5, 7, 11, 21, 22, 23]. E. Kats, P. Lazerfeld the main factor determined so called opinion leaders and their relationship with change agents [10]. T. Hägerstrand considers diffusion of innovation as a spatial process and diffusion rate of innovation puts not dependent on geographic distance, but on the possibility of transmitting cities, and on how are strong and effective relationships between people there [9]. By Y. Shumpeter time is a major factor in the diffusion of innovation, defined as a process of transferring technology by companies in different countries [19]. Geoffrey A. Moore to the factors influence the diffusion of innovation considers the market volume of the diffusion object and the level of development of market communications [13]. E. Rogers argues that the social system has yet another important kind of influence on the diffusion of new ideas. Innovations can be adopted or rejected by individual members of a system, or by the entire social system, which can decide to adopt an innovation by a collective or an authority decision [15]. In the drug diffusion study by Coleman identified: similarity in age, religion, hometown, and the medical school attended were important factors of diffusion of innovations. But the most important variables determining who-to-whom links in the medical community were such professional affiliations as

practicing in the same clinic, hospital, or office partnership. Doctors were more likely to talk about the new drug if they worked together social-prestige factors, convenience, and satisfactions are also often important components [8]. But implementations of evaluation methods of factors influence the diffusion of the enterprise innovation activity results still remain uninvestigated and classification of the factors was not built.

The aim of the paper is to offer the classification of the factors influencing the innovation diffusion, the methodology of evaluation of the factors under investigation for the analysts-diffusers with the aim of managerial decisions proof which are directed into the receiving of the desired effects of the diffusion of enterprise innovation activity results.

## MATERIAL AND METHODS

To reveal the significance of the influence of the facts underlined above on the phenomenon of diffusion of the enterprise innovational activity results throughout 2016 we had been conducting the research applying the method of survey, which had lasted during the period of 2012-2016 ys. The application of an expert method was caused by the investigation of non-standard objects of innovations diffusion management, which depend on the peculiarities of an enterprise-diffuser, the conditions of its functioning and the subject of innovations.

The process of picking over the samples of the experts under survey had two stages: the determination of the general totality of probable candidates and the formation of the meaning of assumed limit fault of the results of the survey. A limit fault is accepted to have at the level of 0,15. At the stage of the formation of the general totality of probable candidates of the experts we have determined the quantity of respondents with the necessary level of competence (the experience of the realization of the programs of innovations diffusion, being at a managerial post during the program of innovations diffusion, the wish to participate in the survey). Out of this totality, we have chosen the experts who turned out to be the best professionals. Out of 300 probable experts, we have chosen the group of professionals of 18 who are the most competent in the issue under consideration. Then, under the level of significance of 0,05, the number of experts who are supposed to participate in the survey is to be the following:

$$k = \frac{18}{300} \left( 1 - \frac{18}{300} \right) 2^2 \approx 10 \quad (1)$$

Thereby, to achieve the results the fault of which will not exceed the defined limits we need to survey not less than 10 experts.

While determining the validity of the factor we suggest applying one of two methods: the method of immediate evaluation and the method of pair equations. According to the given method, the expert is offered to determine the importance and significance of each factor in a certain scale of the point which is the same for all the experts. The average evaluation of i-factor is determined according to the formulae (3). The coefficient of the validity of i-factor can be calculated according to the following correlation (2):

$$W_i = \frac{\sum_{j=1}^N z_{ij}}{\sum_{i=1}^S \sum_{j=1}^N z_{ij}}, \quad (2)$$

where:  $W_i$  - coefficient of validity of i-factor,  $z_{ij}$  - i-factor, evaluated by j-expert,  $N$  - the quantity of experts.

The method of pair comparison has traditionally two ways of calculation: 1) on the basis of particular pair comparison; 2) on the basis of a full pair comparison.

