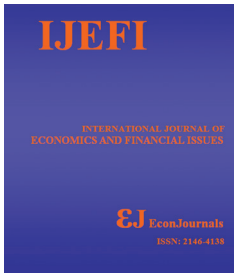

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Assessment of the Company's Performance in Light of Delay in Managerial Information

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ABSTRACT

The goal of the study is to develop a theoretical framework for assessment of the speed of the company's management system performance in light of its informational nature. The article uncovers a law of delay in managerial information and develops a theory of assessment of the speed of the company's performance on the basis of experimental and theoretical study. It introduces new options of building the control systems "system pace" and other indicators arising out of the "system pace:" Time of the management cycle, stages and levels of management. The parameters of managerial information – the pace of reception, processing, reflection, decision-making and execution of the decision – were obtained theoretically and experimentally, using a well-known normal distribution law. The experiments that confirm the theory were taken.

Keywords: Company, Management, Information, Delay, System
JEL Classifications: D23, D83, D85

1. INTRODUCTION

New challenges and threats to the world community require faster response from the management systems. Time becomes the determinant in the management system in order to meet the economic interests of the state and institutions. The companies operate in a highly competitive environment, and only those with the strongest management, responsive to the challenges of the management system, will succeed on the market. To achieve this, it is necessary to take into account not only the economic, but also informational essence of management. Only in this case the management system can cope with the problems of: (a) strategic management (ensuring a competitive advantage of the state and company); (b) current management (efficiency and art of the management that determine its success).

In this regard, the following goal was set in this study: To develop a theoretical framework for assessment of the speed of the company's management system performance in light of its informational nature. The following tasks were set to meet this goal:

- Justification and formulation of the law of delay in managerial information;
- Shaping of the parameters of management systems in stages that determine this delay;
- Shaping of the parameters of building management systems in stages and levels of management (formalized description of the delay law);
- Analysis and report on the results of the study.

2. COVERAGE AND METHODOLOGY OF THE STUDY

One should not reduce the problem to finding some sort of static, "frozen" balance of the economic system. The difficulty lies in the constant motion of financial, material and information flows in time and space. In order to achieve the best proportionality of the complex dynamic economic system, it is necessary to assume such parameters of its development which would provide the greatest efficiency. The link, the "general background" of the material, financial and information flows of economic systems is time. Both material and information flows move and transform in time.

Based on the provisions of the systems theory laid down by Bertalanffy (1950), (1968), Rapoport (1986), subsequent studies

(Blauberg and Yudin, 1973), (Mesarovich and Takakhara, 1978), (Hull, 1970), (Yudin, 1978), (Shein, 2002) and the organization and management theory of Taylor (1911), Lewin (1943) and other authors, we have developed a theory of delay in managerial decisions in companies. Furthermore, a systematic approach is widely used in the management theory of Senge (1990) and others. Based on the principles of the system approach, the principles of cybernetics and computer science were applied in the study, laid in the works of Forrester (1961), Shannon (1948), Bir (1959) and other works. The law of economy of time is implemented at the enterprise level. Not only a further study of the law is urgent today, but also so does its realization in the establishment and operation of management systems.

The calculation and constructive, abstract and logical, economic and mathematical methods of study were used. The functioning of the economic system was considered as a constant and continuous movement and transformation of the material, financial and information flows. Their slowing means a stop of the company's performance. Since the transformation of flows in time occur at a certain speed, consequently, the production, sales and financial processes have a certain pace. It is proved that the information processes reflect the material flows and are characterized by similar timing parameters. The study considered that most of the economic processes in economic management, such as planning, financing, lending, etc., also have informational nature and occur over time.

3. RESULTS OF THE STUDY

3.1. Theoretical Formulation of the Law of Delay in Managerial Information

The analysis confirms that the factor that unites the object and the subject of management is time. At the same time, the order (entropy) that occurs in the material field "brings to life" the information that is already in a modified and updated form returned to the production of goods to combat and eliminate the disorder. The time between the occurrence of the disequilibrium and its elimination depends on the perfection of the management system.

