

# Mechanism of Logistics System to Support the Innovative Development of Industry in the Region

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**Abstract—**In the era of intensive scientific and technological development of advanced countries, increasing importance is attached to innovation. Innovation activity is a set of flows of material, informational and financial resources. Therefore, logistics of the innovation process is necessary for effective innovation, which will allow achieving optimal ways of innovative development of the industry of regions in the long run. The purpose of this work is the analysis of theoretical regulations and the development of practical recommendations aimed at creating a logistics system to support innovative development of the region. The research subject is a set of organizational and economic relations that arise throughout the entire chain of movement of material, informational and financial flows at all stages of the innovative project implementation. The result of the work is the developing of a structural scheme of the logistic system to support innovative development of the region, and proposing a solution using a logistic model for the specific task of calculating graphs (schedules) based on critical path method. The obtained results can be used at a regional level in the process of formation and implementation of the strategy of industry innovative development, as well as in the educational process when studying “Innovative Management” discipline. The logistic approach application to the implementation of an innovation project will make it possible comprehensively, from systemic positions, to cover all stages of the circulation sphere: from supply to marketing to the end-consumer, which will provide the achievement of synchronization and integration of resource flows ensuring innovation.

**Keywords**—innovation process, logistic model, innovation project, network graph, region, innovation chain

## I. INTRODUCTION

Currently, one of the most important areas of Russian economy growth, as well as an effective way of confronting world competitors in the period of globalization, include the use of opportunities and achievements of the Russian scientific and technological complex and the involvement of its activity results in the economic turnover. Introduction of innovations

into the economic turnover and the supply to end-consumers on a regional market is only a part of the complicated spatial and temporal process associated with the release of new products, the use of new technology and accompanied by various flows (information, financial, etc.). In scientific literature, a similar process from the moment of consideration of ideas and projects to the development, creation and marketing of innovative products is called the innovation process [1–6]. As a rule, it covers many implementing organizations and has various ways to promote products.

In this complex scheme of innovative production, there is practically no link responsible for the entire chain of movement of material and related flows from production to marketing of innovative products. This, in turn, leads to the existence of a gap between systems of acquisition and capitalization of knowledge, fragmentation of efforts in promoting R & D results into the real economy sector and, ultimately, to a loss of coordination and manageability of creation processes and sale of innovative products.

The current situation in the manufacturing sector of economy necessitates the creation of such organizational and economic conditions in the region that would contribute to achieving integration, synchronizing innovation flows, as well as promoting them at all stages. As G.D. Kovalev notes, it can be achieved not so much the effectiveness of the innovation stage as the reliability and speed of the transition from any previous stage to the next one [7–11].

These mechanisms relate to logistics tools that is the activity aimed at effective management, planning and movement of material and corresponding financial and information flows. Logistics is an example of using a systematic approach to solving business problems. In this case, consistency implies the following points [12]:

1. All participants in the distribution of goods (suppliers, consumers, transport, etc.) are part of a whole, and the process itself is a complex problem.

2. Integrity is a necessary condition for obtaining an integral synergistic effect, namely, the system must perform a given objective function, not by its individual elements and subsystems, but the logistics system as a whole.

3. Relations between all participants in the process are organized and interconnected with the technology of the product distribution process.

In other words, logistics allows us to comprehensively, from systemic positions, cover all stages of the circulation sphere: supply - production - storage - distribution - transport - demand - consumption. In this case, we can observe the process of production and marketing of an innovation product by uniting all participants in this process that is integration of participants into a single logistics network. This indicates that the dynamics and results of the creation and implementation of innovations depend primarily on participants in the innovation process and their interaction.

