

INNOVATIVE DEVELOPMENT PROGNOSTICATION AT THE INDUSTRIAL ENTERPRISE LEVEL

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Abstract. The article displays results of the practical approbation of the methodical approach to prognostication of the innovative development perspective directions. at the machine building enterprise LLC “Turbomach” (Sumy) by means of applying trend watching analysis. Six perspective tendencies of development were built on the basis of income data clustering and modeling.

Key words: innovative development, perspective fields, prognostication.

Introduction

At present, the enterprise activity is greatly influenced by rapid development of new technologies, science, the social and economic development orientation, competition increase, acceleration of the cycle of new goods and services introduction to the market. Under changeable environmental conditions native companies face the need to introduce new development directions, able to bring enterprises' activity to the qualitatively new level, reveal their competitive advantages and reduce faults, and also find wide market opportunities and outline threats to be avoided. Only complex efforts at creation and introduction of innovations ensure such enterprises' activity. In order to increase this process's efficiency the innovative activity is necessary to be organized. Therefore medium- and long-term prognostication is helpful tool to elaborate most advantageous and efficient strategy and tactics. In order to ensure efficient functioning of the innovative system at the industrial enterprise and to increase its competitiveness, special attention should be paid to innovative activity prognostication and perspective development directions.

The matter of innovative activity prognostication is urgent and is studied by the following native and foreign scientists: Bilovodska (2004), Volkov and Skliarenko (2003), Drucker (2003), Kvasha (2010), Kosenko (2006), Krasnokutska (2003), Kuzmin (2008), Pererva and Goncharova (1998), Rogers (2009), Chukhray (2002), Shipulina (2012), Shumpeter (1982), etc. However most works deal with approaches, based on analysis of processes development retrospective and building of their further development models. Nowadays Ukrainian industrial enterprises face the impact of environmental factors and phenomena which are only being formed but they create perspective tendencies for medium- and long-term periods. They determine main development directions both for separate enterprises and for the whole industry. Foresight, trend watching, trend hunting and trend setting are scientific directions prognosticating social and economic processes and phenomena, forming tendencies of future activities. The mentioned fields are being studied by the following native and foreign scientists: Carriero et al. (2009), Kirnos (2013), Panchenko (2011), Fedulova (2008) and others. However almost all of them regard the state activity or separate good or brand as prognostication objects.

The study of prognostication methods (Rosokhata 2013: 16) enables to select and unite methods for prognostication of innovative development perspective directions (PIDPD) at the industrial enterprises, which allow to combine the qualitative analysis of information concerning perspective development directions and their quantitative estimation with the purpose of future development models elaboration. The authoring methodical apparatus of PIDPD (Rosokhata 2014: 17) involves a complex process of prognostications, consisting of logically built stages.

Thus, the aim of the study is to develop methodic grounds for PIDPD stages implementation and their practical approbation with the purpose to trace the efficiency of their application at industrial enterprises' activity.

The research tasks and methods are:

- selection and analysis of an industrial enterprise for practical approbation;
- qualitative prognostication of innovative development directions for the chosen enterprise according to author's methodical apparatus of trend watching analysis;
- compiling the quantitative prognostication of innovative development directions for the chosen enterprise through a combination of cluster analysis and economic and mathematical modeling methods.

Due to research questions the content of the paper consists of the following sections: analysis of LLC "Turbomach", trend watching of LLC "Turbomach", clustering of perspective tendencies of LLC "Turbomach" and formation its IDPF, modelling of IDPF of LLC "Turbomach".

1. Selection and analysis of an enterprise

The approbation of the study was carried out at machine building enterprise LLC “Turbomach” (Sumy), founded in May 1999. It is one of the leading scientific and manufacturing enterprises in Sumy Region, Ukraine (21). The enterprise deals with repair and modernization of pumping and compressor equipment for chemical, petrochemical branches, power industry and metallurgy.

The conducted coefficient analysis of the financial accounting of LLC “Turbomach” proves negative changes in enterprise’s activity.

