

## Innovative prospects, nonlinear dynamics and the regional industry development

Sergey Chuprov  
*Baikal State University*  
*Russia*  
*chuprov@isea.ru*

**Abstract.** Globalization processes enveloping the world's economic relations as well as the increasing competition on domestic and foreign markets shape up the prospects for innovative development of industrial complexes and regional industries. Our paper focuses on the Irkutsk region that characterizes East Siberia's leading fuel and energy, timber processing, metallurgical and machine-building complexes, as well as the petrochemical industry. We assess the favorable innovative conditions that influences accelerated modernization of production complexes. Moreover, we discuss the influence of information factor on behavior of industrial enterprises and their stability in the environment of innovative changes and the economy of knowledge.

Our results draw from the theory of nonlinear fluctuations that enable us to analyze the stability in developing economic systems. Moreover, we discuss dynamic processes of economic evolution within related changes and efficiency of activities of the regional developing industrial enterprises using the elements of the catastrophe theory.

**Keywords:** economic development, industry, innovation, regional development

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### INTRODUCTION

In the foreseeable future, the priority of the socio-economic development of the Upper Angara region is lawfully determined by innovative transformation of the industrial sector in Irkutsk region (oblast). This is happening not only due to the fact that the chosen direction fits into the mainstream of modern economic development, but also due to its the powerful scientific, technical, and industrial potential (Glazyev, 2011; Tatarkin, 2007). Therefore, it was recognized that the innovative image of the industry would solidify the Upper Angara region not only with the status of a scientific-educational leader but also with a role of an industrial center of Siberia.

However, the economic crisis of 2008-2010 has aggravated the unfavorable scenario conditions for the implementation of the innovative industrial modernization scheme halted the transformation of the "inertial" regional industry into the innovative breakthrough trajectory. Despite the progressive dynamics of the industrial production index in the region, the striving with fulfilling the economic reforms and measures remains an issue (Table 1).

Table 1

## Indices of industrial production of Irkutsk region by the types of activities (2008 – 2015)

Year	2008	2009	2010	2011	2012	2013	2014	2015
Indices of industrial production	106,0%	95,1%	116,7%	109,2%	112,8%	112,7%	103,0%	104,5%
Mining	103,1%	110,9%	133,4%	160,0%	144,0% %	136,2%	110,0%	109,7%
Manufacturing	106,9%	93,3%	113,2%	92,6%	95,5%	99,1%	100,1%	101,9%
Production and distribution of electricity, gas, and water	102,0%	97,5%	131,0%	98,3%	108,9%	86,2%	93,0%	96,9%

Source: The Ministry of Economic Development of Irkutsk Region ([www.irkobl.ru/sites/economy/socio-economic/socio-economic\\_situation](http://www.irkobl.ru/sites/economy/socio-economic/socio-economic_situation)).

The decline of the index was caused by the productions in all kinds of economic activities, besides mining of fuel and energy mineral deposits, also by the manufacturing of food products and chemical production. Since 2010, the path of index increment under all kinds of economic activity was followed by the decrease of the indexes of mining of fuel and energy mineral deposits, manufacturing of food products, production of various non-metallic mineral commodities, as well as the production of electrical equipment, electronic and optical equipment. Furthermore, the growth of industrial production index was driven by the rates of mining of mineral deposits under support of enterprises from number of branches: forest industry complex, metallurgical and machine-building complexes, production of construction materials (in 2011), chemical and oil-refining complex, construction materials (in 2012), enterprises performing wood processing and production of petrochemicals (in 2013).

Moderate changes in the index of processing productions, which furthermore, in 2009 and in 2011-2013, dropped even lower pointing at the negative dynamics of recession in the volume of production and indicted the discordance of that trend.

Low level of innovative activity of enterprises remains to be a demanding problem of regional industries, which hampers perspectives of their successful development. As a result, in 2010-2014 there were about 31- 49 enterprises, which conducted innovative activities, in Irkutsk region. The amount of innovative production of enterprises in these years constituted from 0.5 to 1.6% (!) of total volume of shipped production of all organizations in the region. Financing of education and science from the funds of the regional budget in 2010 – 2014 was restricted by the miserable amount of 0.02 – 0.04%. ([http://irkutskstat.gks.ru/wps/wcm/connect/rosstat\\_ts/irkutskstat/resources/f641e0004e640a06994aff21f378d622/nauka2.html](http://irkutskstat.gks.ru/wps/wcm/connect/rosstat_ts/irkutskstat/resources/f641e0004e640a06994aff21f378d622/nauka2.html), access: 27.06.2016).

