A NEW LOOK ON THE SYSTEM BASIS OF THE ECONOMIC BEHAVIOUR PROBLEMS

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ABSTRACT

The paper is dedicated to the exposition of the basic ideas of conceptual modelling paradigm and its implementation in COMOD-technology. The context of such technology is that only experimental data from studied objects or phenomena are used as initial information.

INTRODUCTION

The nonconventional aspects of economic behaviour implicate the use of means designed specially for management problems solution. Those means include, for example, tools of strategic marketing, innovation potential forecasting, investment planning etc. Effective theoretical methods and new technology of research are essential for the development of the complex managerial and economic systems analysis tools.

Many laboratories, research groups in universities and industrial companies are occupied with problems, related to explaining behaviour, state description and basing of evolving mechanisms of complex systems. For these purposes, specialists use an extensive empirical material. Empirical data may describe complex objects and phenomena in all accessible for studying aspects, using the whole set of practically possible observation and measuring channels, in all of the typical and special appearances of variability mechanisms, that are interesting for analysis.

COMOD-technology deals with the systems that, in broad sense, are open dynamic systems. COMOD-technology is oriented to extracting common variability mechanisms of complex systems and investigating these mechanisms with conceptual models.

Inductive approach to reconstruction idea's realisation is a base of COMOD-technology. It contains no searching procedures and oriented on qualitative methods for which system dimension is inessential. The basic concept of COMOD-technology is its ability to reconstruct «physical space» of open systems. COMOD-technology reaches its results by revealing system's behaviour types and variety of potential states. It is directed on systems' reconstruction, basing typical forms of local and global behaviour, exploring the nature of systems' inner interaction. COMOD-technology essence is determined by non-linear simulation paradigm.

THE INVESTIGATED SYSTEM'S SOURCE CONCEPTION

COMOD-technology is oriented to general system problem solving (Kachanova and Fomin 1997). A system concept serves as a researching object in COMOD-technology. The common propositions, that compose the source conception base, are as follows:

- a system manifests itself on a set of independent observation objects;
- variability of each object conforms to system's regularities;
- variability of investigated system, like variability of each object, is observed on the same indices set;
- system's essence is determined by: empirical data, the structure of indices interconnection, parameter which characterises variability mechanisms that are mapped on interconnections' structure.

Data System (DS)

DS is the initial object for COMOD-technology. It represents the system variabilities in the form of empirical data.

- DS representation form - Data-table: rows - single objects' observation, columns - indices, which characterise attributes and states of observation objects.
- DS elements - Integer or real.

- Indices set - Common for all observation objects.
- Observation data - Any observation is assumed as independent. Observation number is enough for statistical analysis of indices binary interconnections.
- Data characteristics - Data gaps are allowed, if they are not premeditated. Measurement scales may be interval, ordinal or nominal. Distribution functions have no limitations. Interconnection type also has no limitations.
- Indices variability - Reveals system's variability manifestation.

Connection Graph (CG)

While constructing the CG, all indices in DS are assumed to be equal in rights. CG is an initial general structural model of the system, in which all potentially possible types and manifestation forms of its variability are integrated (Kachanova and Fomin 1996).

- CG Structure - Vertices are indices in DS. Edges are significant connections of indices pairs.
- CG marking-out - "+" marks positive connection, "-" marks negative connection, "*" marks complex connection.
- CG marking correctness criteria - Signed balance of all cycles.

In case of undetermined indices interaction structure within a system, one may start from the mutual influence assumption, realised in full aggregates by the principle "all has an influence on all". The structure problem is resolved according to the "bottom-up" scheme, starting from a structure of all binary connections. Each binary connection is an image of integrates interaction effects in two-dimensional space. Every single binary connection does not carry the whole information about relations between the two indices. The combination of all binary connections, that contains such indices, may carry a lot of information about the investigated reality in that part of its space, in which the given connection is appeared.

When revealing each individual binary connection, its qualitative characteristic - connection's closeness - is determined. The use of this estimation is possible only in case of comparability of appearances, which forming these connections. A common condition, which provides such comparability, is the ordering of indices' values in each connection.