After the conducted enterprise’s inner state estimation with the purpose to substantiate PIDPD, the next step is to evaluate its market positions, based on SWOT analysis.

Thus, the strengths of LLC “Turbomach’s” activity are qualitative production, modern equipment and high image, and the weaknesses include poor marketing strategy, slow introduction of new production and high operational expenses.

Most promising opportunities are increasing the production of pumps, component parts, heating equipment and component parts for compressors and pumps, as well as the popularization of non-standard special equipment and innovative projects financing. Most probable threats are competitors’ aggressive marketing and innovative policy, political situation instability, changes in legislation and regulatory documents, and the excess demand for products and services.

The SWOT analysis results reveal the necessity of strategic orientation to innovative development. Thus, the generation and implementation of innovative projects become reasonable tasks for future. This is due to the market environment capabilities and features of LLC “Turbomash.” However, prior to generating ideas of innovative projects the most promising areas for projects implementation should be determined.

2. Trend watching of LLC “Turbomach”

The next stage of implementation of PIDPD methodic apparatus at the industrial enterprise is tendencies trend watching (Illiashenko 2014: 5). Figure 1 presents stages of trend watching analysis in the PIDPD system, and the next step is to set searching parameters for tendencies allocating.

LLC “Turbomach” is a production enterprise, and its main direction is products manufacturing. Regarding PIDPD main tasks, it is reasonably to distinguish three main criteria, which will help to choose tendencies in trend watching research, particularly:

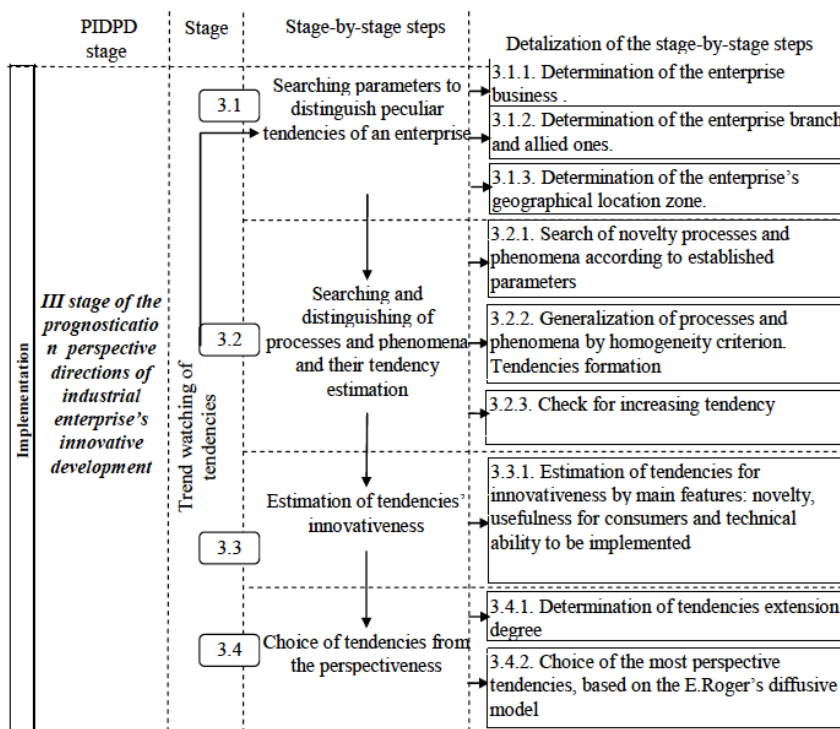
- orientation to main (producing) activity of the industrial enterprise;
- orientation to the innovative development;
- orientation to maintenance of the adopted aspects of market relations.

The given criteria give opportunity to distinguish alternative tendencies in social and economic processes and phenomena, which have already been formed and continue their formation in society (Olefrenko 2014: 12).

According to the author's approach, these phenomena within PIDPD must be chosen by the criteria of tendency, innovativeness and perspectiveness.