The expenses provided for 2014 at the amount of 4 000.0 thousand roubles and for 2015 at the amount of 4 500.0 thousand roubles are aimed at the fulfilment of the Irkutsk region Law «On Oblast State Support of Science and Technology, and Innovative Activities». Financing for implementation of science, research and development activities remains unsatisfactory as well: the expenses are provided in the regional budget for 2014 for these purposes are around 9 600.0 thousand roubles and for 2015 in the range of 10 800.0 thousand of roubles.

Our paper aims at discussing the globalization of world economic relations and the increasing competition in the domestic and foreign markets, as well as tackles the problems of production, distribution and innovation implementation in the activity of industrial enterprises (Chuprov, 2012; Drucker, 2007; Urbancová, 2013; Hubulava et al., 2015).

## GLOBALIZATION OF WORLD ECONOMY AND INDUSTRIAL ENTERPRISES

Maintaining the world's trends induces us to look at the process of globalization and economic growth from the point of promoting effective and steady activity of industry enterprises. It is understood that this should not become the sidestep from the challenges of the new era and the growing mutual dependence of national economies, but should be targeted at the lucrative creation of interstate relations and development of competitiveness of homeland economy, taking instability of its indexes into account.

It is a circumstance of no small importance, whereas transformation conversions in commercial area are being performed on the background of sensible shears in the world economic space. Synchronous imposition of those trends is capable to instigate resonant effect with harsh consequences for any country. Under such scenario, the globalization will turn for the economy of any given country (including Russia) as a rooting of pernicious processes and might throw it further back to the scope of outsiders.

This grim picture does not look that unrealistic after all in anticipation of non-linear character of cause-consequence events. The cardinal change of system behaviour turns capable under effect of moderate perturbations. Surely, synergy assigns a part of "detonator" to extremely insignificant changes, which nevertheless are capable to stir rhythm flow of economic process (see Haken, 1993; or Nicolis, 1989). It is needless to say, that an uncontrolled flow of penetrating interferences is able to shatter any industry weakened with shock therapy.

In the conditions of the modern economic system, the risk of skewing in economic relations, which leads to non-equivalent exchange of resources and magnification of social inequality, increases. With regard to that, a natural factor, despite its significance in inter-country relations, is merely one of the components in forming of world revenue whilst today the intellectual (intellectual products, inventions, scientific, literature and other works), technological (innovative), organization-commercial (managing) and the like components appear to be the sort of world's quasi-revenue.

Searching for the equilibrium position by "overtaking" countries on the background of such disharmony of interstate relations will face the obstruction from side of ambitious transnational funds and governments guarding its interests. Counteraction against such appetencies will spread to all of the international economic processes which gives them steadily imbalanced character with the option of dangerous conflicts (Stiglitz, 2002).

Therefore, rash and wide build-in of the world-commercial connections into the global network might bring damage for economic security and suppress "growing points" of any homeland industry. The problem of harmonization of relations between foreign and domestic commodity producers in the absence of macro-economic procedure for their settlement is barely decidable with sufficient reliability. The theory of systems and commercial practice suggest that in order to save competitive advantages and to protect a perspective commodity producers facing coming out of transnational companies' threats can protect themselves with the help of deliberate policy, which integrates the state support of the enterprises (protectionism, state orders, custom duties, tax concessions, investments etc.) and the collaboration with foreign corporations, which possess scientific and innovative potential. Therefore, the quantity analysis of benefits and threats of globalization to economy with factoring in regulating effect to integration processes under various scenario conditions becomes necessary.