Since the information is generated by material processes being transformed through the subject, it regulates the production, whereas any economic system has the following effect: Certain time always passes between the time of appearance of the managerial information on the status of the material process and the execution of the decision taken on its regulation, there is always the fact of delay in managerial information. The magnitude of the delay is determined by many factors, but it largely depends on the perfection of the management system. Based on the understanding of the conclusions obtained above, it seems possible to formulate a law of the delay in managerial information in economic systems.

Managerial information that is "brought to life" by disorder (entropy) of the material processes "returns" after being transformed and supplemented by the function – management – to the material field to "combat" this disorder over time, as if with a certain delay. The extent of the information delay depends on many factors, but the very fact of the delay in information from the subject to the object in economic systems is an objective phenomenon in communication.

The law of the delay in managerial information in communication systems determines the law of the pace and transformation of information and material flows in time and space. Information, time and space objectively bind here. Information and material flows move through the levels of hierarchy in time. The time factor is objective and unambiguous, it can be neither "held" nor accelerated. The "time grid" is superimposed on the material, financial and information flows. All this shows that it can be the "basis" for measuring the pace and transformation of information in communication systems in the company management. Besides, managerial information also moves through the levels of the hierarchy, which gives grounds to speak about the space-time nature of the parameters of the information flows of the management system.

The importance of the law uncovered here for managerial practices is that a careful study of the delay in stages and levels of management makes it an objective basis for the development of methodological principles of organization and functioning of the mechanism of company management, because this law reveals the informational essence of the management of production of goods and a space-time aspect of the movement and transformation of managerial information.

3.2. Shaping of the Parameters of Management Systems in Stages and Levels

Academician Trapeznikov (1972) believes that not only management, but also the physical work has the informational nature: "There are only three types of "products" in the real world: matter, energy and information." The idea of the "effect" of delay in information is referred to in economic cybernetics (Wiener, 1948), (Ashby, 2005), (Ponomarenko et al., 2012), (Korbovsky, 1982) and in other special studies (Akchurin, 1979) (Makarsky, 1977). The link between material and information processes should be regarded as proven on the basis of the studies of the above authors and our own studies. Information flows "lead" the material ones, and time is an indicator of their relationships. Therefore, in the development of the theory of building the management systems in light of its informational nature, we further fulfill the task of finding the law of relationships between information, production and the time factor.

Just as in the field of production of goods, the organization of labor processes in management requires efficient coordination of all of its stages and links. The level of organization of managerial labor, efficiency and appropriateness of specific labor determine the effectiveness of the management system, and hence the level of organization of the entire production process of the economic system.

Labor processes in the management of production and sales occur in a certain sequence, require an optimal composition of the suitably qualified specialists with a specific work regime. Like any dynamic process, it occurs in time, just as a function of the economic system occurs in space (in the levels of the hierarchy).

In building the production management system, one should take into account the general principles of the organization of labor processes: Coordination, regularity of pace, uniformity, continuity and route, concurrency, urgency and material interest. In addition, the principles of document flow in management systems are known: Appropriateness, reliability, completeness of information, competence, consistency, adaptability and efficiency.

The peculiarity of the organizational principles in the labor processes in management is also determined by the specificity of the subject of labor – an information essence. In this regard, the conducted studies of information flows in management systems do not exhaust the tasks set. On the contrary, their receipt calls for the next stage of the study – the study of the transformation in the management information process into functions of time and formulation of the criterion and principles of efficiency assessment in terms of shaping the parameters of building the management system with extensive use of economic and mathematical methods. The laws of the information essence of management can only be identified by applying numerical material and quantitative parameters. Analysis and monitoring of the information process of the economic system in the conditions of rational managerial labor and the data of the studies of other authors allowed us to finally identify the main stages:

a. Receipt of the primary information into management system (accepting applications);
b. Processing information;
c. Display of resulting information;
d. Making decision;
e. Execution of the decision.

