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The concept of contradiction finding and classification in the field of marketing communication quality management

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Abstract. This article presents new concept of a systematic approach to quality management of marketing communication. The major research objective was to develop a method which facilitates efficient quality management of marketing communication in a holistic manner. The elements of marketing communication are defined, and the subsystem of marketing information is distinguished. A qualitative model of marketing communication was developed referring to the basics of Qualitology and the principles of qualitative modeling, valuation and systemic approach. Using the ENV and OTSM model of TRIZ contradiction, the problem of qualitative contradictions in the marketing communication system was indicated. Grey Incidence Analysis and Theory of Correlation and Regression are used to identify the structure of marketing communication and to find contradictions within its structure. The inventive principles for solving contradictions in the field of marketing are indicated. The innovative aspect of the research consists of an application of qualitative modeling, methods of Grey System Theory and Theory of Correlation and Regression, and methods of Theory of Inventive Problem Solving. The method introduced enables the recognition and classification of contradictions on its impact for marketing communication quality. In the last section, the direction for further research in the field of systematic thinking application for marketing communication quality management is indicated.

Keywords: Systematic Thinking, Contradiction Modeling, Qualitology, Grey Relations, Marketing, Uncertain Systems, Quality Management

1 Introduction

The work considers the problem of contradictions in the area of quality management of marketing communication of industrial enterprises. The increasing complexity of production processes and the pursuit of enterprises for innovation (product, process, organizational or marketing) requires the creation of relationships with relevant market players (Pacholski et al., 2011). In the activities of industrial enterprises, several kinds of relationships can be distinguished, among others (Mantura, 2015; Morgan and Hunt,

1994): relationships with the supply market (i.e., between the company and the suppliers and co-operators in the market supply), relationship with the sales market (i.e., between the company and the clients (agents and final customers) and co-operators in the distribution channel), relationships in the system of competition (i.e., between the company and competitors, current and potential, as well as industry and non-industry), relationships with the system of power (i.e., between the company and the institutions of power), relationships with the education system (i.e., between the company and the education institutions), relationships with research system (i.e., between the firm and research institutions), relationships with social system (i.e., inter alia, opinion-forming entities that affect the way in which the public perceives changes shaped by the company in diverse activities and situations). The management of the enterprise relationships in a complex and dynamically changing market structure requires from the management the so-called new generation competences (Duncan and Moriarty, 1998) allowing for the creation of cross-functional knowledge (Korhonen-Sande, Sande, 2014) and effective adaptation of the company to changing market environment conditions (Rajnoha et al., 2014). Shaping the relationships between the company and its market environment and the relationships between functionally diverse organizational units of the company is one of the basic functions of marketing (Gummesson, 1994). The key roles here are the processes of information transfer as part of marketing communication. External Marketing Communication, i.e., communication between organizational units of the company and market environment entities, ensures the understanding the intentions, capabilities and potential of the company's partners (Andersen, 2001). Internal Marketing Communication, i.e., communication between organizational units of the company, enables, among others, recognition of the surrounding market reality from different perspectives and contributes to the so-called synergy effect in shaping the targeted changes of the company and its environment (Lu et al., 2007). Internal Marketing Communication enables the integration of information shaped by functionally diversified employees of the company. Company employees are perceived as the so-called "part-time marketers" (Gummesson, 1987). A comprehensive approach to marketing information of company employees is to improve the actions taken to adapt the company to the market environment and to impact this environment in order to achieve its own goals. The aim of this paper is to develop the concept of Contradiction Finding and Classification for improving the quality of Internal Marketing Communication of an industrial enterprise. When developing the concept of contradiction finding and classification, three different theories based on the principles of system thinking were referred to, namely:

1. basics of Qualitology (Kolman, 2009; Mantura, 2010), in order to develop a qualitative marketing communication model;
2. basic of Grey System Theory (Liu et al., 2016), to order the relations between particular features of elements belonging to the marketing communication system;
3. basics of Theory of Inventive Problem Solving (Altshuller, 1996, 1999), in order to model and solve the problem of contradictions emerging during the improvement of the quality of marketing communication.

The studies also refer to the basis of Correlation and Regression Theories, by applying the method of correlations analysis using the Pearson's linear correlation coefficient to check whether there is a problem of contradictions between the elements of marketing communication. Firstly, the paper explains the essence of qualitology, Theory of Grey Systems and Theory of Inventive Problem Solving points out the principles, methods and tools used in this work. Secondly, a qualitative model of the marketing communication system was developed, defining the set of its elements and their structure. Attention was paid to the problem of contradictions between the various qualitative categories of the marketing communication system, emerging at the stage of designing desirable quality changes. A method for classifying qualitative contradictions was developed, due to their importance determined by the impact of certain contradictions on the changes in the state of marketing information quality (cf. Cavallucci et al., 2011). Fourthly, methods and tools derived from the basics of TRIZ that support the resolution of current and significant qualitative contradictions to improve marketing communication of the company have been distinguished.