However, the accelerated leap of the domestic economy, which soaks the newest knowledge and generates innovative information, is not going to leave the option for gaining equilibrium state in the world space, let alone to promote its steadiness. It would not be out of place to remind the work of Kondratyev who stated that "particularly taken economy of separate countries, which do not demonstrate headlong rates of development, but on the contrary develops slowly, stands as a rule closer to equilibrium state than national

economy of quickly developing countries. Uniformly, economy of every country in some periods stands closer to equilibrium state than in other periods” (Kondratyev, 1991, p.320). At the meantime, synergy postulates unbalanced system behaviour as a necessary condition for its development, which moves the whole system closer to equilibrium, and then throws the system away of it entraining the system to new bounds with the flow of novation (Zhang, 1991). Considering this, unbalanced conditions of a changing economic system appear to be more typical for it than balanced ones.

This is why, the saturation of industrial complex of the country with science-intensive information and its materialization through management and production activities will allow (at least partially) to weaken chaotic processes of the development of the country industry and to piece out for performing of quasi-balanced upward movement. Otherwise unbalanced behaviour of domestic enterprises can become steady, not only in relation to innovative type of progressive transformation, but under influence of prevailing degradation trends. Furthermore, at the moment of reaching bifurcation point, trajectory of movement of the industrial complex will be hardly predictive and will be ridden by conditions of transient process flowing. Avoiding such scenario of economic dynamics supposes the increase of the importance of institutional and innovative factors of economic development. Thanks to them, it is managed to minimize risks of enterprises’ crisis and to strengthen their competitive positions in globalizing economy.

With respect to this, formulation of institutional aspects of enterprises’ activities, related to analysis of their cognitive mechanisms and promoting process of perception and interpretation of information incoming from the outside, seem to be constructive. Cognitive mechanisms in the structure of the enterprise under the concept of Kleiner (2004) create the base of knowledge, which is concentrated within organization but allocated between separate people, groups and collectives. These mechanisms are formed under the influence of individual as well as group peculiarities of intellection, cultural ambience and system of enterprise institutions, which in turn can make impact on steadiness of its functioning, which is determined via ratio of possibilities’ scope and boundaries of responsibility of subject of making and performing decisions. The greater is the skewness between them; the lower is steadiness of such a system. Maturation of corporate culture at an industrial enterprise is dependant on its information resource on the one hand, and on acquired skills of management under extreme situations on the other hand.

The part of information factor in the national innovative systems is getting especially sizeable whereas it presets not only vector of social development, but also stipulates rates of the economic growth of the country. Despite certain inconsistency of influence of scientific and technical progress on dynamics of macroeconomic indexes, these problematics are apparently based on difficulties of measuring cost of information resource, effects from scientific and technological achievements, and contribution of innovations to solving social problems of the state. Such approach generalizes a wide variety of scientific fields and, that is rather important, binds its theoretical models to commercial practice of leading industrial states. That is why investigation of technological and institutional characteristics of modern innovative processes by national and foreign analysts deserves support, and investigation conclusions, which are being published, allow us to talk about substantiation of new, innovative paradigm in economic science.

In the light of evolution theory that is developed nowadays, unbalanced conditions of an economic system, “aloof” from neo-classical orthodoxy in some degree, not just to help finding plausible explanation but also to give a clue for understanding a tendency of changing technologies. Increasing pressure of innovations on technological processes provides dynamics for the enterprises’ activities, giving them no opportunity to support a quasi-balanced state with restricted hesitations around its specific for a system’s behaviour. Leaving path of equilibrium is not considered already as grievous abnormality of a system’s movement, but contrariwise, is the consequence and cause of technological development of an enterprise. Breach of equilibrium is the consequence because it is caused by reaction of a system to innovative disturbances, and a reason,

whereas coerces enterprises to strive for research and implementation of technological novelties for saving competitive positions at the market. In such abruptly changing ambience, management of enterprises is not going to give a thought of balancing supply and demand equilibrium in relation to commodities, which is being produced by them, all the more so obtaining equilibrium in harshly disturbed ambience is quite uneasy.

Along with that, the character of substitution of obsolescent technology for more progressive one cannot but face influence of demand factors as well. Addressing to this aspect of evolution theory, Mayevskiy writes: "Substitution of technologies is basically an unbalanced process in the sense that public needs for old technologies with the lapse of time get less than possibilities of their production, and needs for new technologies — get more. Namely this circumstance stipulates arise of profit from developments" (Mayevskiy, 2001, p.6). Of course, demand for the future products is quite complex to forecast on the background of high uncertainty, what also deprives an enterprise with opportunity to perform balanced motion.

