Contributions to the Development of a General Methodology for Innovation and Forecasting

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ABSTRACT
The paper presents authors' contributions to the achievement of a first variant of the innovation and forecasting methodology. The various tools of TRIZ methodology (laws of systems development set for technical systems, the matrix of contradictions, the 40 inventive principles, the 39 parameters, Su-Field analysis, the method of the 9 screens etc) are already available, or can be customised to the specific type of the organization system. The TRIZ methodology for economics was embedded in a more general methodology for innovation and forecasting. The eight laws of evolution systems were customised to economics. The authors also make a comparative analysis of the technical TRIZ matrix to the company management matrix. Based on the analysis performed, it can be concluded that a general methodology can be prepared for innovation and forecasting, making use of TRIZ methodology, by customising some classical instruments of the technical field, and bringing in other specific economic tools.

KEYWORDS: *innovation, forecasting, matrix, methodology, TRIZ.*

JEL CLASSIFICATION: *C53, E17.*

INTRODUCTION

Considering the Kano model (Ionescu & Vişan, 2009) for a company, to be competitive on the market, that company should provide permanent conception of enchanting characteristics for the company's products. With this end in view, the company should operate under modern management conditions, use well defined forecasting and innovation general policy, including technological forecasting, and technological innovation, in particular.

From the specialist literature in this domain (Belous, 1990; Ionescu & Vişan, 2009; Ioniţă, 2008) the authors are acquainted with several methods of innovation and stimulation of inventiveness, based to a certain extent on algorithmic presentations. There is also available a wide range of short and long time forecasting methods, including technological forecasting, but there has not been defined a general methodology of innovation and forecasting yet. One outstanding method that could be basically used as the fundamentals of such methodology is the TRIZ method. This method combines several operation tools (Mazur, 2011) (the 40 inventive principles, the 39 parameters, the matrix of contradictions,

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ARIZ algorithm, Su-Field analysis, the 76 Standard Solutions, the 9 screens, etc.). Even if originally, this method was intended for the technical field, at present there have been made considerable steps in adapting this method to fit the non-technical domains, as well (such as economics, quality management, business, etc.). In this sense, starting from the above mentioned assumptions, this paper recommends to the professional reader a general methodology of innovation and forecasting based on TRIZ methodology, while customising part of the classical instruments available in the technical field and also adopting other instruments from economics. The authors' intention is to present this methodology as based on the TRIZ method in principal, while also making use of other known methods that have already been defined in the specialist literature, as well as original methods conceived by the authors for the purpose of this paper.

1. DETAILED STRUCTURE OF METHODOLOGY

For a detailed structure of the suggested methodology in this paper, the authors focus on a detailed analysis of the methods and operation tools customised by the authors from the TRIZ methodology; in addition the authors make use of other methods, and instruments also, assumed from the professional literature.

As a result, the detailed structure of the suggested methodology in this paper, as well as methodology stages, phases and steps are described in what follows:

STAGE 1. Analysis of the current status of an organisation (system)

Phase 1.1. Systemic and functional analysis

At this phase, a systemic and functional analysis of the organisation is provided.

Phase 1.2. Analysis of product characteristics based on Kano Model

Step 1.2.1. Analysis of delightful characteristics of each product

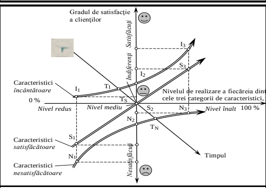
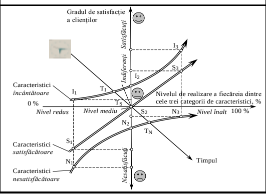
One of the most important approaches to product characteristics and the way products are perceived by clients, which we owe to Noriaki Kano (Ionescu & Vișan, 2009) is a very useful approach for a company, when dealing with their technological forecast. This is a very relevant analysis, because it shows which products of an organisation are attractive for its clients, due to their delightful characteristics. These characteristics show the level of innovation at a given moment, and therefore the lack of such characteristics implies the need for innovation. Based on clients' satisfaction criterion, Noriaki KANO provides a breakdown of a products' characteristics into three distinct groups: dissatisfactory, satisfactory and delightful characteristics.

The dissatisfactory characteristics, in the sense of a product inducing dissatisfaction, refer to those characteristics of a product which generate, either dissatisfaction, when not achieved in the finished product, achieved but failing to meet client expectations, or indifference, when achieved in the finished product at high level of expectations. In point of these characteristics awareness and perception by the clients, the dissatisfactory characteristics are „expected", or „implied"; while considering product quality, they show the expected product quality. Satisfactory characteristics are those product characteristics, which clients know, require and ask for. In the case clients find no such characteristics in the product, they would be dissatisfied. On the contrary, if they are to be found in a product, clients are satisfied. Satisfactory characteristics show the "expected quality", because they are features of a product defining for the client. Delightful characteristics are those product characteristics, which clients do not ask for, as they have no knowledge of, and consequently, the lack of these characteristics induces no dissatisfaction, but delight, or strong satisfaction, when they are identified in a product. These characteristics show the product quality, which generates client's enthusiasm.