## II. RESULTS AND DISCUSSION

The innovation process participants include subjects of innovations (customers), entrepreneurs (industrial enterprises), executors of works on the project (including suppliers of raw materials, component items), investors, and other entities. Some authors represent all participants in their works [1] in the form of the following integrated blocks:

- information block (provides the system with information about nature of innovations that are required by economic entities, and transfers information about availability of innovations);
- scientific and technical block (develops innovations, the need for which has arisen in environment surrounding the system);
- production block (ensures production of innovations in quantity required by the consumer);
- consuming block (implements innovations and ensures their productive use that is turns novelty into innovation);
- block that forms the incoming flow (performs actions to provide the system with required financial, logistical and other resources);
- block that forms the outgoing flow (performs actions for implementation of innovations and goods produced on their basis).

Depending on scale and complexity of the innovation project, several dozens and hundreds of enterprises that carry out specific innovation operations can take part in its implementation. The main form that allows tracing the interaction of participants (subjects) of the logistics innovation system is the construction of logistics chains that reflect the movement of the entire innovation flow that is to say promotion of innovative products at the stages of development and its implementation to the consumer. The work of B. Santo presents a logistics chain in the form of a closed innovation chain (Fig. 1). He considers this graphic model as cybernetic [13, p. 117].

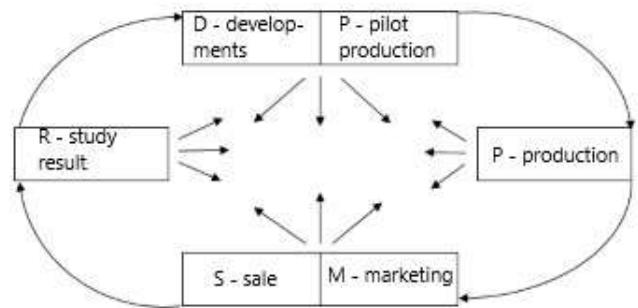


Fig. 1. Closed innovation chain

This model transfigures the innovation process as an integrated system in which the elements of the process form subsystems. These subsystems are in constant connection with each other, the system has multiple feedbacks.

Graphic model presented in Fig. 1, expresses the continuity of information processing. The closure of the process is vividly represented by the fact that it is almost impossible to determine the first or last stages of innovation, the beginning or the end. Continuous processing of information, its constant updating begins together with the system formation.

The elements of the circle, that is, the innovation subsystems (production base, scientific research base, trading networks) are the stages of information processing, and the interaction between them is a necessary condition for innovation. The absence or disruption of connection between any two subsystems can put under threat the continuity of the information flow and, further, the novelty success.

Thus, the structural scheme construction of the logistics system to support the innovative development of industry in the region is a prerequisite for a visual representation of the innovation flow promotion in main stages - from preparing pre-project proposals to marketing products to the consumer. Fig. 2 shows a possible scheme of interaction between the subjects (links) of the innovation system at meso-level, where the resulting innovative logistic chains oriented on material, information and financial flows are considered and displayed.

Having studied and analyzed all possible connections in the innovation space, having built alternative logistic models, the only correct solution can be found in a complicated set of economic relations arising from innovations. G.D. Kovalev names this decision as innovative communication [7].

Briefly describe the scheme of interaction between the subjects of the innovation system, shown in Fig. 2. At the request of industrial enterprises or other generators of ideas, marketing service of the logistics center conducts research, which reveals what a particular competitive product should be (in the case of demand orientation). According to the information received in the research center or at the industrial enterprise, a construction or technology production is developed and an approximate calculation of costs is carried out. Next, the logistics service compiles an approximate chain of movement of the material flow (supply, production, transportation, marketing). After considering all the options, a

decision is taken on the project implementation. After that, the flow of scientific and technical information, passing the manufacturing enterprise, merges with the flow of raw materials and is converted into a product. Next, product distribution is carried out: a part - directly to end-consumers, a part (if required) - to the regional distribution center for further storage and distribution. All flows of production and sales of an innovation product are coordinated by the logistics center to minimize costs.