A binary connection represents a complex multidimensional indices dependency in a plane. If some uniform and comparable in their variability mechanisms are integrated, they generate a stochastic connection as a dominant in two-dimensional distribution. In the other cases, stochastic connection's type is complicated, what means the influence of mechanisms of various types. The occurrence of strong stochastic connection in CG indicates the system's uniformity and the action of the uniform variability mechanisms. Such type of CG is not inherent for complex systems. If CG includes complex connections then the system may contain heterogeneous processes and its variability is generated by interacted dissimilar mechanisms.

It is necessary to mark out the edges of CG with values of behaviour attributes in order to provide CG with features of a system behaviour model. Regarding the changing of indices' values, all edges have one common property - mutual data ordering for each connection. The ordering is displayed by the expression degree of monotonous compatibility character of indices values variability and contrast, with which these characteristics are observed. Monotony's conception conforms to connection's simplicity and contrast conception conforms to the strength of its appearance. The complex measure of these two properties is their sign, which in turn is a qualitative «contrast-weighted» estimation of expression degree of connection's typical monotony. Such measure expresses dominant of group, integrated on the connections, multiple interactions.

Systemological essence of signed balance criterion

Signed balance is a universal system property - system invariant (Kachanova and Fomin 1998b; Kachanova and Fomin 1996). If all of the cycles in CG meet the signed balance criterion, then DS represents a varying system with peculiar uniform behaviour. If at least one of CG cycles is unbalanced, then DS maps a system, in which multiple behaviour forms may take place.

Systemological essence of signed balance criteria is related to the principle of symmetry. If the criterion of signed balance takes place for CG then there is a certain symmetry type within the system (Kachanova and Fomin 1998b; Kachanova and Fomin 1998c). The fact of absence of signed balance in an open system's CG appears in existence of odd cycles.

Systems reconstruction conception

The following propositions compose the conception basis:

- the complex system structure is given by unbalanced signed CG; the CG's disbalance establishes the fact that an influence of multiple relations had appeared within the system, through edges marking-out;

- unbalanced CG carries information about some variants of co-ordinated marking-outs; in each variant any active multiple interconnection has only one variability type;

transmission from unbalanced CG to its variants with co-ordinated marks is provided "from bottom upwards", starting from primary CG fragments, whose essence is determined by: CG subgraphs, that considered as structures of primary system units; the ability of counting the final number of variants of co-ordinated marking of each primary system unit.

Primary system units

The structure models construction of primary system units is based on the following principles.

- "Bottom-up" - Construction process is organised using "bottom-up" induction principle. As a basic structure elements CG contradiction triangles are used.
- Locality - The complexity of contradictions' triangle is disclosed by complete quadripartite aggregates, which contain this triangle completely. Locality is determined as a multivertices structure formed from all polygons (tetrahedrons), which have contradiction triangle as a common base.
- Maximality - All the possible relations connected by one ternary relation, given by the contradiction triangle.
- Structural isolation - A many-vertices structures constructed on the locality and maximality principles, are structurally isolated in CG.
- System isolation - A structurally isolated CG fragment is a system isolated fragment (the primary system unit), if it has symmetry, which is revealed on the basis of signed balance criteria.
- Symmetry forming primary system unit - Locality is isolated into the primary system unit, if a multi-vertex structure, which consists of N tetrahedrons, meets the constrictions that allow to reveal localities with axial symmetries in CG.

Sharing structure (SHARE)

A primary system unit in COMOD-technology corresponds to a sharing structure (SHARE). The locality of primary system unit is determined by the SHARE kernel because of its particular axial symmetry. A dual-factoring is a fundamental property of SHARE. Both of the factors are formally equal in symmetric organisation of SHARE locality. They have ability of to interact, consolidate and form a unit (Fig. l).