Innovation paradigm also allows the conclusion on substantial influence to country's competitiveness not only institutional factors of technological process, but also globalization of science researches. In addition to intrinsic process and obvious advantages of cooperation of science schools, one also should not forget the held by the policy of merger of a real competitor or its takeover, what barely promotes growth of the national innovative systems potential. Besides strengthening of impact of trans-national corporations to the scientific research course, inevitable leakage of information, technologies and specialists occurs in home base country. Due to it, institutional problems of ruling over competition and mutual relations of countries involved in process of science – education exchange arise. At that market of information services and science-intensive industries turn out to be the most agile sector of the global economy.

## OUTLINES OF THE STRATEGY FOR SOCIAL AND ECONOMIC

The innovative vector of modernization of Irkutsk region and its industry is stipulated by logics and dynamics of scientific and technological transformation of the commercial area, conclusively substantiated in conceptual workouts and fixed in regulatory decisions of federal bodies of management. This entails The Strategy for Social – Economic Development of Siberia until 2020 (The Strategy for social-economic development of Siberia until 2020, 2010), developed with factoring in The Strategy for National Security of Russian Federation until 2020 (On the Strategy of the Russian Federation national security until 2020, 2009), The Concept for the Long-Term Social-Economic Development of the Russian Federation for the Period until 2020 (The Concept for long-term social-economic development of the Russian Federation for the period until 2020, 2008).

Innovative processes in real sector of Siberian economy fall behind the other ones in Russia in terms of indexes of enterprises innovative activity, release of new production and quantity of utilized new production technologies. The Strategy states that in post-reform period the crisis entailed degeneration of performance of science-intensive and capital-intensive technological productions, such as production of machines and equipment (including electrical machines and equipment, electronical and optical equipment), production of facilities for radio, television and communication, as well as production of transport facilities and equipment.

Innovative infrastructure and area of high-technology business have suffered sensible losses, consequently of which terms of implementation for infrastructural projects have increased. Within the context of achievement of strategic goals and priorities of social-economic development of Siberia, it is provided as follows (The Strategy for social-economic development of Siberia until 2020, 2010):

Massive technological upgrading of Siberia regions in economy and social area by implementing innovative technologies, which promote new brands for production of commodities and services;

Increasing of labour productivity, widespread implementation of modern methods of management;

Increasing of the quality of human capital, preparation of specialists for implementation of key investment projects for development of economy and social area of Siberia at modern level;

State support for development of innovative activity infrastructure, as well as transport, energy, information-communicative and social infrastructure;

Implementation of large-scale investment projects for deriving and processing of natural resources;

Accelerated diversification of the Siberia economy for the account of rapid development of processing and reprocessing productions, increase of share of enterprises with innovative technological ways.

Under The Strategy, development of an innovative system has been planned in Siberia, in the structure of which there are interrelated organizations, producing and/or disposing knowledge and technologies, and networks of institutions of legal, financial and social nature, which promote close cooperation of educational, scientific, entrepreneurial and non-commercial organizations. Formation of innovative model for development is being designed, which provides creating of innovation generating centres by way of forming “the belt of implementation” on the base of national research universities, federal universities, academic centres, their branches, science cities, technical-implementation zones and technological parks. Target codes of development of Siberia innovative system presented in the Strategy are specified in Table 2 that follows.

Comparison of target indicators for 2015 and 2020 shows that the substantial growth is anticipated in number of advanced production technologies (by 1.7), share of organizations, which implement technical innovations (by factor in the mean of 1.7), share of innovative production in total amount of shipped commodities and rendered services (by factor in the mean of 1.5).

Complex development of processing industry and works, and designing and implementing innovations should be pointed out among top strategical priorities of Irkutsk Oblast development in 2010-2020. In Irkutsk Oblast, it is planned to implement the project of “Creation of Industrial Techno park of High-Tech Materials”, besides an innovative territorial-production cluster will be formed in the city of Irkutsk.