Information from the work sites is received by the management subsystem using a communication linkage, then it is processed, aggregated, systemized and displayed in an electronic environment (on network media of the economic information display) – on the computer screen and submitted to the top manager for decision-making.

The adopted decision is passed for execution.

Each of the selected management stages occurs in time and has certain duration. The sum of these periods gives us the "time of the management cycle:"

$$T_c = \sum_{i=1}^{n} t_i \qquad (1)$$

Where, T_c is time of the management cycle;

t_i is duration of the i^{th} stage of management;

n is number of stages of management.

The duration of the cycle and individual stages is determined by many factors: Organizational and technical equipment of the managerial labor, the level of development of feedback of the communication system, the form of management organization, the area of activity, the company's economic size, the specificity of the economy sector.

3.3. Mathematical Description of the Parameters of Management Systems in Stages and Levels

Let's introduce a new parameter of the information flow of the management system – [*taui*] – the pace of the information movement in stages of management. Due to the stochastic nature of information processes, the variable [*tau*] is random. In this regard, we have established the laws of random variable distributions for the conditions of the agricultural enterprises of Zhambyl region of Kazakhstan on the basis of studies. The information distribution law – [tau_i] – was obtained experimentally, where the mathematical description is given in Table 1.

Figure 1 shows the example of information receipt and its expectation and variance [sigma] = 43.4.

Thus, experimental (1, 4, 7, 10, 13), theoretically functional (2, 5, 8, 11, 14) and theoretically integral (3, 6, 9, 12, 15) distribution forms were obtained in the above mathematical expressions. The value of the expectation and variance of the remaining stages – processing, display, decision and execution – were obtained through the same procedure. Their values are the following:

- Information processing – 160.2 and variance – 60.06;
- Display of the information – 348 and variance – 116.2;
- Making decision – 582 and variance – 194.0;
- Execution – 1,638 and variance – 546.

Now new obtained data – expectations of the pace of information in stages – made it possible to establish the proportions of durations of the stages of management in the overall "management cycle time," which is reflected in Table 2.

We have considered the laws of distribution of information pace [*tau*] in certain stages as a research method, a method to establish the laws of the information flow transformation.

Based on the data obtained, the basic parameters of information flows necessary to build management systems were elaborated and justified: The average time of occurrence, the time of completion of management stages, the rate of efficiency and time of delay in management stages.

Average time of occurrence (Figure 1) of the management stages for the considered array of information can be determined:

- Receipt of primary information (applications) $t_{REC} = M[\tau_{REC}]$;
- Information processing $t_{pr} = M[\tau_{pr}]$;
- Display of resulting information $t_{DI} = M[\tau_{DI}]$; (2)
- Making decision $t_d = M[\tau_d]$;
- Execution of the decision $t_E = M[\tau_e]$,

Where, $\tau_{REC}, \tau_{pr}, \tau_{DI}, \tau_D, \tau_E$ are paces of receipt, processing, display, decision and execution respectively.

The time of the completion of the stages of management for the considered array of information was determined by formulas (3)-(7):

$$t_{REC} = \sum_{i=1}^{f} \tau_{RECi}; \qquad (3)$$

$$t_{PR} = \sum_{i=1}^{f} \tau_{pri}\ ; \quad (4)$$

$$t_{DI} = \sum_{i=1}^{f} \tau_{OTi}\ ; \quad (5)$$

$$t_{D} = \sum_{i=1}^{f} \tau_{pi}\ ; \quad (6)$$

$$t_{E} = \sum_{i=1}^{f} \tau_{ui}\ ; \quad (7)$$

Where $\tau_{RECi}, \tau_{pri}, \tau_{DIi}, \tau_{Di}, \tau_{Ei}$ are paces of the movement of the i^{th} volume of information on the stage of receipt, processing, display of the information, decision and execution of the decision, respectively.

The efficiency of the management system was established by the time delay in execution of the decision:

$$t_d^c = M[\tau_E] - M[\tau_{REC}], \quad (8)$$

Where t_d^c is the indicator of the efficiency of the system functioning;

$M[\tau_E], M[\tau_{REC}]$ are expectation of variables of the pace of execution of the decision and the pace of information receipt.