2 Characteristics of the applied concepts of system thinking

The use of methods, techniques and research tools of three different concepts that take the basis of a system approach, as well as methods of mathematical analysis of phenomena correlations, requires the indication of their essence and the relevance of applicability for solving specific problems in managing the quality of enterprise marketing communication. The subsequent subsections explain the essence, selected methods and tools of Qualitology, Theory of Grey Systems and Theory of Inventive Problem Solving.

2.1 Qualitology

Qualitology is an interdisciplinary field of knowledge dealing with all issues related to quality. Research referring to the fundamentals of Qualitology can be classified into two basic fields (Borys, 1984), i.e., Qualitonomy, as the descriptive field of the quality theory (Kolman, 2009; Mantura, 2010) and Qualimetry as the formal field in the quality theory, dealing with the use of numeric (mathematical-statistical) methods in quality theory and their application (Borys, 1984; Azgaldov et al., 2015). The general goal of qualitology is "to create a scientific basis for qualitative cognition and qualitative shaping of reality by man". The qualitative approach in researching and shaping objects is expressed in the application of the principles of a qualitative approach (Mantura, 2010), i.e., Principles of Qualitative Mapping, Principles of Anthropocentrism (humanocentrism), Principles of Complexity, Principles of Systemicity, Principles of Synergy, Principles of Kinetics, Principles of Probability, Principles of Evaluation, Principles of Optimization, Principles of Normalization and Principles of Economics. In the literature on Qualitology, it is assumed that the qualitative principles can be applied to every object being recognized or created (Mantura, 2010). In this paper, the Principle of Systemicity is applied, which consists in adopting the basics of general system theory and

treating the object as a system. The system is a set of elements remaining in mutual relations. The principle of systemicity explains the “mysterious theorem” (von Bertalanffy, 1968) that “the whole is more than the sum of parts” (Aristotle), which consists in the fact that “constitutive characteristics are not explainable from the characteristics of isolated parts” (von Bertalanffy, 1968). It is assumed that the internal structure of the object is a set of relations between the qualitative categories (features and its states) belonging to the elements of this object (subsystem), and the external structure is a set of relations between qualitative categories belonging to the object and qualitative categories belonging to the objects in its surroundings (supersystem). For our conducted research, in order to identify the relations between the elements of marketing communication, the selected methods of Grey Systems Theory were used. This work also applies the Principle of Quality Evaluation, which consists in considering the need to transform the non-evaluated (absolute) quality of objects into evaluated quality. This is connected with the Principle of Anthropocentrism, i.e., axiological approach to reality and consideration of the quality of the object in relation to the system of human needs, values, goals and requirements. Quality evaluation is associated with the so-called phenomenon of Differentiation of Valued Quality. The reason for this phenomenon is the antinomy (contradiction) of the nature of the features evaluated on the basis of various criteria for assessing their value. This means that a feature belonging to an object can simultaneously take the form of:

1. maximizing, more-is-better (stimulant), i.e., a quantity that is beneficial for large values from the variability range of the feature;
2. minimizing, less-is-better (drawback, destimulant), i.e., a quantity favourable for small values from the variability range of the feature;
3. optimizing (mediment), i.e., the quantity used for intermediate values from the feature variability range (Kolman, 2009, p. 66).

In the research conducted for the solution of the emerging problem of qualitative contradictions, reference was made to the fundamental postulate of classical TRIZ, postulate of contradictions and methods for modeling contradictions for business and management.

2.2 Grey System Theory

Theory of Grey Systems was introduced relatively recently in China, in 1982. It was created by a Chinese scholar, Professor Deng Julong, and presented in the publication entitled “The Control Problems of Grey Systems” (Liu and Lin, 2006; Cempel, 2014; Liu et al., 2016). It is assumed, like in control theory, that the darkness of colours is used to indicate the degree of clarity of information. The word “black” is employed to represent unknown information, “white” for completely known information, and “grey” for that information which is partially known and partially unknown (Liu and Lin, 2006). Research methods and procedures developed within the framework of Grey Systems Theory entitle to inference based on incomplete, uncertain and few information about the systems being studied (Liu and Lin, 2006). In the conducted research, the state of quality of particular elements in the marketing communication system is

evaluated by the employees of a company's organizational units. Therefore, in the conducted research it is assumed that incomplete information means a limited, for pragmatic reasons, set of characteristics defining the individual elements in the marketing communication system. An uncertainty of information results from the human cognitive limitation and the experience of people who evaluated the state of the features belonging to the elements of the marketing communication system. Limited information refers to the research sample. Grey methods define the system mapping procedure based on the minimum sample $n \geq 4$ (Cempel, 2014). On the basis of the concept of Contradiction Finding and Classification for improving the quality of marketing communication, Grey Incidence Analysis (GIA) method of Grey Relationship Analysis was applied. These methods refer to resolving problems such as which factors among the many are more important than others, have more effects on the future development of the systems than others, cause desirable changes in the systems so that these factors need to be strengthened or hinder a desirable development of the systems therefore they need to be controlled (Liu, Lin, 2006). For such a future research objective, the basis of cooperative grey games, to capture the dynamics of interaction among individual assessment of the quality of marketing communication, can be applied (Fang et al., 2010; Palancia et al., 2017).