In time, the delightful characteristics become known by all clients and competitors, successively depreciating down to unsatisfactory and even dissatisfactory characteristics of products.

To provide analysis of delightful characteristics, the authors of this paper conceived the model shown in Table 1 below.

Table 1: Model of product characteristics analysis of an organisation, based on Kano Model

Name (Code) of product	Approach model (Kano)	Categories of characteristics									
		Dissatisfactory characteristics (CN)			Satisfactory characteristics (CS)			Delightful characteristics (CI)			Total of delightful characteristics
		Name	UM	Val.	Name	UM	Val.	Name	UM	Val.	
Product 1		CN_{11} CN_{12} … CN_{1k}									
……….	………….										
Product n		CN_{n1} CN_{n2} … CN_{np}									
Total of delightful characteristics per organisation											

Source: Authors

Step 1.2.2. Determining the innovation degree of each product

Determining of the innovation level of each product can be provided by applying a customized methodology from the professional literature (Ionescu, 2007) based on the weighted sum of three indicators: one indicator corresponding to the number of delightful characteristics from Kano model, one indicator corresponding to the 5 Altshuler innovation levels and one indicator of the ideal level. The latter indicator is in its turn obtainable through weighted sum of several sub-indicators that are used to determine the degree of ideality from several points of view. The weighted sums shall be determined by using the Analytical Hierarchy Process and Thomas Saaty's scale of 9 points). To provide the innovation level assessment for a product, a global indicator is recommended of the innovation level, I_{NI}, to be determined from the equation below (Ionescu & Vişan, 2006):

$$I_{NI} = I_{SC} \cdot p_{SC} + I_{IN} \cdot p_{IN} + I_{ID} \cdot p_{ID} = I_{SD} \cdot p_{SC} + I_{IN} \cdot p_{IN} + \left(\sum_{k=1}^{9} i_k \cdot q_k \right) \cdot p_{ID}, \quad (1)$$

where p_{SC}, p_{IN} and p_{ID} are the weighted sums of the three indices, i_1, i_2, …, i_9 are the degree of ideality values, and q_1, q_2 …, q_9 are the weighted sums of degree of ideality indicators.

The weighted sum of each category is 1, namely:

$p_{SC} + p_{IN} + p_{ID} = 1$

and

$q_1 + q_2 + ... + q_9 = 1$. Depending on the domain, where the methodology is applied, certain weighted sums may be null.

The methodology can be applied in four steps, noted A, B, C and D, as detailed below:

A. To determine the indicator of client satisfaction. It has been considered necessary that the indicator of client satisfaction, I_{SC}, only refers to the delightful characteristics of Kano model, because, on the one hand, the achievement of such characteristics implies effort of innovation from the part of organisations and on the other, they are generally the decisive element for a client buying a product. For the purpose of evaluation, it is recommended that the index I_{SC} receives grades on a scale from 1 to 10, function of the identified delightful characteristics number.

B. To determine the inventiveness indicator. Considering the degree of inventiveness involved in a product, this paper suggests the customizing of products classification based on the five levels of inventiveness solutions and necessary sources of inspiration, as determined by Altshuller (Ionescu & Vişan, 2009):

- **first level products** – which imply no invention, new products being obtained through routine improvements brought onto existing products through well known methods in the field, with own knowledge as the only source of inspiration;
- **second level products** – new products obtained through minor improvements brought to existing products, having science as an inspiration source in the specific domain of designers, which are generally solved through compromise;
- **third level products** – new products achieved through fundamental improvements brought to existing products, through known methods, with solutions to be identified in related domains, or borrowed from other domains;
- **fourth level products** – products, either new in principal, or new generation products based on new principles, with solutions derived through clarification of the phenomena from different domains, less understood until that moment;
- **fifth level products** (products based on rare scientific discoveries, which essentially are altogether new products, with solutions identified through overcoming the boundaries of science, known at a given moment.

Considering this classification, the following scale is recommended for the inventiveness indicator, I_{IN},: grade 2 for the first level product, grade 4 for the second level product, grade 6 for the third level product, grade 8 for the fourth level product and grade 10 for a fifth level product.