According to the results of trend watching analysis at LLC "Turbomach" 50 perspective tendencies were generated and selected by the tendency, innovativeness and perspectiveness criteria. These tendencies are the base for further analysis and for innovative development perspective directions (IDPD) forming at the analyzed industrial enterprise.

Figure 1. Stages to conduct trend watching analysis in the PIDPF system



3. Clustering of perspective tendencies of LLC "Turbomach" and formation its IDPF

According to author's approach of the methodic PIDPD apparatus, next stage following trend watching is perspective tendencies clustering (Rosokhata 2014: 18) and IDPD formation. This process provides consequent steps. In order to estimate tendencies quantitatively and to build income data for tendencies cluster analysis let's conduct calculation of tendencies extension speed by formula (1):

$$V = \frac{DTE}{t}, \quad (1)$$

where V is the velocity of tendency extension, %/year; DTE is the degree of tendency extension (formula(2)); t is the period of the tendency existing, years.

$$DTE = \frac{\sum_{i=1}^n \Delta RNTS_i}{PNTE} * 100\%, \quad (2)$$

where DTE is the degree of the tendency extension, %; $\Delta RNTS_i$ is the growth of the real number of tendency occurrence in i -th period, times of occurrence; $PNTE$ – potentially possible number of tendency extension cases, times of occurrence; i – ordinal number of the year from the tendency existence period; n – number of years in tendency existence period.

Having calculated tendencies extension velocity it is reasonable to estimate factors and their constituents assisting tendency extension, by methodic, presented in table 1.

According to factors' constituents estimation and tendencies extension speed, final data appears to be an incoming data for cluster analysis of the perspective tendencies. Clustering analysis of tendencies is conducted with purpose to range them by groups forming the basis for IDPD. Since the cluster analysis calculation is a complex process, some special software is reasonable to be applied. The "IBM SPSS Statistics 18" program was chosen for a cluster analysis. Tree-like clustering method was chosen for clustering analysis; Euclidean distance is the distance between objects; intergroup relations strategy is the clustering strategy.

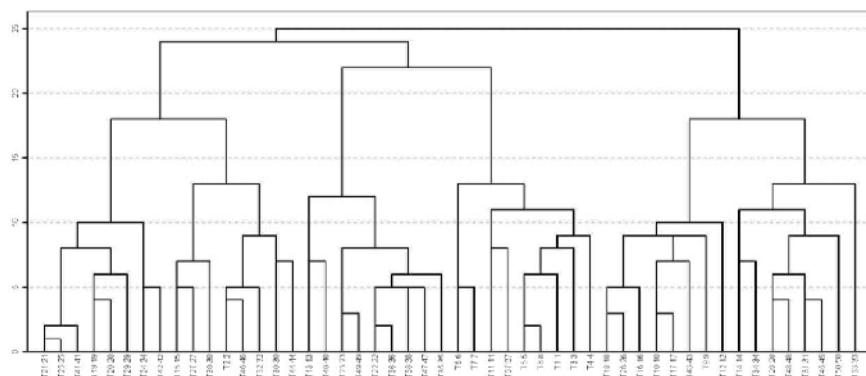
Due to the calculations, conducted in "IBM SPSS Statistics 18", results of the clustering analysis present matrix of closeness of calculated distances between objects by the chosen methodic, table of agglomeration steps i.e. regular steps of tendencies uniting into clusters; table representing which tendencies belong to clusters and the dendrogram of tendencies uniting into clusters (Figure 2).