SHARE structure	Partial CG subgraph is represented as a multi-vertices structure
KERNEL SHARE	A contradiction triangle as a base of multi-vertices structure
KERNEL BASE	The base of contradiction triangle
SPECIAL VERTEX	Contradiction triangle's vertex, which opposes the kernel base
Additional vertices	Two sets of tetrahedron's vertices
SHARE factors	The union of the set of additional vertices with the corresponding kernel base vertex

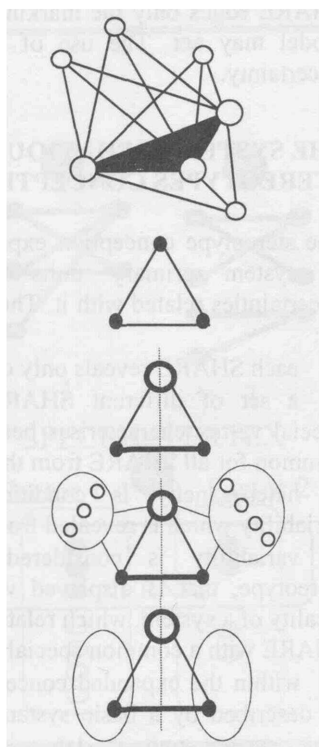
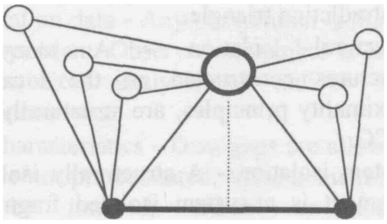


Fig. l. Sharing structures



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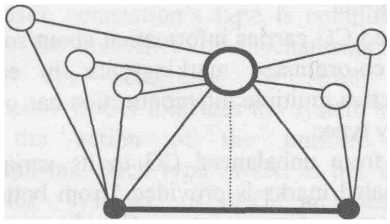

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Fig. 2. Variants of marking-out co-ordination in SHARE.

The signed balance within SHARE

Theoretically the problem of co-ordinating of edge sign marking in SHARE is always solvable (Kachanova and Fomin 1998b). The CG signed balance problem is resolved on the family of all SHARE separately for each model from this family. The kernel symmetry is significant. It asserts important morphology distinction and generates two symmetrical variants of signed balance in SHARE (Fig.2).

In both variants, a new marking-out of particular kernel edges and edges that are adjacent to their corresponding factor is determined. If sign changing of a kernel edge is theoretically correct and physically substantiated, then applying to other SHARE edges only the marking co-ordinated ideal model may act. The use of ideal model causes uncertainty.

THE SYSTEMS BEHAVIOUR STEREOTYPES CONCEPTION

The stereotype conception expands the conception of system primary units and resolves the uncertainties related with it. The expansion is based on:

- each SHARE reveals only one heterogeneity;
- a set of different SHAREs with the same special vertex characterises heterogeneities, that is common for all SHARE from this set;
- heterogeneity is conditioned by systems' variability which is revealed from empirical data;
- variability is considered as a behaviour stereotype, that is displayed within a determined locality of a system, which related with the set of all SHARE with a common special vertex;
- within the expanded conception, a system can be described by a basic system units group; each basic system unit is determined for a specific locality of a system evolved from all of the primary system units, which give the SHARE with the same special vertex; a basic system unit has, within its locality, a finite number of co-ordinated marking variants; a basic system unit with a co-ordinated marking determines a typical behaviour stereotypes, which describes a class of distinctive system's variability specific forms.

Basic system unit isolation

Following the system's source conception, contradiction triangles reveal heterogeneity, which is inherent to DS through signed balance criteria. According to systems reconstruction conception, primary system units localise DS heterogeneity and, depending on symmetry principles and dual-factor interaction, determine systemic mechanisms of their generation. Primary system units cover the whole diversity of variability of the investigated system. Basic system units allows to determine a variety of action forms of common system mechanism and offer such form as one of possible behaviour stereotypes that corresponds to a basic system unit within its locality.

- "Bottom-up" - The isolation of a basic system unit is executed by "bottom-up" induction scheme. Primary system units are used as a base for building basic system units.
- Maximality - Behaviour stereotype, typical for basic system unit, is manifested on the whole set of primary system units, which create this behaviour stereotype.
- Localisation - A behaviour stereotype is a dominant form of a system variability action of which is restricted within its locality.
- Symmetry - A basic system unit holds an axial symmetry, inherent to each integrated SHARE within it.
- Dual-factor interaction - A basic system unit inherits the dual-factorial organisation of primary system units and their ability to dual-factorial interaction with a dominant behaviour type forming.
- Polarity - Basic system units factors result from correctly oriented factors of different SHAREs.