C. To determine the ideality indicator. The ideality indicator, I_{ID}, shows the product ideality, according to specifications, as per the work (Ionescu, 2007). Quantification of product ideality level can be done on the basis of the nine indicators for ideality measurement (Ionescu & Vişan, 2009) showing the progress of a system tending towards the Ideal Final System (SFI). We recommend that these indicators are assigned grades on a scale from 1 to 10, function of their achievement level. Each indicator has the weighted sum q_i the value of which depends on the product type. These indicators and grades associated to their levels of achievement are defined below:

1. Indicator of system dimensionality, i_1 shows the product development in the sense of dimensionality degree increase: zero dimensions - 0D, Point – grade 2, one dimension - 1D, Straight line – grade 4, two dimensions - 2D, Plane – grade 6, three dimensions - 3D, Volume –grade 8, for more than three dimensions-complex structures– grade 10.

2. Indicator of aggregation state, i_2, shows the product development in the sense of its flexibility increase through change of aggregation state: solid state – grade 1, liquid state – grade 3, gaseous state – grade 5, plasma – grade 7, field – grade 9, and for vacuum state – grade 10.

3. Indicator of type, nature and frequency of actions applied on the system, or achieved by the system, i_3.: continuous actions – grade 3, vibratory actions – grade 6, vibratory actions with resonance frequency – grade 9, and for stationary waves – grade 10.

4. Indicator of system "porosity" degree, i_4, shows the increase of technical system flexibility through system development from mono-solid to fine solid dispersed particles: grade 1 for mono-solid, grade 3 for homogeneous solid, grade 5 for large voids solid, grade 7 for hollow capillaries solid, grade 9 for porous material and grade 10 for fine solid dispersed particles.

5. Indicator of system's dynamic capability, i_5: for rigid system – grade 1, for system with 1 to 3 joints – grade 3, for multi-joint system – grade 5, for elastic system – grade 7, for highly flexible system – grade 9 and flexible field system – grade 10.

6. Indicator of human factor involvement, i_6, shows the decrease of human factor involvement, with the progress of the system towards ideality: grade 3 for man-actuated systems, grade 6 for man-controlled systems, grade 9 for systems with human interface and grade 10 for autonomous and self-reproducible systems.

7. Indicator of system multiplicity, i_7: grade 2 for mono-system, grade 6 for bi-system and grade 10 for poly-system (Ionescu, 2007).

8. Indicator of nature, type and dimensionality of the system functions and properties, i_8. shows that a developed system has multiple functions achievable in different ways. The authors recommend assigning grade 2 for mono-function system, grade 6 for poly-function system and grade 10 for poly-function system with opposed functions.

9. Indicator of system convolution degree, i_9. As discussed in the works (Ionescu, 2007), the degree of convolution is expressed by the convolution coefficient Cc, which is a measure of the system ideality degree, defined as, either the ratio between the number of fields and the total number of elements in the system (substances, and fields), or the ratio between the number of functions and the total number of elements involved in carrying out system function, taking values in the range [0, 1]. Based on these assumptions, the authors suggest to grant indicator i9 the value 0 if Cc = 0, value 1 for $C_c \in (0; 0{,}15)$, value 2 for $C_c \in (0{,}15; 0{,}25)$, value 3 for $C_c \in (0{,}25; 0{,}35)$, … value 9 for $C_c \in (0{,}85; 0{,}95)$, and value 10 for $C_c \in (0{,}95; 1]$.

By analogy with the calculation procedure for the global indicator of a product quality level, the authors have focused on the analysis o two methods for determining the ideality indicator, I_{ID}, namely the weighted sum of the 9 indicators and their weighted multiplication. As a conclusion, to determine the indicator I_{ID},, it is more appropriate to use the weighted sum model, because in the case of weighted multiplication, the ideality indicator can be zero, which is not always the case. Starting from these assumptions, the ideality indicator, I_{ID}, shall be determined by aid of the formula $I_{ID} = \sum_{k=1}^{9} i_k \cdot q_k$, where i_k stands for the nine indicators of the ideality degree and q_k for their weighted sums, with the property that $\sum_{k=1}^{9} q_k = 1$. The weighted sums of indicators will be set up depending on the evaluated product (using for instance the AHP method) and will be applicable for all the products of the same category.

D. To determine the global indicator of innovation level. This indicator has been determined by aid of formula (1), on the basis of results obtained at stages A, B and C.

To efficiently operate with this methodology, a simple Excel application can be used.

Step 1.2.3. Determining the need to have new delightful characteristics for a product

Based on the results from prior steps, if the innovation level of a product has been found to be under the minimum determined level, new delightful characteristics shall be conceived for each product.

Phase 1.3. Description of the "mini-problem"

In terms of TRIZ methodology, "mini-problem" means the attempt to offer solutions, without performing a real system change, or with minimal changes brought to the system. It is a starting basis for analysis, aiming at innovation inside the organisation, through minimal changes.

Phase 1.4. Determining of conflicts (contradictions) in the system (organisation)

At this phase, the main contradictions inside the organisation must be determined, according to the distinct TRIZ categories: Determining of the "physical contradictions" (altogether opposed requirements are attached to one and the same entity) and identifying of the "technical contradictions" (improvement of one parameter brings about depreciation of another parameter). In addition, appropriate and detrimental actions are highlighted inside the system/organisation.