This principle was used to establish the time of delay in the certain stages of management; let's call them special indicators of management efficiency:

- Time of delay in information processing:

$$t_d^{PR} = M[\tau_{pr}] - M[\tau_{REC}]; \quad (9)$$

- Time of delay in display of the information:

$$t_d^{DI} = M[\tau_E] - M[\tau_{REC}]; \quad (10)$$

- Time of delay in making decision:

$$t_d^{D} = M[\tau_D] - M[\tau_{REC}]. \quad (11)$$

Ideally, $t_d^c = 0$. In real systems, $t_d^c \neq 0$ and has a positive value. The condition

$$t_d^c \to \min \quad (12)$$

Should be taken as a criterion for optimization of management systems.

Due to the peculiarities of each type of the process, the level of production management and diversity (entropy) of the managed object, the system receives requests with a certain pace. The variable t_{REC} is a determinant for the value of the average time of occurrence of other stages of management $(t_{REC}, t_{pr}, t_{DI}, t_D, t_E)$.

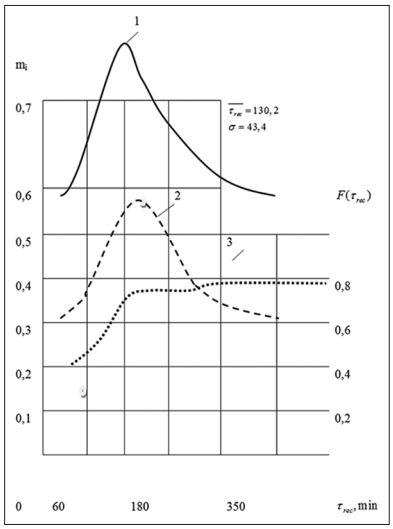
Table 1: Law of distribution of[tau$_i$]–the pace of the information movement in stages of management

Received experimentally	Received theoretically	
	Through a density function	Through a distribution function
a) Information receipt		
$1 - f(\tau_{rec})$	$2 - f(\tau_{rec}) = \frac{1}{43,4\sqrt{2\pi}} \cdot \left[-\frac{(\tau - 130,2)}{2 \cdot 43,4^2} \right]$	$3 - F(\tau_{rec})$
b) Information processing		
$4 - f(\tau_{pr})$	$5 - f(\tau_{pr}) = \frac{1}{80,06\sqrt{2\pi}} \cdot \left[-\frac{(\tau - 280,06)^2}{2 \cdot 80,06^2} \right]$	$6 - F(\tau_{pr})$
c) Display of information		
$7 - f(\tau_{DI})$	$8 - f(\tau_{DI}) = \frac{1}{116,2\sqrt{2\pi}} \cdot \left[-\frac{(\tau - 348,6)^2}{2 \cdot 116,2^2} \right]$	$9 - F(\tau_{DI})$
d) Making decision		
$10 - f(\tau_D)$	$11 - f(\tau_D) = \frac{1}{194\sqrt{2\pi}} \cdot \left[-\frac{(\tau - 582)^2}{2 \cdot 194^2} \right]$	$12 - F(\tau_D)$
e) Execution of the decision		
$13 - f(\tau_E)$	$14 - f(\tau_E) = \frac{1}{546\sqrt{2\pi}} \cdot \left[-\frac{(\tau - 1638)^2}{2 \cdot 546^2} \right]$	$15 - F(\tau_E)$

Table 2: Structure of time of the management cycle (T_c) in stages of the expectations in minutes

Company type management level	Stages of management					
	Receipt	Processing	Display	Decision	Execution	T_c
Agricultural						
Developed	48	56	26.5	86.5	392	678
Weak	469	592	-	943	943	6040
Water management						
Developed	130.2	150	68.4	68.4	233.4	1638
Weak	744	854	-	-	1280	8588
Proportions of durations of the stages of management	0.079	0.092	0.042	0.042	0.142	1.0