Table 1. Factors assisting tendency extension speed

Factor code	Factor	Factor description	Determination of the factor constituent	Factor constituent	Methodic to calculate factor constituent
X_I	Relative advantages of innovation	Degree of innovation advantage against other production types (me-too products)	X_{I1}	Economy	Degree of the economy tendency
			X_{I2}	Technic- produce-ability	Degree of the technological tendency
			X_{I3}	Ecological compatibility	Degree of the ecological tendency

X_2	Innovation availability	Degree of simplicity of understanding, using and adjusting to innovation.	X_{21}	Degree of simplicity of understanding	Consumers' marketing inquiry
			X_{22}	Degree of simplicity of using	Research and expert analysis
			X_{23}	Degree of simplicity of adjusting	Analysis of the producing potential of the enterprise
X_3	Compatibility of innovation	Degree of innovation compatibility with the existing system of values, past experience and consumer's needs.	X_{31}	Compatibility of innovation with consumers' needs and demands	Marketing field studies
			X_{32}	Compatibility of innovation with social norms	Marketing cabinet studies
X_4	Approbation	Possibility of approbation in some limited scales	X_{41}	Possibility of approbation at the industrial enterprise	Analysis of the enterprise productive potential
			X_{42}	Possibility of approbation at the occupied market part	Probationary marketing, focus-groups of consumers
X_5	Communicative-ness of innovation	Possibility to extend innovation among other consumers	X_{51}	Possibility to increase market part	Diagnostics of the competitive space
			X_{52}	Possibility to increase demand	Diagnostics of the marketing communications competitiveness

Figure 2. Dendrogram of the perspective tendencies clustering at LLC "Turbomach"



The results of the cluster analysis led to conclusions, that tendencies must be divided into the following six clusters, which depend on certain factors components. Constituents of factors, which mostly impact the cluster forming, are selected by the following criterion: if a value of factor's impact on all tendencies of a cluster ranges 0,5-1, then the factor constituent has the largest influence on the IDPD extension speed. Table 2 shows the cluster analysis results and tendencies generalization in IDPD at LLC "Turbomach", particularly it represents the dependence of tendencies, united into clusters, on factors of their extension

Table 2. Interpretation of the cluster analysis data. Formation of IDPD

Cluster	Marking of tendencies, included into cluster	Generalized title of IDPF	Factors, which impact greatly the IDPF speed extension
1	$T_1, T_3, T_4, T_5, T_6, T_7, T_8, T_{11}, T_{37}$	Production of new goods and their components	$X_{11}, X_{12}, X_{22}, X_{51}$
2	$T_2, T_{15}, T_{27}, T_{30}, T_{32}, T_{39}, T_{44}, T_{46}$	Technical changes with purpose of ecologization	$X_{12}, X_{13}, X_{21}, X_{32}, X_{42}$
3	$T_9, T_{10}, T_{12}, T_{16}, T_{17}, T_{18}, T_{26}, T_{43}$	Technical changes in ergonomic features	$X_{21}, X_{31}, X_{32}, X_{51}, X_{52}$
4	$T_{13}, T_{22}, T_{23}, T_{35}, T_{36}, T_{38}, T_{40}, T_{47}, T_{49}$	Technical re-equipment of the internal mechanisms of production	$X_{11}, X_{12}, X_{23}, X_{41}$
5	$T_{14}, T_{28}, T_{31}, T_{33}, T_{34}, T_{45}, T_{48}, T_{50}$	Applying new materials	$X_{21}, X_{22}, X_{51}, X_{52}$
6	$T_{19}, T_{20}, T_{21}, T_{24}, T_{25}, T_{29}, T_{41}, T_{42}$	Improvement of production technologies and quality standards increase (including unification)	$X_{12}, X_{21}, X_{32}, X_{41}$

Note: $T_1 - T_{50}$ – perspective tendencies of LLC “Turbomach”, selected on the basis of trend watching; $X_{11}, X_{12}, X_{13}, X_{21}, \dots, X_{52}$ – relative estimations values of factors constituents, assisting extension speed.