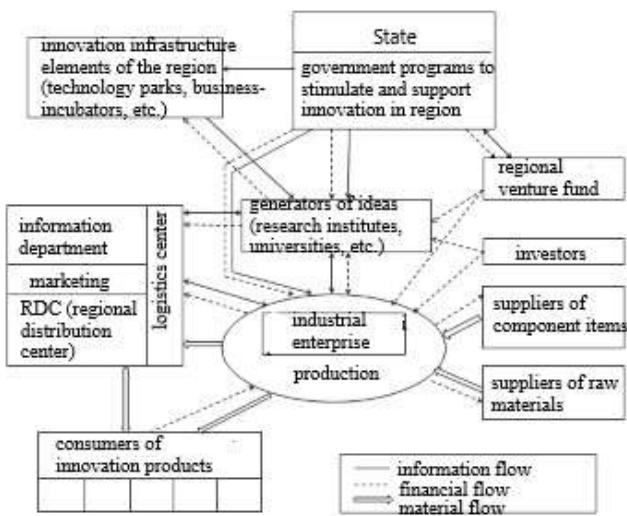


Fig. 2. Integrated scheme of the logistics system to support innovation in the region

State regulation in this logistic system includes laws and regulations, the formation of a competitive basis for the selection of projects, the organization of a pledge system and a surety. For innovative projects that have won competitions, the state makes direct investments, subsidies, participation in financing projects, creating conditions for a favorable investment climate, etc.

Thus, by building logistic models that reflect the totality of the main logistics operations throughout the entire innovation process, a number of important tasks can be solved. Some authors in their works consider the following as main ones [1, p. 29]:

1. Calculation of graphs (schedules) by the critical path method.
2. Planning of financial flows and assessing the economic efficiency of innovation projects.
3. Selection of the project optimal variant according to criteria of the greatest efficiency or least costs.
4. Organization of the logistic model for time, resources, cost.

Consider on the example of a specific innovation project, how the first task from the above list can be solved by means of the logistic model.

In domestic practice of logistics, the construction of network graphs for performing a complex of works is referred

to network planning and management methods [14, p. 316]. Network modeling is one of the most powerful methods of graphical modeling of organizational and technological processes. The network model is depicted as a graph, which can represent any complex of interrelated works: scientific, construction, managerial, etc. The PMS (project management system) methods make it possible to formulate optimal plans according to the chosen criteria and carry out optimal control.

In our case the network model is presented in the form of a network graph (NG), namely, a scheme that reflects the whole range of activities in a strictly defined order (logistics operations), ensuring the achievement of the final goal. The main elements of the network graph are work (depicted by an arrow - a quasi-vector), event (depicted by a circle), and a path.

The construction of the network model implies the following main steps:

- defining goals and limitations of the project related to duration of its cost and quality;
- determining the list (set) of works included in the project, and assessing (forecasting, calculation) the duration of each work (logistic operation);
- establishing and analyzing work order relationships and forming a network graph reflecting these relationships;
- constructing a calendar network graph based on estimates of the work duration and the calculation of time parameters.

As an example, we use innovative projects "Fire-resistant building materials / insulations based on large-capacity waste production "Vinizol" / "Penozol", developed in Irkutsk region [15]. We apply the economic-mathematical model of the network planning and management tasks to solve the problem. [44, pp. 322 - 328].

Table I shows the list of works of the innovation project, as well as minimum and maximum terms of these operations to calculate the expected duration of their implementation.

TABLE I. PROCESS (PROJECT) WORK

Process (project) work i - j	Symbol	Content of process (project) work	$T_{i-j}^{\min}$	$T_{i-j}^{\max}$
1-2	a	search for premises (industrial enterprise) for production of their own	3 months	1 year
1-3	b	sending an application to logistics center, requesting information on possible variants for premises	1 month	3 months
2-3	c	sending an application to logistics center to manage further chain of implementation flows movement of the innovation project	1 month	3 months
2-4	d	premises equipment, preparation for production, production of innovation products	9 months	1.5 years
3-5	e	management of logistics center specialists with the flows that accompany production, its shipment to RDC for storage and further distribution	1 month	3 months

Since the works of our network graph are non-deterministic, so the execution time cannot be determined exactly, the

expected duration of their performing  $T_{i-j}^{ex}$  is determined by the formula:

$$T_{i-j}^{ex} = \frac{2T_{i-j}^{\max} + 3T_{i-j}^{\min}}{5}, \quad (1)$$

where  $T_{i-j}^{\min}$  - minimal (optimistic) duration of this work (the work duration under the most favorable conditions of its performance),  $i = 1, 2 \dots m-1, j = 2, 3 \dots m$ .