Figure 1: Variation of time for the execution of management stages: (1) Experimental (——); (2) Theoretically functional (-----); (3) Theoretically integral (·····)



In this case, the condition of consistency of the stages of management must be met for the effective functioning of the system:

$$M[\tau_{REC}] \geq t_{PR} \geq t_{DI} \geq t_D \geq t_E \quad (13)$$

Next let's introduce the concept of the system pace – $[tau_c]$. In general, it should be justified based on the maximum value of the time of occurrence of the stages of management:

$$t_c = t_{max} \quad (14)$$

Subject to the conditions (13), the system pace is:

$$\tau_c = M[t_{REC}]. \quad (15)$$

The main of these stages, as is known, is the average time of occurrence of the stage of making decision – t_D, because all other are directed at its provision. If the conditions are not met (13) and the average time of making decision is greater than or equal to the expectation of the pace of receiving applications

$$\tau_D = M[\tau_{REC}], \quad (16)$$

Then the following path should be chosen in design or improvement of the management system:

a. Improving the structure and membership of the top management in order to increase its diversity or
b. Assign the value t_p to $[tau_c]$.

While moving, each i^{th} volume of information (application) transforms and passes all stages of management (Figure 2) within a predetermined time of the cycle T_{ci}:

$$T_{ci} = \tau_{RECi} + t_{PRi} + t_{DIi} + t_{Di} + t_{Ei} \quad (17)$$

Where T_{ci} is a special cycle of management;

$t_{PRi}, t_{DIi}, t_{Di}, t_{Ei}$ – processing, display of information, making decision and execution, respectively.

As we can see, each request, after passing through all stages of management, is completed with the execution of the decision – this is a cycle of information transformation. If any i-th volume of information J_i (the i^{th} query) "is damped" at any stage of management, then we are dealing with an information system failure, which lowers the production efficiency.

So, the most important parameters of the management system are formulated at this stage of research: Pace of the flow of information $[tau_i]$, system pace $[tau_c]$, indicator of efficiency (t_d), and condition of the management system optimization $(t_d^c \to 0)$.

3.4. Building Management Systems Based on the Flow of Information in Stages and Levels

We adhered to the rules of stage-by-stage development accepted in the study and formalized the law of delay in information uncovered earlier, based on the research results of the previous section.

According to the method described it the beginning, the studies of delay in managerial information continued not only in stages, but also in the prevailing levels of management. The research results are summarized in Table 3.

Deep analysis of the research results allowed us to establish the following law unknown in the economic and technical science: The pace value [tau] in stages of management in its technological sequence increases (Figure 2) in the processing of the same "portion" of information. Moreover, it was found that the ratio [delta tau] can differ across various management systems. However, the law of the change (increase) in the stages of management is maintained at all times. The studies of the uncovered law established that the value changes not only in time but also in space in relation to the level of the system hierarchy (Figure 3).

As can be seen from the chart, the now space-time variable [Σ delta tau] also changes in stages of management:

$$\sum \Delta\tau_0 \prec \sum \Delta\tau_{PR} \prec \sum \Delta\tau \prec \sum \Delta\tau_D \prec \sum \Delta\tau_E \quad (18)$$

This shows that it is essentially impossible to develop a management system that provides instant conversion of information through all stages of management. However, according to the derived criterion of the system optimization (according to expression (12), variable (t_d^c) should be minimized. Some delay in information from its occurrence to the implementation of solutions by all calculations presented here is a law.

Therefore, any management system also has a certain value of time of delay during normal operation. Let's introduce the parameter $t_{\min}^c$ the moment of inertia of the management system – to estimate it. This value will also differ across various systems, depending on its perfection. In the general case:

$$t_{\min}^c = n \cdot \tau_c, \quad (19)$$

Where n is the number of stages of management;

τ_c – pace of the system.