Table 2

Target indicators of development of Siberian innovative system (2008 – 2020)

Indicators	2008	2010	2011	2015	2020
1	2	3	4	5	
Number of personnel occupied with research and works, persons	53 956	55 100	57 300	59 000	61 000
Share of young scientists up to 39 years, per cents of total number of scientists	12	14	15	22	27
Number of international research centres within the territory of Siberia, unit	12	13	13	15	20 - 23
Share of scientific magazines having international rating, per cents of total number of similar magazines in the Russian Federation	2	2	2	5	7
Number of invention patents, unit	2 163	2 500	2 700	3 600	4 200
Number of created advanced production technologies, unit	93	115	138	200	340
Foreign trade turnover (export and import of technologies and services of technical nature), per cents of figure over the Russian Federation	5,7	7	8,3	9	12

1	2	3	4	5	
Share of scientific-research organizations and higher colleges having access to the Internet via dedicated channels, per cents of total number of scientific-research organizations and higher colleges	58	62	75	90	100
Share of organizations performing technical innovations, per cents of total number of organizations	7,7	9 - 10	11	12-15	20 - 25
Number of students per 10 thousand of population, people	488	490	494	496	520
Human development index	0,745	0,758	0,76	0,781	0,885
Share of innovative production in total amount of shipped commodities and rendered services, per cents	2,1	3 - 4	5	8	10 - 15
Share of expenses for Research and Technological Development in total amount of shipped industry production, per cents	Less than 1	1	1,5	2	2 - 4
Share of high-tech sector in gross regional product, per cents	2 - 5	7 - 8	9	10 - 13	14 - 17

Source: The Strategy for social-economic development of Siberia until 2020. Enactment of the Government of the Russian Federation of 5th of July 2010 No. 1120-p. (2010)

*// Legislation Bulletin of Russian Federation, 33, 9003-9058.*

Priority directions of implementing innovations in the real sector of Irkutsk Oblast economy are considered as follows: new technologies in mineral resources complex of Siberia, information and telecommunication technologies, increase of gas and oil recovery volumes, petrochemistry, gas chemistry, wood chemistry, power electronics, biotechnologies, food products and medicaments, energy saving technologies, aircraft industry, and solar energy.

Until 2021, it is planned to carry out the modernization of Irkutsk region economy on innovation basis, to consummate realization of main projects in transport and energy construction, large-scale resource projects, and to attain the creation of comfortable environment for population livelihood.

Discussing progress in the implementation of The Strategy for Social-Economic Development of Siberia until 2020, it has been noted that 42 of 58 plan activities have been executed under the plan, monitoring of the process of performing 16 plan activities are going on, and annual reports to the Government and interested federal bodies of executive powers are being provided. Along with that, the draft plan of the project of plan activities to implement the Strategy was accepted. According to that draft, the subjects of the Russian Federation, which constitute Siberian Federal District, are charged with development of the strategy for innovative activities in regions and establish a set of measures to create conditions, which induce development and implementation of innovations in Siberian regions, including state support for organizations and enterprises implementing innovative technologies, among them, innovative enterprises being created under higher colleges and science institutions.

## DIRECTION PROSPECTS FOR INNOVATIVE DEVELOPMENT

Irkutsk region has sufficient human, natural, scientific, technical and production resources to overcome negative consequences of institutional reforms and to provide the region's industry with fast effective development performance. These purposes presuppose advanced innovative development directions for production complexes in terms of regional industries (Voropai, 2007; Lelek, 2014).

The fuel and energy complex is convincing in its contribution to the economy of the Irkutsk region and covers electrical and heat power engineering, coal and oil-refining industries. In developing oil, natural

gas and coal deposits the industry has substantial resources for improving the region's structure of the fuel and energy balance (increasing the share of environmentally friendly fuels), for expanding the involvement in its economic turnover of oil and gas resources (including the gasification of the region and development of gas chemical utilization), for increasing efficiency of energy use with use of technical and organizational innovations for energy saving and reduction of negative impact of the energy sector on the environment.