Factor polarity

Despite the fact that polarity takes place, it doesn't appear on a set of separately studied system units, whether they are primary or basic system units. The meaning of factor polarity and the problem of their orientation determination within a system first of all should be disclosed and considered when forming basic system units from primary units with a common special vertex (Kachanova and Fomin 1998b).

Integrated SHARE (ISHARE)

In COMOD-technology, a basic system unit is ISHARE (Kachanova and Fomin 1997; Kachanova and Fomin 1998b; Kachanova and Fomin 1998c). It has the same morphology as SHARE. The kernels of all SHAREs that form ISHARE are polar. The SHARE factor polarity conforming is a necessary condition of forming a dual-factor construction of ISHARE. Dual-factor construction is a fundamental property of ISHARE (Fig.3).

Any vertex of ISHARE kernel plays a crucial role, when revealing and discovering the heterogeneities of DS. Any supplementary (out of kernel) vertex helps to reveal these heterogeneities, but it has no importance when disclosing it.

Signed balance in ISHARE

Problem of elimination of uncertainty, which occur when co-ordinating the signed marks independently from the studied SHARE, finds its principal solution within ISHARE context. During these processes, the specific role of ISHARE kernel is revealed:

- ISHARE inherits SHARE characteristics, namely, the 2-variation of co-ordinated kernel marks;
- in each variant, signed balance is achieved by changing the signs of all lateral edges of the same factor; such method is justified for all lateral kernel edges;
- possibility of lateral edges sign changing for supplementary factor's vertices is conditioned to their subordinated status system relation to kernel.

ISHARE reveals and describes the system's possible behaviour stereotypes that are conditioned by the dominance principle. The combination of all ISHARE forms reconstruction family.

THE CONCEPTION OF SYSTEM BEHAVIOUR COMPONENTS

SHARE and ISHARE solve localisation issue and revealing behaviour stereotypes. The stereotypes set

ISHARE structure	A partial CG subgraph which is the union of SHAREs
SPECIAL VERTEX	Special vertex, common for all SHARE
ISHARE kernel	Occurs when combining all of the SHARE kernels. The bases of SHARE kernels in CG form: - bounded subgraph (connected kernel); - unbounded subgraph
ISHARE factors	A union of similarly oriented SHARE factors. They are divided into subsets: - vertices, that belong to ISHARE kernel; - vertices, supplementary to ISHARE kernel (such subset must be empty)

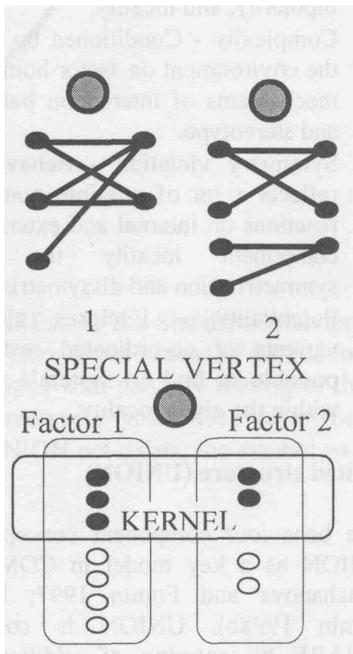

Fig.3. Integrated SHARE.

doesn't impart all forms and types variety of system variability. Components' conception develops the idea of system description by a set of its reconstruction stereotypes:

- stereotypes locality is studied through its interaction with its surrounding;
- on the base of structural and morphologically similar heterogeneities, inherent to behaviour stereotypes, complicated heterogeneities are formed, which are conditioned by system's characteristic nonlinearities;
- the term of basic system units expands to behaviour components term;
- reconstruction family of behaviour components is created.

Behaviour component isolation

Systemological essence of behaviour component is conditioned by its inherent basic properties - locality, maximality, potentiality, bipolarity, complexity.