$T_{i-j}^{\max}$  - maximum (pessimistic) duration of this work (the work duration under the most adverse conditions of its performance),  $i = 1, 2 \dots m-1, j = 2, 3 \dots m$ .

Represent the initial data for the calculation of network parameters in Table II.

TABLE II. INITIAL DATA FOR CALCULATION OF NETWORK GRAPHS PARAMETERS

Work immediately preceding this $(i-j)$ -th work	Process (project) work	Labor intensity (duration) of this work, working day
$h - i$	$i - j$	$T_{ij}$
-	a	201
-	b	55
a	c	55
a	d	384
b, c	e	55
d	f	73
d	g	55
b, c	h	55
f, e	i	55

The third column contains data on the expected duration of a process, calculated by the formula (1).

Fig. 3 presents the network graph of a complex of works, built on the initial data from Table II.

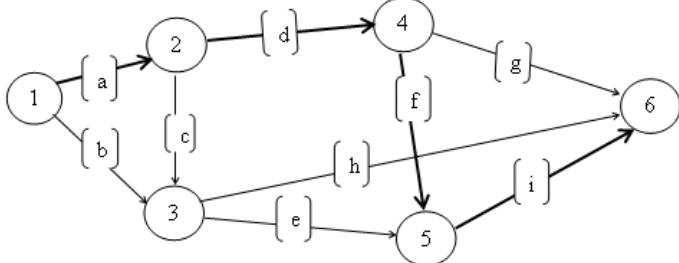


Fig. 3. Network graph of a complex of works

Below, we present all the conventions necessary for calculation time parameters of the network graph.

$h, i, j, k, m$  - NG event number;

$i$  - number of initial event of this work,  $i = 1, 2 \dots m-1$ ;

$j$  - number of final event of this work,  $j = 2, 3 \dots m$ ;

$m$  - closing event number of NG;

$i-j$  - given work of NG;

$h-i$  - work immediately preceding this  $(i-j)$ -th work;

$j-k$  - work immediately following this  $(i-j)$ -th work;

$T_{ij}$  - labor intensity (duration) of this work;

$T_{ij}^{ES}$ ,  $T_{ij}^{EE}$  - respectively, the time points of the earliest start and end of this  $(i-j)$ -th work;

$T_{ij}^{LS}$ ,  $T_{ij}^{LE}$  - respectively, the time points of the latest start and end of this  $(i-j)$ -th work;

$T_{cp}$  - length of NG critical path;

$r_{ij}^1$ ,  $r_{ij}^2$  - private time reserve of this  $(i-j)$ -th work, respectively, first and second types;

$R_{ij}$  - full (total) time reserve of this  $(i-j)$ -th work;

$r_{ij}^n$  - independent (free) time reserve of this  $(i-j)$ -th work;

$T$  - duration of the entire complex of works of this network graph.

Next, to calculate the time parameters of the network graph, we use the following basic calculation formulas:

$$T_{ij}^{ES} = \begin{cases} 0, & \text{if } i=1; \\ \max_{h-i} T_{hi}^{EE}, & \text{if } i>1; \end{cases} \quad (2)$$

$$T_{ij}^{EE} = T_{ij}^{ES} + T_{ij}; \quad (3)$$

$$T_{cp} = \max_{i-m} T_{ij}^{EE}, \quad (4)$$

where  $m$  - closing event number of NG;

$$T_{ij}^{LE} = \begin{cases} T_{cp}, & \text{if } j=m; \\ \min_{j-k} T_{jk}^{LS}, & \text{if } j<m; \end{cases} \quad (5)$$