The petrochemical industry in its development is undergoing progressive changes that are connected with intensification of extraction of hydrocarbon deposit stock. An increase of mining and oil and gas deep processing will allow both to completely gasify Irkutsk Oblast and to support exports, but also to increase production of mineral fertilizers, construction of electric and heat-generating capacities on the basis of gas-turbine plants, production of construction materials. In the end, the people in remote areas will receive natural gas for utility and industrial needs, while a number of regional economy industries (agriculture, construction, and others) will get the impulse for expanding their activities which will result in defusing a tense ecological situation in Irkutsk region

The timber industry complex has rich forest resources and its development prospects are primarily involved in deep processing of raw materials. Creation of vertically integrated structures with implementation of all technological stages from timber harvesting to production and sales of final products (timber, sawn wood, pulp, plywood, fiberboard, chipboard and paper products) meet customers' needs, including the ones outside the country, mainly in China, Japan, India, Ireland and Denmark. Additional production facilities and modern technological equipment of the enterprises will provide an opportunity to deepen chemical and forest-chemical processing of wood with purpose of engaging in the processing both small-scale, low-quality and softwood timber and production of highly profitable products, including first-class furniture (Voropai, 2007).

The metallurgical complex of Irkutsk Oblast in the future is bound to implement its resource capabilities in output of some kinds of high-demand metal products for both Russian and foreign consumers. First, high-purity silicon production for manufacturing of aluminum-silicon alloys and silicon-organic compounds by Russia's enterprises, and also for alloy production by companies in Europe, North America and East Asia. Second, new capacities commissioning production of primary aluminum (mostly for the countries of West and East Asia) and gold. Third, getting increasing manufacturing of alumina and chlorine-free potash fertilizers, cement, salts of rare metals (rubidium, cesium), etc. And finally, overcoming the dependence of companies on alumina import (Voropai, 2007).

The engineering complex of Irkutsk Oblast is preset by large-scale and medium-scale enterprises of mechanical engineering which are concentrated in the following main areas:

- manufacture of military and civil aircrafts;
- manufacture of machinery and equipment, including mining and concentrating, petrochemical and metallurgic industries for non-ferrous and ferrous metallurgy;
- manufacture of electrical products;
- manufacture of finished metal products as well as enterprises engaged in varioust kinds of repair work

In the regional engineering, the leading role belongs to the corporations that expand the aircraft market due to the increase in the production of modern military and civil aircrafts. Another key direction of mechanical engineering development in Irkutsk region is production of machinery and equipment for basic nature management industries: production of equipment for the mining, mining and concentrating, gold-mining industries, for the coal-mining industry, the timber petrochemical industry and the timber complex. In addition to these, of significant importance is manufacture of electrical products (Vinokurov, 2012).

## INNOVATIVE MODERNIZATION AND EFFECT OF DEVELOPMENT OF PRODUCTION COMPLEXES

Modern economy of knowledge is formed at the background of accelerating innovational development of economic structures and extensive use of high technologies in production of goods and provision of services (Zumbusch & Scherer, 2013; Kasperowicz, 2014). Moreover, it includes forming of innovative risk management instruments (Miciuła, 2015). Development prospects for production complexes of Irkutsk region are in accord with the innovative modernization of the national economy aimed at generating design and technological knowledge, their materialization in science-intensive projects and developing the output of competitive products. The current problem is acquiring a dominant and urgent nature, also due to Russia's entering to the World Trade Organization, which results in increasing the risks of regional sales "compression" in regard to commodity producers and their loss of a number of profitable segments of the manufactured products market. Thus, the industry in Irkutsk region is now experiencing a whole spectrum of threats both from the globalizing world economy and internal production, technological and financial-economic imbalances.

Under the pressure of these external and internal frictions operation of industrial complexes will grow dynamically up to the loss of stability, and therefore they need to develop innovative development projects. The latter are formed not only under the influence of universal regularities in formation of economy knowledge, but in the framework of the region's resource potential disclosed above.

Prerequisites for accelerated modernization of the region's production complexes result from the favorable innovative conditions and include the following items:

- powerful scientific and educational potential of Irkutsk Oblast for training highly qualified personnel for industrial branches;
- broad opportunities for implementation of special training, retraining and advanced training of personnel for innovative activities;
- maintainance of high-tech production complexes for development of science-intensive competitive products;
- creation and development activities in regard to the Irkutsk innovative business-incubator, formation of the regional technopark;
- an advantageous geographical and economic position of Irkutsk Oblast for intensification of scientific-technical cooperation and business contacts.