## RESULTS AND DISCUSSION

The conducted research revealed that the following factors influence the enterprise innovational activity diffusion:

A) the market volume of the object of diffusion (market volume may be determined by the quantity of potential consumers(users) of a specific result of enterprise innovational activity. For instance, if diffuser offers innovational technology of catching the wastes at metallurgy plants, then the market volume of this technology in Ukraine is limited by the number of metallurgy enterprises;

B) the diversity of the market of diffusion object(in this case we mean the structuring, segmentation of consumers (users) of a specific object of diffusion. The more are the market segments, the more peculiarities should be taken into account by enterprise-diffuser being on the market);

C) the market competitiveness concerning the object of diffusion (market competitiveness takes place when the object of diffusion has the analogues or the goods to replace. As a rule, innovation market is a monopoly market since the goods that first appear on the market

have no analogues that is why enterprise-diffuser is a monopolist. If to speak about pseudo-innovations (improved goods and technologies), the competitiveness is present here, which strongly changes the circumstances of these innovations spread on the market);

D) the quality of the object of diffusion (the totality of features which characterize the specificities of the object of diffusion(functionality, durability, eco- friendliness, easy to use, safety, etc.) complete the basis of its competitiveness);

E) the price of the object of diffusion(one of the factors of competitiveness of the object of diffusion. Its significance depends on the character of the object of diffusion. If innovation is the object of diffusion, which turns enterprise-diffusion into a monopolist, then the significance of this factor lowers dramatically.);

F) the level of development of market communication (the phenomenon of diffusion means the establishment of communication with potential consumers (user) of the object of diffusion. The more developed market communications are, the easier it is for diffuser to enter the market, advertise, inform the subjects of the market about the advantages of the object of diffusion offered);

G) the character of the object of diffusion (positively influences the diffusion of enterprise innovational activity results diffusion; negative impact on the diffusion of enterprise innovational activity results);

H) the level of development of the management system of enterprise-diffuser (the level of development of the management system of enterprise-diffuser may be determined with the help of organizational structure of enterprise management, informational and communication system f management, the system of rules and procedures, corporal etiquette, experience and traditions of in the sphere of managerial and technological problems solutions. The

conducted research allows us to claim that the symbiosis of these components fully informs us about the development of the system of management of an enterprise. The higher is the level of this system development, the bigger are the chances for diffuser to achieve desirable effects out of the spread of the results of innovational activity on the market);

J) the level of the development of information safety in the system of information supply of the enterprise-diffuser (conducting the diffusion of a specific result of innovational activity an enterprise suggests its potential consumers (users) an innovation itself, brand or the right to use them, which have a specific exclusiveness, a competitive advantage. If at the early stages of diffusion opponents are able to offer the analogues at the market, then the process of commercialization, which accompanies the phenomenon of diffusion, will be economically effective. Judging by this, the precondition of the results expected from the diffusion of innovational activity of enterprise are the achievement of a decent level of informational safety at an enterprise. Informational safety, on the one hand, is a component of any system of informational supply, but on the other hand, it is its parameter, which characterizes the quality of this system);

K) the level of creativity of an enterprise - diffuser (the level of creativity of enterprise-diffuser makes up the possibilities of an enterprise to accumulate creative ideas to realize managerial initiatives and the solutions to managerial and technological problems. The higher is the level of creativity, the bigger is the probability of timely and fullness of the achievement of strategic and tactic goals of the diffusion of enterprise innovational activity results).

Table 1 depicts the evaluation of the underlined factors (A, B, C, D, E, F, G, H, J, K) by ten experts (I, II, III, IV, V, VI, VII, VIII, IX, X).