- "Bottom-up" - The construction of behaviour component results from embedding basic system unit in environment.
- Locality - Locality of a component matches the locality of basic system unit.
- Bipolarity - Fully inherited from the basic unit and manifests through two distinguished oriented factors.
- Maximality - Obtained as a result of maximal possible expansion of a basic system unit, which keeps its characteristic features as bipolarity, and locality.
- Complexity - Conditioned by the influence of the environment on factor homogeneity and on mechanisms of interaction between the factor and stereotype.
- Symmetry violation - Behaviour component reflects a set of possible non-linear system's reactions on internal and external influence. In component locality the processes of symmetrisation and dissymetrisation occur.
- Potentiality - Encloses all characteristic variants of co-ordinated restrictions, makes possible to find all system's variability types within the given locality.

United structure (UNION)

The behaviour component concept is realised in UNION as a key model in COMOD-technology (Kachanova and Fomin 1997; Kachanova and Fomin 1998b). UNION is constructed upon ISHARE by entering of additional connections from CG. As a result of such operation unbalanced cycles arises. Hence, the problem of signed balance is newly proposed. An uncertainty appears, which may be resolved using standard models. Furthermore, there is a problem of UNION, which is related to determination of conditions of its existence. This problem of UNION is removed using interaction models and entering typical classes of marking variants.

Standard models

The standard model concept generalises restrictions co-ordinated variants in ISHARE and transfers them completely into UNION, what provides signed balance in all of the cycles. Standard model determines those additional connections, whose signs must be changed. The factors of each standard model are homogeneous, which simplifies the elaboration of the hypotheses about the mechanisms of dual-factor interaction. With such interaction, model's dominant is capable to suppress all of the other system's internal interrelation mechanisms, subjecting them to uniform behaviour - behaviour invariant.

Interactions models

Unlike ISHARE, UNION represents an open system. Global structural relations are appearing within it, which cover several different localities. Each locality represents its own UNION. The UNION problem's solution is connected with constructing models of different interaction types and their implementation to any UNION with the aim of explaining possible variety of their co-ordinated markings.

- Primary basic model - Embodies a triangle structure, is a SHARE kernel, has 4 variants of co-ordinated marking, carries a conception of standard and non-standard behaviour forms.
- Basic interaction models - Is acquired by inductive step from primary basic models to models, which consist of several contradiction triangles; each model has a special type of geometrical symmetry.
- SIM (Similarity model) - Reveals the similarity of two different SHAREs.
- SWI (Switching model) - Removes, in terms of behaviour, apparent on morphological level the heterogeneities of each of the two factors.
- ABS (Absorbing model) - Describes the mechanism of absorbing SHARE within UNION.
- SEP (Separation model) - Determines the factor heterogeneities, that are capable to have significant influence the component's behaviour.
- STR (Stratification model) - Reveals the true heterogeneities of UNION factors.
- INT (Joint influence model) - Defines the dual-factor interaction, which is made by non-standard way.

- ADD (Addition model) - Reveals basic models, which contain possible violation of dual-factor interaction.

Marking classes and behaviour variants

Despite the diversity of behaviour component variability, UNION reduces them to only two stereotypes of behaviour standards. Component has a dominant behaviour, which is formed on the base of dual-factor interaction, in spite of the standard behaviour form in UNION locality. Any type of non-standard behaviour is generated when dominance principles are violated. The violation may be caused by strong influence of environment on the component and its heterogeneities.

The problem of UNION is uniquely solved for all marking co-ordinated variant from the class 1 (areas A and B on Fig.4). For all the other marking variant classes (classes 2,3,4 and corresponding areas C, D, E on Fig.4) behaviour stereotype justifying is possible on the base of interaction models, that are capable to explain typical differences of non-standard behaviour forms. The more complex behaviour forms are investigated on global simulation stage, where the system's behaviour is studied as a whole and the interaction mechanisms between different UNIONs are resolved. UNION analysis doesn't assume the generation of all possible variants of coordinated marks with consecutive explanation of each variant. COMOD-technology determines, always, which stereotypes from four possible variants are allowed for UNION, and which deviation of its marking from standard ones could be explained on the base of interactions' models.