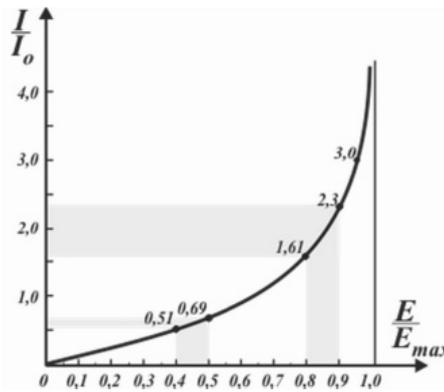
However, there arises logical question about the effect of innovative development of production complexes, as perfection of their management systems, they are reaching, requires use of information and computer technologies, designing of algorithms and software products, and this is connected with additional costs that are covered by the revenues. The effectiveness of the system depends on its structure and cost, pay-offs and paybacks, while having in mind that stability of the enterprise's profit is provided by the aggregate of components of the management system. Modern researches confirm the fact that the effect of information sector's growth reflects laws of the transition to the information society and increase of attention to information area. Significance of information for an enterprise increases with the increase of information capacity of production (correlation ratio is equal to 0,65) (Popov, 2011).

When making a comparative analysis of the management system effectiveness one has to assume that its value is proportional to the amount of information that the system generates to suppress frictions violating stable activities of production complexes. Indeed, the increase in controlling information requires innovative modernization of the system, accumulation of its capacities and values (channels of data collection, storage facilities and processors for converting information, means of their display, and so on). Therefore, in order to

assess the effectiveness of industrial enterprises and their performance it is logical to make use the information criterion, proposed in the 1960s by Trapeznikov (1983).

In its essence, part of the information is embodied in the objects of labor, the other part is accumulated in the form of knowledge, and, finally, part of it is consumed in the labour process in struggle against irregularity. In the economic system of the enterprise, information not only enters it, during management performance in the form of made decisions and reports, but it is also materialized in objects and means of labor in the form of knowledge embodied in them. Moreover, saturation with information of both the management process and means of labor makes it possible to identify localization and weakening of hindrances in the enterprise, as well as to reduce irregularity of its functioning. As a result, the economic effect of the enterprise increases with a decrease in the irregularity rate in the performance of economic systems and reduces with propagation of chaos in them.

According to the concept articulated by Trapeznikov (1983), the maximum values for the economic system effect are implemented only by rapid increase in its value (Trapeznikov, 1983). Therefore, in the framework of the statistical approach, as shown by the following analysis, there is a mathematical relationship between the volume of the source  $I_0$  and of the accumulated  $I$  information and the effect of the functioning  $E$  (in regard to the maximum possible effect  $E_{max}$ ) in the economic system (Figure 1).



**Figure 1. Relationship between the relative values of the number of controlling information  $I$  amounts and the activities effect  $E$  of the enterprise**

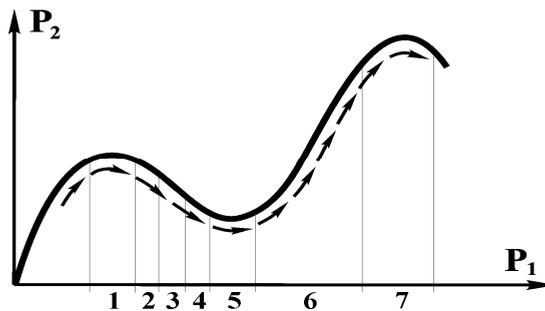
Source: Chuprov. S.V. *Management of production systems' stability: theory, methodology, practice.* 2nd ed. Irkutsk, BNUEL Publishing, 2012.

As a result, maintenance of stable level of economic effect  $E$  in the field of large values makes the enterprise increase the payback period of its management system, and within the limits of approximating its effect to the maximum  $E_{max}$  the payback period increases exponentially. Thence, while modernizing the management system in order to increase the effect level  $E$  from 0.80 to 0.90 from the maximum  $E_{max}$ , the payback period of the improved management system will increase by a factor of 1.71 in comparison with increasing the effect from 0.70 to 0.80 from  $E_{max}$ . By continuing an increase of the effect level  $E$  for the enterprise gets a payback from 0.90 to 0.95, the period of its management will increase in 2.00 compared with the option of increasing the effect from 0.80 to 0.90 of the maximum  $E_{max}$ .