**Table 1.** The points offered by the experts to each of the factors

Factors Experts	A	B	C	D	E	F	G	H	J	K
I	60	20	70	80	60	20	70	40	50	30
II	50	80	40	80	70	30	20	30	70	60
III	60	20	30	70	90	40	80	50	40	60
IV	30	30	70	20	30	20	40	20	70	20
V	100	30	60	30	50	20	10	50	60	10
VI	60	40	20	40	40	30	40	10	30	50
VII	100	70	40	30	20	60	70	80	60	50
VIII	20	80	60	30	80	70	40	20	20	50
IX	100	50	20	30	50	60	40	80	20	20
X	60	20	10	80	80	40	50	20	40	70

Notes: it was made by the author of the paper according to the results of conducted expert research. Each expert was to evaluate the factors according to 100 point scheme. Minimal point was 10, maximum – 100.

On condition of quantity approach application, it is important to establish the validity of experts. It is caused by the fact that the experts may vary at the level of competence, experience and some other subjective factors connected to the views, cognitive and other peculiarities. If the validity of experts is similar, then to evaluate the significance of the factors we can apply the following formulae:

$$z_i = \frac{1}{N} \sum_{j=1}^N z_{ij} \tag{3}$$

If the validity of experts is different, it is necessary to apply the coefficient of validity. Then the formulae of validity of a separate factor will be the following:

$$z_i = \sum_{j=1}^N \omega_j z_{ij} \tag{4}$$

where:  $\omega_j$  – coefficient of validity of j- expert.

Sometimes the evaluation of a certain amount of factors needs a multilevel analysis and considering different factors. For instance, experts face the problem to evaluate three alternative projects to promote the goods and service based on Internet commercials. These projects differ from the point of view of their price and the results of realization. They also mean the application of different methods of goods promotion. Then, it is possible to form two tables of evaluation in the dependence on advertising: to evaluate the level of efficiency on the basis of the correlation of expenditures and the amount of realization, popularize the brand of enterprise - producer, widen a target public of consumers, etc.

Table 2 illustrates the meaning of factors significance while accepting the experts' opinions equally valid.

**Table 2.** The evaluation of factors and their validity in points

Factors Experts	A	B	C	D	E	F	G	H	J	K
I	60	20	70	80	60	20	70	40	50	30
II	50	80	40	80	70	30	20	30	70	60
III	60	20	30	70	90	40	80	50	40	60
IV	30	30	70	20	30	20	40	20	70	20
V	100	30	60	30	50	20	10	50	60	10
VI	60	40	20	40	40	30	40	10	30	50
VII	100	70	40	30	20	60	70	80	60	50
VIII	20	80	60	30	80	70	40	20	20	50
IX	100	50	20	30	50	60	40	80	20	20
X	60	20	10	80	80	40	50	20	40	70
Total	640	440	420	490	570	390	460	400	460	420
Validity	64	44	42	49	57	39	46	40	46	42

Notes: it was made by the author of the paper according to the results of conducted expert research.

As it is clear from the tab.2, the validity of factor A is the highest, as an average point is the highest for it. The factors D and A are the following(s) in terms of validity.

While analyzing evaluations in point, ranging is often applied. The aim of ranking is to determine a monotonous

sequence of factors validity arrangement. Ranks may be given by experts or be calculated on the basis point evaluation analysis. All identified rankings for data from Tabl. 1 are presented in Tabl. 3.

**Table 3.** Ranges of factors (the highest range corresponds to the highest point evaluation, the lowest corresponds to the lowest)

Factors Experts	A	B	C	D	E	F	G	H	J	K
I	4	1	9	8	6	1	8	6	6	4
II	3	9	5	9	7	3	2	5	9	8
III	3	1	4	8	9	5	9	6	4	8
IV	2	2	8	1	2	1	2	2	8	2

V	5	2	6	1	3	1	1	5	6	1
VI	2	2	2	4	2	1	1	1	3	3
VII	4	4	3	1	1	3	5	4	5	3
VIII	1	4	4	1	3	4	1	1	1	3
IX	4	4	3	2	2	4	2	4	2	2
X	3	3	3	4	4	4	4	3	3	4
Average range	3,1	3,2	4,7	3,9	3,9	2,7	3,5	3,7	4,7	3,8

Notes: it was made by the author of the paper according to the results of conducted expert research.