Now, let's formulate and write down the law of delay in information on the basis of these calculations. Its economic and mathematical expression:

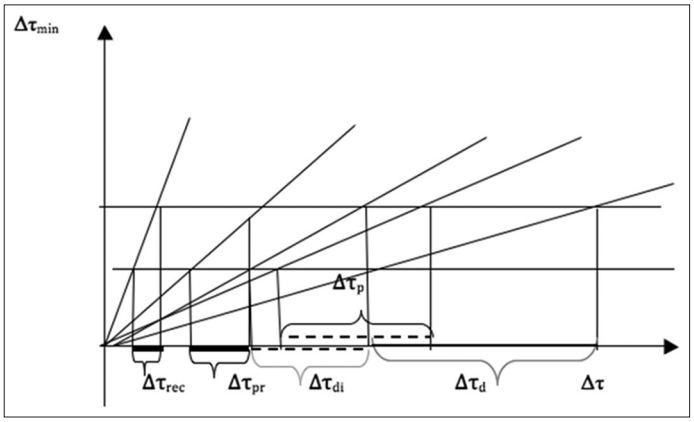
$$t_d^c \geq t_{\min}^c \text{ or } t_d^c \geq n \cdot \tau_c . \quad (20)$$

3.5. Assessment of the Company's Performance based on Delay in Managerial Information

When the information moves and transforms in stages of management – receipt, processing, display, decision and execution of the decision, – the pace of managerial information [tau] increases in time and space. The fact of the change does not depend on the perfection of management and direction of the management system that affect the degree of change. In the general case, the delay value cannot be less than the value obtained as the product of the number of stages of management and pace of the system $(n \cdot \tau_c)$ which describes the inertia of the system $(t_{\min}^c)$.

These calculations are quantitatively confirmed by data in Table 4. The degree of delay in managerial decisions dramatically increases alongside the levels of management. At the same time, at the weak level of management system, it is much higher than at the developed level. The value of [Σ delta tau] for water management systems is almost double the agricultural systems.

Figure 2: Law of change in the pace of information in stages of management



The value of delay in managerial decisions, which in our case is equal to time of the cycle in the rational management systems in terms of development of economic methods of management, is the moment of inertia of the system – $t_{\min}^c$ and is $t_{\min}^c$ = 678 min for agricultural and $t_{\min}^c$ =1,711 min for the water management company (Table 5)

According to formula (8) and the data in Table 3, we obtained the efficiency indicator t_3^c for the companies under study; the results are summarized in Table 4. It is much higher in the conditions of the development of self-management than in case of administrative management.

To assess the growth of the management system efficiency, the coefficient of the efficiency growth was introduced – $K(\sum \Delta\tau)$, which is a ratio of the degree of delay in the system under study to the same indicator of the management system in the conditions of the development of self-management:

$$K(\sum \Delta\tau) = \frac{\sum \tau_i}{\sum \Delta\tau_{selfmanagement}} . \quad (21)$$

As shown in Table 4, the efficiency of the improved management system increased by 8.89 times compared to the administrative

Table 4: Time of the cycle (T_c) and the degree of delay in managerial decisions in levels of production management in companies (Zhambyl region, Kazakhstan)

Company types and management levels	Time of the management cycle (T_c) min		Degree of delay, times	
Level of management	Weak	Developed	Weak	Developed
Agricultural companies				
Operator	15	15	1	1
Link	19	19	1.27	1.27
Team	1.103	137	150	9.1
Operations control center	5.055	609	337	40.6
Company	5.942	678	402	45.2
Water management companies				
Operator	21	21	1	1
Team	2.178	357	194	17
Operations control center	7.805	1.638	372	78
Company	8.588	1.711	409	81.5