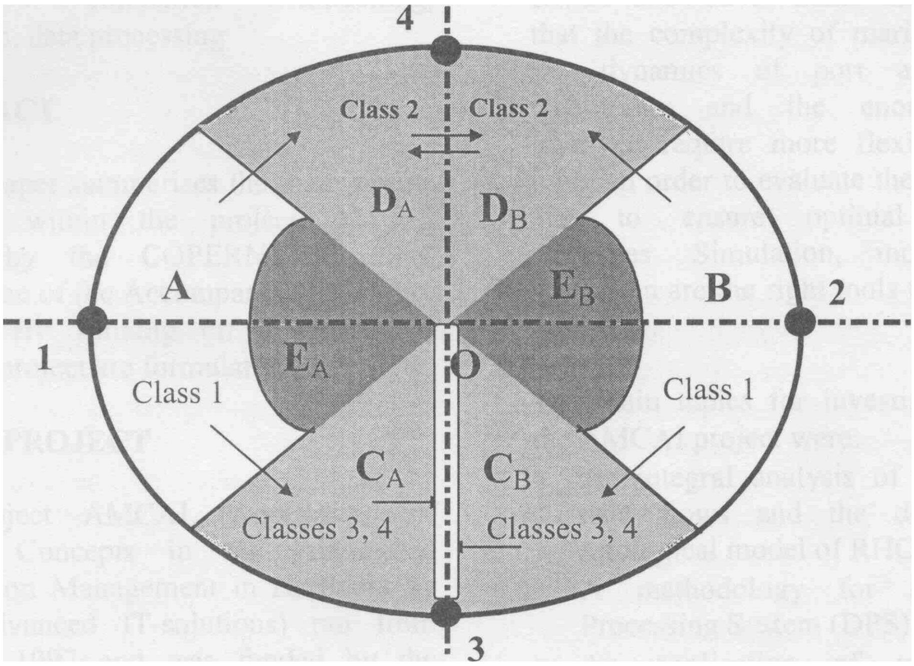

Fig. 4. Behaviour stereotypes and their changing for UNION with many SHAREs: A, B - Standard behaviour stereotypes, without changing the kernel (class 1); C_A, C_B - standard behaviour stereotypes in case of destruction of separated SHAREs (classes 3 and 4); D_A, D_B - standard behaviour stereotypes with partially loosing of the ability of united dominant forming (class 2); E_A, E_B - standard behaviour stereotypes, typical for "stereotypes mixture" C_A, D_A and C_B, D_B correspondingly (classes 2, 3 and 4); point 0 - UNION not exists; the symbol -> - stereotype changing under the influence of the environment.

RESUME

COMOD-technology application results in structured conceptual models of complex systems. Offered technology has been completely implemented in the program COMOD (COMOD 1993).

REFERENCES

SPbEEU - SIMPROMASH. 1993. *COMOD. Conceptual Modelling. User's Guide.* St.Petersburg, Russia (in Russian).

Kachanova T.L.; B.F.Fomin. 1996. "A New Theoretical Concept of Signed Balance and Systemological Platform of COMOD-technology." In *Proceedings of the 2nd International Symposium on Intelligent Systems* (St.Petersburg, Russia, Jun. 1-4). Moscow, RUDN-PAIMC, 33-38.

Kachanova T.L.; B.F.Fomin. 1997. *Reconstruction of Complex Systems Behavior Using Experimental Data.* SPbEEU Publishing Center, St.Petersburg, Russia (in Russian).

Kachanova T.L.; B.F.Fomin. 1998. *A New Methodological Platform of Systemology.* SPbEEU Publishing Center, St.Petersburg, Russia (in Russian).

Kachanova T.L.; B.F.Fomin. 1998. *Symmetries, Interactions in Localties, Behavior Components of Complex Systems.* SPbEEU Publishing Center, St.Petersburg, Russia (in Russian).

Kachanova T.L.; B.F.Fomin. 1998. *COMOD-technology. Systemology of Phenomenon.* SPbEEU Publishing Center, St.Petersburg, Russia (in Russian).