An average range is calculated based on arithmetic mean according to the formulae:

$$r_s = \frac{1}{N} \sum_{j=1}^N r_{ij}, \tag{5}$$

where:  $r_s$  – average rank;  $r_{ij}$  – rank of  $i$ -factor, evaluated by  $j$ -expert.

Under the condition when more than one factor is given the same rank, standardization is necessary which is determined on the basis of the arithmetic mean of cardinal numbers determined on the ground of factors arrangement according to the level of their importance. Table 4 illustrates the arranged sequences of the validity of the factors under research according to the level of significance.

**Table 4.** Range evaluations of the factors under research arranged according to decrease

I	II	III	IV	V	VI	VII	VIII	IX	X										
C	9	B	9	E	9	C	8	C	6	D	4	G	5	B	4	A	4	D	4
D	8	D	9	G	9	J	8	J	6	J	3	J	5	C	4	B	4	E	4
G	8	J	9	D	8	A	2	A	5	K	3	A	4	F	4	F	4	F	4
E	6	K	8	K	8	B	2	H	5	A	2	B	4	E	3	H	4	G	4
H	6	E	7	H	6	E	2	E	3	B	2	H	4	K	3	C	3	K	4
J	6	C	5	F	5	G	2	B	2	C	2	C	3	A	1	D	2	A	3
A	4	H	5	C	4	H	2	D	1	E	2	F	3	D	1	E	2	B	3
K	4	A	3	J	4	K	2	F	1	F	1	K	3	G	1	G	2	C	3
B	1	F	3	A	3	D	1	G	1	G	1	D	1	H	1	J	2	H	3
F	1	G	2	B	1	F	1	K	1	H	1	E	1	J	1	K	2	J	3

Notes: it was made by the author of the paper according to the results of conducted expert research.

As it is clear from the table 4, after the arrangement of range evaluations the sequence of factors changes. It makes it impossible to keep them in one table. That is why standardized ranges can be calculated only for one vector of ranges meaning. It is caused by the previous

ranges summing under the conditions when the quantity of the experts is larger than one.

We shall calculate standardized ranges of the factors (see Tabl. 5).

**Table 5.** Ranges standardization for the factors under research

I	II	III	IV	V	VI	VII	VIII	IX	X										
C	9	B	8	E	9,5	C	9,5	C	9,5	D	4	G	9,5	B	8	A	8,5	D	9
D	7,5	D	8	G	9,5	J	9,5	J	9,5	J	7,5	J	9,5	C	8	B	8,5	E	9
G	7,5	J	8	D	7,5	A	6	A	7,5	K	7,5	A	7	F	8	F	8,5	F	9
E	6	K	8	K	7,5	B	6	H	7,5	A	5,5	B	7	E	5,5	H	8,5	G	9
H	6	E	7	H	6	E	6	E	3	B	5,5	H	7	K	5,5	C	3	K	9
J	6	C	4,5	F	5	G	6	B	2	C	5,5	C	4	A	3	D	3	A	3

<b>A</b>	3,5	<b>H</b>	4,5	<b>C</b>	3,5	<b>H</b>	6	<b>D</b>	2,5	<b>E</b>	5,5	<b>F</b>	4	<b>D</b>	3	<b>E</b>	3	<b>B</b>	3
<b>K</b>	3,5	<b>A</b>	2,5	<b>J</b>	3,5	<b>K</b>	6	<b>F</b>	2,5	<b>F</b>	1	<b>K</b>	4	<b>G</b>	3	<b>G</b>	3	<b>C</b>	3
<b>B</b>	1,5	<b>F</b>	2,5	<b>A</b>	3	<b>D</b>	1	<b>G</b>	2,5	<b>G</b>	1	<b>D</b>	1	<b>H</b>	3	<b>J</b>	3	<b>H</b>	3
<b>F</b>	1,5	<b>G</b>	2	<b>B</b>	1	<b>F</b>	1	<b>K</b>	2,5	<b>H</b>	1	<b>E</b>	1	<b>J</b>	3	<b>K</b>	3	<b>J</b>	3
<b>Total</b>	<b>52</b>	<b>Total</b>	<b>55</b>	<b>Total</b>	<b>56</b>	<b>Total</b>	<b>57</b>	<b>Total</b>	<b>49</b>	<b>Total</b>	<b>44</b>	<b>Total</b>	<b>54</b>	<b>Total</b>	<b>50</b>	<b>Total</b>	<b>52</b>	<b>Total</b>	<b>60</b>