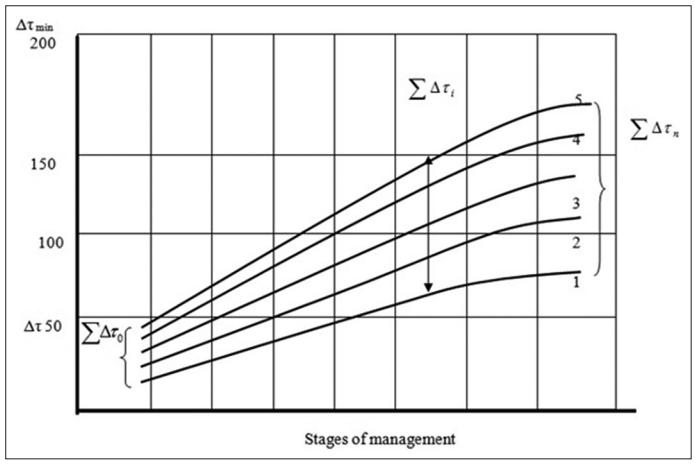
Table 3: Structure of time of the management cycle (T_c) in company management levels (Zhambyl region, Kazakhstan)

Company type and management level	Time of stages of management									
	Receipt		Processing		Display		Decision		Execution	
Level of management	Weak	Developed	Weak	Developed	Weak	Developed	Weak	Developed	Weak	Developed
Agricultural companies										
Operator	-	-	-	-	-	-	6	6	9	9
Link	-	-	-	-	-	-	8	8	11	11
Team	-	-	-	-	-	-	317	32	1040	105
Operations control center	469	48	592	56	No	265	645	862	3880	392
Company	469	48	592	56	No	265	943	155	3880	392
Water management companies										
Operator	-	-	-	-	-	-	8	8	13	13
Team	-	-	-	-	-	-	268	47	1640	310
Operations control center	744	130.2	854	150	No	68.4	1,280	233.4	5565	1054
Company	744	130.2	854	150	No	68.4	1677	305	5565	1054

Table 5: Characteristics of the delay in information in management systems in enterprises

Company type and management level	Moment of inertia of the system t_{min}, min	Indicator of the system efficiency t_{min}, min	Degree of delay in levels, times	Factor of growth of the management system efficiency
Agricultural	678	-	-	
Weak	-	3,411	402	1
Developed	-	344	45	8.89
Water management	1,711	-	-	
Weak	-	4,821	409	1
Developed	-	924	81.5	5.02

Figure 3: Law of change (increase) in time and space: (1) operator; (2) link; (3) team; (4) operations control center; (5) company



management in agricultural enterprise and by 5.02 times in water management enterprise.

4. DISCUSSION AND CONCLUSION

On the basis of these studies, the principles of building the management system (synthesis) were formulated: The determinability of the function and the structure of management of arrangement of production and sales, modeling and visualization of managerial information, accounting for informational nature of management and law of delay in managerial information, construction and operation of the management system taking into account the stages and hierarchy with their harmonization and effectiveness of the management system, calculation of the parameters of the flow of information through the "pace of the system" [tau$_s$], modularity of the development.

Thus, the management system created according to these principles will allow the efficient use of the production and financial capacity, and provide optimal conditions for the company operation in a competitive market with its contemporary challenges.

Deep study and description of the law of delay in information in managing the economic systems allowed to provide numerical methods for assessment of the functioning of companies.

The qualitative and quantitative determination of the law of delay in managerial information was formulated. New information parameters of the design and assessment of the management systems were introduced: Pace of the system – [tau_c]; time of the management cycle – (T_c); criterion of the optimization of the management system – $(t_d^c \to 0)$; moment of inertia of the management system – $t_{\min}^c$; space-time parameter of the management system – $\sum \Delta\tau$; coefficient of the efficiency growth – $K(\sum \Delta\tau)$, $(\sum \Delta\tau)$, and methods of their calculation.

The management system established using this methodology will allow the efficient use of productive capacity, and provide more optimal conditions for activity of the companies in the competitive market. The theory allows to assess the companies by time of delay in managerial decisions $t_{\min}^c$ and to determine the change (growth or drop) in this indicator $K(\sum \Delta\tau)$ of the company when comparing their competitiveness.

The study should continue in the direction of a broad experimental verification of the theory and implementation of this methodology and methods in the practice of operation of modern companies.

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