$$T_{ij}^{LS} = T_{ij}^{LE} - T_{ij}; \quad (6)$$

$$r_{ij}^1 = \begin{cases} T_{ij}^{LS}, & \text{if } i=1; \\ T_{ij}^{LS} - T_{hi}^{LE}, & \text{if } i>1; \end{cases} \quad (7)$$

$$r_{ij}^2 = \begin{cases} T_{cp} - T_{ij}^{EE}, \\ T_{jk}^{ES} - T_{ij}^{EE}, \end{cases}$$

if  $j = m$ ;  
if  $j < m$ ; (8)

$$R_{ij} = T_{ij}^{LS} - T_{ij}^{ES} = T_{ij}^{LE} - T_{ij}^{EE};$$
(9)

$$r_{ij}^H = r_{ij}^1 + r_{ij}^2 - R_{ij}$$
(10)

According to the above formulas, Table III presents the calculation results of time parameters of the network graph.

TABLE III. CALCULATION RESULTS OF NETWORK GRAPH PARAMETERS

Work <i>i-j</i>	Network graph timing								
	$T_{ij}$	$T_{ij}^{ES}$	$T_{ij}^{EE}$	$T_{ij}^{LE}$	$T_{ij}^{LS}$	$r_{ij}^1$	$r_{ij}^2$	$R_{ij}$	$r_{ij}^H$
1 - 2	201	0	201	201	0	0	0	0	0
1 - 3	55	0	55	585	530	530	201	530	201
2 - 3	55	201	256	585	530	329	0	329	0
2 - 4	384	201	585	585	201	0	0	0	0
3 - 5	55	256	311	640	585	0	329	329	0
3 - 6	73	256	329	695	622	37	366	366	37
4 - 5	55	585	640	640	585	0	0	0	0
4 - 6	55	585	640	695	640	55	55	55	55
5 - 6	55	640	695	695	640	0	0	0	0
critical path length $T_{cp}=695$									
critical path work: 1-2, 2-4, 4-5, 5-6									

Perform a brief analysis of the network graph (Table III, Fig. 3). The network graph presented in Fig. 3, contains five full paths, where one is critical. In our case, the following path is critical (the longest): 1 - 2, 2 - 4, 4 - 5, 5 - 6 (highlighted in bold in Fig. 3). The length of this path is 695 days ( $201 + 384 + 55 + 55$ ). This means that the minimum possible execution time of the whole complex of works is 695 days. Any delay in the performance of any work on a critical path in the future will lead to a violation of the timing of the entire complex of works. The remaining four full critical paths have some margin of time. For example, the path 1 - 2, 2 - 4, 4 - 6 has a reserve of 55 days (8%), the path of 1 - 3, 3 - 6 has a reserve of 366 days (53%). Hence, the intensity of the last path is equal to 0.47, which means that the performance of work 1 - 3, 3 - 6 belonging to this path may be delayed for no more than 366 days.

Thus, methods and models of network planning on the basis of the initial information make it possible to determine the earliest and latest possible start and end dates for a specific work of the whole complex, identify critical work, the untimely execution of which entails a change in the total execution time of the whole work complex. Analysis of works having certain reserves of time provides most efficient use and allocation of

resources for the work during the entire monitoring and progress regulation of the complex of work.

### III. CONCLUSION

The use of a logistic approach to the implementation of scientific ideas can contribute to the creation of such organizational and economic conditions in the region that would be conducive to achieving the integration of innovative flows, their advancement at all stages and, as a result, accelerating the implementation of innovation projects and programs at regional level. World experience shows that the speed of bringing scientific research to a market product becomes the most important factor for adapting to competitive conditions of the world economy in the period of globalization. Therefore, using the logistical coordination of processes throughout the entire chain of movement of the material flow, finance, information in the process of realizing an innovation project, it is possible to optimize the implementation of the innovative development of industry in regions and, as a result, boost the economy of the country.

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