Notes: it was made by the author of the paper according to the results of conducted expert research.

Expert V needs to arrange the factors validity in a new way after the ranges standardization. It testifies to the fact that the expert under consideration doubts the importance of certain factors. As it is obvious from the table 5, factor «X» possesses the largest meaning of standardized ranges sum. It testifies to the fact that it has the largest validity. Factor «VI» is the less valid.

Having calculated the sums of frequencies vertically and horizontally, the matrix of pair equations of the researched factors it is necessary to calculate the coefficient of the significance of the factors. It may be done according to the formulas:

$$W_i = \frac{\frac{1}{S} \sum_{i=1}^N (R_{ij} + B_{ij})}{K}, K = \frac{1}{2} N(N-1), \quad (6)$$

where:  $K$  – general quantity of pair equations made by all the experts;  $R_{ij}$  – the sum of frequencies for  $j$ -expert from the right column of comparison matrix;  $B_{ij}$  – the sum of frequencies from the lower column of the comparison matrix for  $j$ -expert.

To calculate the coefficients of the significance of the researched factors it is necessary to calculate the average meaning of the frequencies sums vertically and horizontally of the comparison matrix. The results of calculations are illustrated in table 6.

**Table 6.** The results of calculations of average meanings of frequencies for the analyzed factors according to each expert

	I	II	III	IV	V	VI	VII	VIII	IX	X
Average frequency	2,5	2,7	2	2,5	1,8	2,1	2,5	2,2	2,7	2,5
$\frac{1}{S} \sum_{i=1}^N (R_{ij} + B_{ij})$	2,5	2,7	2	2,5	1,8	2,1	2,5	2,2	2,7	2,5

Notes: it was made by the author of the paper according to the results of conducted expert research.

Coefficients of significance for the analyzed factors ( $W_1, \dots, W_{10}$ ) were counted and the resulting the following values:

$$K = \frac{1}{2} N(N-1) = \frac{1}{2} 10(10-1) = 45;$$

$$W_1 = \frac{2,5}{45} = 0,0556; \quad W_4 = \frac{2,5}{45} = 0,0556; \quad W_3 = \frac{2}{45} = 0,0444;$$

$$W_2 = \frac{2,7}{45} = 0,06; \quad W_5 = \frac{1,8}{45} = 0,04; \quad W_6 = \frac{2,1}{45} = 0,0467;$$

$$W_7 = \frac{2,5}{45} = 0,0556; \quad W_9 = \frac{2,7}{45} = 0,06;$$

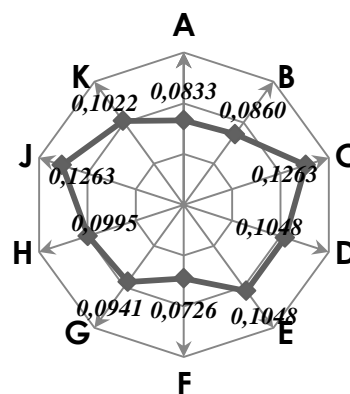
$$W_8 = \frac{2,2}{45} = 0,0489; \quad W_{10} = \frac{2,5}{45} = 0,0556.$$

As we see, we may conclude that the factors «B» and «J» are the most significant.