The given comparative analysis of the management system effectiveness in regard to ensuring the *stable* value  $E$  of the economic effect of the enterprise resulted from the fact that in this case the effect value must be in the given interval from the lower to the upper limit. The author's calculations have confirmed that the increase of the level for stable economic effect of the enterprise's activities from  $0.80 \div 0.90$  to  $0.90 \div 0.95$  from the maximum limit  $E_{\max}$  is reached only by increasing the payback period of the management system by a factor of  $1.64 \div 2.03$  in comparison with a version of the management system modernization, providing a transition from  $0.70 \div 0.80$  to the range of  $0.80 \div 0.90$  from the maximum level  $E_{\max}$  (Chuprov, 2012).

## NONLINEAR DYNAMICS OF ECONOMIC EVOLUTION AND EFFICIENCY

Taking into account the characteristics of nonlinear processes and the nature of the economic systems' development, let's use qualitative conclusions of the mathematical "perestroikas" theory that (Arnold, 1990). Given the fact that the restructured economic system (in our case - an enterprise) is nonlinear and is in a "bad" stable-state condition, there are notable stages of its ascending development in order to move to a better stable-state condition. A visual representation of these stages is given in Figure 2, which allows us to use the following notation: P1 - the level of entrepreneurship and P2 - the level of economic efficiency of the system.



**Figure 2.** Restructuring of the economic system from the "perestroikas" theory standpoint

Source: Arnold V.I. *Catastrophe theory*. 3rd ed., ext. Moscow, Nauka Publishing, 1990.

We characterize the stages of restructuring of the economic system, marked in Fig. 2 on the abscissa axis with figures 1 to 7:

- Stage 1. Being in a stable inefficient state, the enterprise has great difficulties in overcoming the resistance of the current organization of production and management, and begins to move to a higher level of economic efficiency of its operations;
- Stage 2. The enterprise's movement gathers head, but the action of conservative forces of its economic system (outdated infrastructure, lack of investments, the inertia of the company's management style, etc.) gains strength and the level of economic efficiency of the enterprise is markedly reduced;
- Stage 3. The enterprise's movement rate increases even further, but the influence of conservative forces of its economic system still affects it and even reaches its maximum; as a result, the level of economic efficiency of the enterprise continues to decrease;

- Stage 4. Before the level of economic efficiency of the enterprise becomes minimal, the resistance of its economic system turns weak, and after its complete disappearance, gives way to the positive scenario (upgrading and increasing the flexibility of the equipment, the introduction of high-tech industries, etc.) of the enterprise resource development.
- Stage 5. Inertia of deterioration of indices for the enterprise's economic efficiency ceases, they are at the lowest level; the trajectory of movement is at its pivot point; and when the positive forces start prevailing, the level of the enterprise's economic efficiency starts rising;
- Stage 6. The movement ("pulling") towards a better, stable state gathers head; capital improvements ensure a rapid growth of economic efficiency and a progressive development of the enterprise;
- Stage 7. The enterprise movement trajectory shows that its "climbing" to the peak of economic efficiency comes to its end; thereby the enterprise gains a stable state that differs from the initial state in its higher efficiency.

From the "perestroikas" theory standpoint, a less-developed economic system gathers a better stable state, yielding lower losses than a developed one. The stability of the developed system runs it into additional trouble of gaining a stable efficient state. Moreover, if a jump, not a continuous transition, to a new, better stable state would be possible, then, when approaching it, the system would evolve ("gravitate") to it by itself.

## CONCLUSIONS

The design of innovative development of industrial complexes reveals both potential resource opportunities of Irkutsk region and, what is notable for upgrading these systems, the nonlinear dependence of their functioning efficiency on the volume of useful information coming into their management system.

Analytical value of information approach is that it allows us to further and deeper identify the existing regularities and to evaluate the amount of influence of the enterprise's knowledge on its development in the complex interaction of information, organizational, managerial, economic and other processes at the enterprise. The multifaceted development of this problem makes it possible to better understand the mechanism of an effective and stable performance of enterprises in the environment of innovative changes and the economy of knowledge.

The current theory of economic development embraces achievements from a broad range of branches of knowledge, and, primarily, those that address nonlinear processes in nature and in the society. This allows us to broaden our conceptual horizon of the innovative development of the region economic systems in terms of globalization and increasing competition on domestic and foreign markets.

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