Phase 1.5. "Distortion" of conflicts

After determining the conflicts inside organisation, at the last phase of the first stage, the analysis of conflicts is necessary in extreme conditions, considering at least four scenarios:

- Excluding detrimental actions ⇒ Only appropriate actions are maintained (the most favourable situation)
- Excluding appropriate actions ⇒ Only detrimental actions are maintained (the most unfavourable case)
- System size tends to infinity ⇒ What happens to conflicts?
- System size tends to zero ⇒ What happens to conflicts?

Stage 2. Analysis of resources

Resources are *elements of the system* or its environment *that are not used at a given moment, but could be used to solve some problems later.* According to the specialist literature (Prakash, 2009) the main categories of resources are: *resources of space, time, materials and field, power, or system resources, operational resources and information resources.* First, they attempt to resolve contradictions or conflicts in a system, while using only internal system resources, in an effort to actually set a system as close to the Ideal

Final System. If this is not possible, they resort to external resources. Therefore, an approach to the resources analysis should be provided by phases, as follows.

Phase 2.1. Analysis of internal resources

Phase 2.2. Analysis of external resources

Phase 2.3. Description of operation time (TIME)

Time is a very important resource in system problem solving. In the analysis of time resources, it is required to perform the analysis of three periods, namely: T1 - Pre-operation, T2 - Shelf operation, T3 - Post operation period.

Phase 2.4. Description of the operation zone (SPACE)

A thorough Space and Time analysis requires a description of the zone / zones / area of operation from two points of view, namely:

- Highlighting the area/areas, where appropriate actions are manifested (ZONE 1)
- Highlighting the area / areas, where detrimental actions are manifested (ZONE 2)

Phase 2.5. Listing of internal and external resources of the system and its environment

After the analysis made at previous stages, a listing shall be provided of all internal and external resources of the system.

Stage 3. Defining the IDEAL FINAL RESULT

There is a universal criterion of choosing the best solution, i.e. ideality. After Mazur, the degree of ideality means "the ratio between the useful effects of the system and the sum of costs and detrimental effects involved in a system" (Mazur, 2011). Ideality is measurable by indicators presented at the first stage of this methodology.

The contradiction definition can be found in the principal TRIZ methods and tools under several forms, of which the most important are detailed below:

- Stating a problem as a physical contradiction. Physical contradictions *are the cause of technical contradictions*. A physical contradiction arises, when *two conflicting requirements* are attached to *one and the same item*, or object of a system. To solve physical contradictions, the Separation Principles as defined by Altshuler, are applicable, of which the most important are the Principle of Separation in Time and The Principle of Separation in Space. Solving a physical contradiction is very difficult, but if a success, this is truly an innovative revolutionary solution. In most cases, the physical contradiction cannot be resolved and the question is reworded as a technical contradiction that is to be resolved by using the Matrix of Contradictions.
- In the Su-Field method, ideality is declared as follows: *"There is an element X in action that can turn detrimental action into appropriate action";*
- In the nine-screen method and the multi-screen method, ideality is figured in the last column, where the target is shown that the system is aiming at, in the future.

Stage 4. Achieving short-term forecasts

Short-term forecasts are made by using established methods from the professional literature.

Stage 5. Achieving medium and long-term forecasts

Medium and long term forecasts are made by using established methods from the professional literature (Mazur, 2011) as well as a range of methods adapted by authors from TRIZ methodology (laws of systems evolution, the method of the 9 screens etc.).

Step 6. Achieving innovation

At this stage, a decision is made to achieve innovation through own efforts, or through purchase of licenses, know-how, etc. and the company actually performs in the innovation process, both in the case of the company products, and its organisation, using TRIZ methods and tools adapted to the economic sector, and the TRIZ methodology for management and business.

Stage 7. Evaluation of innovation economic efficiency

Economic efficiency of the innovation is evaluated through analyzing the relationship between innovation efforts and effects of innovation.

CONCLUSIONS

Based on the analysis made in this paper, it can be concluded that a general methodology for innovation and forecasting can be achieved based on TRIZ methodology, by customising part of the classical instruments of the technical field and bringing in other specific economic tools. On this basis, it can be stated that the goal set up by the authors has been achieved, namely the conception and implementation of a unified methodology for innovation and forecast. This methodology is envisaged to be based mainly on the TRIZ method, while also including other known methods presented in this report, or new methods conceived for this purpose.

The main problems that have to be solved first, before applying the TRIZ method in the case of this methodology and for the purpose of perfecting this methodology, have been considered to be the following: further methodology development, settlement of the future evolution trends of organizations, development of a model of cost estimate in the domain of innovation and forecast, development of a model for the economic efficiency assessment of innovation.

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