Thereby, on the basis of experts' views analysis we shall determine the validity of the researched factors. With the aim of this, we can consider all average factors significance evaluations in the scale from 0 to 1 (see Fig. 1). Factors amount may be calculated according to the formulae:

$$w_j = \frac{\frac{1}{N} \sum_{i=1}^N r_{ij}}{\sum_{j=1}^S \left( \frac{1}{N} \sum_{i=1}^N r_{ij} \right)}, \quad (7)$$

where:  $W_j$  – amount coefficient of  $j$ -factor;  $r_i$  – evaluation of  $i$ -factor by  $j$ -expert;  $N$  – the quantity of experts;  $S$  – the quantity of experts.



**Fig. 1.** Validity of factors calculated based on their range evaluations

As we see from the picture 1, factors «J» and «C» are the most valid, «F» i «A» ones are the less valid. Received amount coefficients may be applied to further analysis of the influence of the given factors on an enterprise. It may also be used for the solution to different problems of optimization and prediction.

Taking into account the processed data of expert evaluations, we build the classification of the above mentioned factors influence the diffusion of the enterprise innovational activity results (Tabl. 7).

**Table 7.** The classification of the factors influencing the diffusion of enterprise innovational activity results

Classification features	Factor Types
According to the Influence Power	The factors influence immensely the diffusion of enterprise innovational activity results; The factors slightly influence the diffusion of enterprise innovational activity results.
According to the Environment Source	The factors of the inner environment which influence the diffusion of enterprise innovational activity results (the quality of the object of diffusion; the price of the object of diffusion; the character of the object of diffusion; the level of development of the management system of enterprise – diffuser; the level of development of informational safety in the system of informational supply of enterprise-diffuser; the level of creativity of enterprise-diffuser); The factors of outer environment, which influence the diffusion of enterprise innovational activity results (the market volume of the object of diffusion; the diversity market of the object of diffusion; the level of market competitiveness concerning the object of diffusion; the level of development of market communications).
According to the Influence Character	The factors positively influence the diffusion of enterprise innovational activity results; The factors negatively influence the diffusion of enterprise innovational activity results.
According to the Ability to Regulate	The factors which are liable to regulation (the market volume of the object of diffusion; the market diversity of the object of diffusion; the quality of the object of diffusion; the price of the object of diffusion; the character of the object of diffusion; the level of development of the system of management of enterprise-diffuser; the level of development of informational safety supply of enterprise-diffuser; the level of creativity of enterprise-diffuser); The factors which demand adaptation to them (the level of market competitiveness concerning the object of diffusion; the level of development of market communication).

Note: built by the author

The classification offered is necessary for the analysts of the enterprise-diffusers during the process of managerial decisions grounding which are directed towards the achievement of the desired effects from the diffusion of enterprise innovational activity results.

## CONCLUSIONS

1. The conducted research demonstrated that such factors as market volume of the diffusion object, the level of market competitiveness, market diversity, the level of market competitiveness, the character, the quality and price of the object of diffusion, the level of development of market communications, the level of

development of the system of management of enterprise-diffuser, the level of development of information safety, the level enterprise-diffuser creativity influence the diffusion of enterprise innovational activity results.

2. In contrast to the other works studied the application of evaluation influence the diffusion of the enterprise innovation activity results.
3. With the assistance of expert method, (the method of research caused by the character of the object of diffusion innovations) we have evaluated the dimension of the factors influence on the diffusion of enterprise innovational activity results.
4. The distribution of the factors according to the character feature of influence can not be generalized for all enterprises-diffusers, as it depends on the range

of circumstances which are specific for each case of diffusion.

5. To distribute the underlined factors according to the influence character we have conducted an expert study in the environment of enterprises-diffusers.
6. Taking into consideration, the processed results of expert evaluations we have built the classification of factors influence the diffusion of the results of enterprise innovational activity results. That enables us to reason managerial decisions directed towards the obtaining of the desired effects of diffusion of enterprise innovational activity results.

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