4. Modelling of IDPF of LLC “Turbomach”

The given tendencies clusters, which form IDPD of LLC “Turbomach” are the basis for the next stage of prognostication that involves the developing of their economic and mathematic models. Modeling was carried out in *MS Excel* (path: Data/Data Analysis /Regression), where dependences of the IDPD tendencies extension speed on factors constituents were revealed. According to the received coefficients the following models are formed:

PIDPD₁ – “Manufacturing of new products and its components”:

$$S_1 = 0,077 + 0,234 \cdot X_{11} + 0,125 \cdot X_{12} - 0,152 \cdot X_{22} - 0,241 \cdot X_{51};$$

PIDPD₂ – “Technical changes with purpose of ecologization”:

$$S_2 = 0,938 - 0,145 \cdot X_{12} - 0,398 \cdot X_{13} + 0,073 \cdot X_{21} - 0,376 \cdot X_{32} - 0,149 \cdot X_{42};$$

PIDPD₃ – “Technical changes in ergonomic features”:

$$S_3 = 0,661 - 0,354 \cdot X_{21} + 0,014 \cdot X_{31} - 0,159 \cdot X_{32} - 0,186 \cdot X_{51} + 0,039 \cdot X_{52};$$

PIDPD₄ – “Technical re-equipment of the internal mechanisms in production”:

$$S_4 = 0,178 + 0,104 \cdot X_{11} - 0,27 \cdot X_{12} + 0,198 \cdot X_{23} - 0,155 \cdot X_{41};$$

PIDPD₅ – “Applying new materials”:

$$S_5 = 0,243 + 0,055 \cdot X_{21} + 0,039 \cdot X_{22} - 0,159 \cdot X_{51} - 0,11 \cdot X_{52};$$

PIDPD₆ – “Improvement of production technologies and increase of quality standards (including unification)”:

$$S_6 = 0,214 - 0,066 \cdot X_{12} - 0,061 \cdot X_{21} - 0,011 \cdot X_{32} + 0,065 \cdot X_{41};$$

where $S_1, S_2, S_3, S_4, S_5, S_6$ – speed of PIDPD₁, PIDPD₂, PIDPD₃, PIDPD₄, PIDPD₅, PIDPD₆ extension, which shows degree of IDPF tendencies introduction in potential consumers;

$X_{11}, X_{12}, X_{13}, X_{21}, \dots, X_{52}$ – relative values of estimation of factors constituents, assisting the extension speed.

According to main steps of models significance and feasibility estimation, and calculation of their accuracy, they were analyzed by the following factors: determination coefficient (R^2), conventional dispersion of the depending variable (σ^2), practical value of Fisher's statistics (F_{pr}) and significancy of models coefficients by Student's t-criterion.

Thus, result of the research enabled to form six clusters of the perspective tendencies for LLC "Turbomach" and to create its IDPD: producing of new goods and their components, technical changes with purpose of ecologization, technical changes in ergonomic features, technical re-equipment of internal production mechanisms, applying new materials, improvement of production technologies and increase of quality standards (including unification). In order to prognosticate the the given IDPD extension speeds, multi-factor regression models were created in *MS Excel*. The estimation of models' and their coefficients' accuracy, significance, feasibility and correspondence to real objects enables the prognostication of innovative projects.

Conclusions

By the completion of our investigation the following results were obtained:

- Qualitative and quantitative prognostication methods were proposed to combine to increase the degree of validity of management decisions concerning directions of innovative development. Trend watching research and analysis tools were proposed for qualitative prognostication. The quantitative prognostication should be comprised of cluster analysis and economic modeling combination. This will allow to group a large array of quality information in order to form separate innovation development directions and develop their prognostication models;
- It is recommended to search and select trends specific to enterprise's functioning according to the developed scientific and methodical approach to trend watching analysis. It involves creation trends based on processes and phenomena selected by the tendency, innovative and perspective criteria;
- Perspective directions of innovative development were proposed to be formed through cluster analysis of promising trends according to factors influencing the degree of diffusion and its quantitative evaluation. The prognostication of defined directions was recommended to execute by constructing economic and mathematical models of their distribution velocity;
- Practical approbation of developed approaches at the example of LLC "Turbomash" proved the effectiveness of authoring approaches appli-

cation at industrial enterprises. Developed models were evaluated for relevancy and feasibility by several criteria. The developed models were recommended to be applied within generation ideas of innovative projects to verify their compliance to perspective development directions.

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