2.3 Theory of Inventive Problem Solving

Theory of Inventive Problem Solving was developed by Genrich Saulovich Altshuller in the period from 1946 to 1998, for the need of systematizing methods of solving creative issues (Skoryna and Cempel, 2010). The essence of the developed concepts, in the most general terms, is to “help the inventor to use his current inventory of knowledge and experience most effectively” (Altshuller, 1975) by adopting a systematic approach to solving complex problems. Theory of Inventive Problem Solving (TRIZ) has been greatly developed and has demonstrated great efficacy in solving difficult technical problems. The current stage of TRIZ evolution and its popularity has been illustrated by world interest in TRIZ, intensity of TRIZ usage in industry and what its recognized area of application is, and how aware the world is of TRIZ compared to other innovation methodologies (Abramov and Sobolev, 2019). Initially, TRIZ was used only to solve technical problems, but over time its application has expanded into organizational, educational and social problems as well as the ones related to broadly understood business. For example, 40 Inventive Principles in Quality Management have been developed that include fields of quality standards, quality control, quality assurance, reliability, customer focus, supplier selection, project management, and improvement teams (Retseptor, 2003), 12 innovation principles for business and management (Ruchti and Livotov, 2001). It is pointed out that the application of TRIZ for business and management has worked in such areas of business operations as, e.g., increasing sales effectiveness, generating a new marketing concept, product or process, analysing customers behaviours and their preferences related with innovativeness of products, resolving a number of conflicts within a supply chain, discovering a new market for a service, predicting potential failures of a new business model, generating radically new advertising concepts, and risk management (Monnier, 2004; Souchkov,

2007; Regazzoni and Russo, 2011; Pryda et al., 2018; Renaud et al., 2018, Koziółek, 2019).

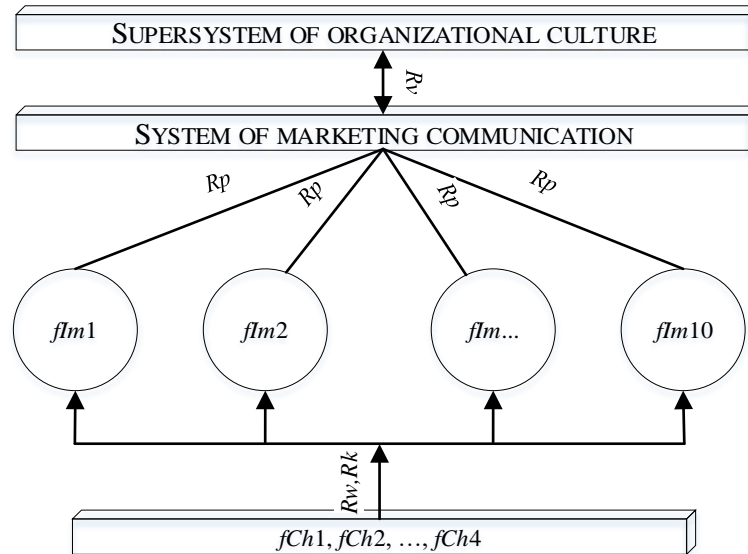
As part of the TRIZ, the principles of guiding thinking in solving inventive tasks have been defined (just principles and not specific formulas and rules) for organizing creative thinking independently of the area of human activity (Altshuller, 1975). The classical TRIZ is based on three Fundamental Postulates, such as: first, postulate of objective laws, which means that engineering systems evolve not randomly but according to certain laws of evolution. Secondly, postulate of contradictions, which means that the inventive task is characterized by the fact that it requires the solution of the so-called technical, physical or administrative contradictions (Altshuller, 1975). These contradictions emerge when the improvement of certain system properties comes into conflict with another of its properties (Andrzejewski and Jadcowski, 2013). Altshuller states that the origin of any innovation problem is a contradiction: "Any problem, to be solved with TRIZ, must be formulated in such a way that it states a contradiction" (Khadija et al., 2019). Third, postulate of the specific situation, which means that each Inventive (non-typical, creative) problem arises within its own individual context (Khomeenko and Ashtiani, 2007). Classic TRIZ solutions include ARIZ (Algorithm for Inventive Problem Solving), Inventive Standards, Substance-Field. A set of complementary theories originated by TRIZ can also be distinguished, i.e., Theory of Technical System Evolution (TRTS in Russian) and Theory of the Development of Creative Personalities (TRTL), and he promoted the initiative to build a General Theory of Powerful Thinking (OTSM), which helps with the development of powerful thinking skills (Altshuller and Filkovsky, 1975 in: Cascini, 2012). While developing the concept of contradiction finding and classification, in order to improve the quality of marketing communication, the contradiction toolkit (Gadd, 2011) and the ENV model were adopted, taking into account the need to classify contradictions regarding their importance (Cavallucci et al., 2011) to positive qualitative changes in marketing communication. Contradiction modeling has been applied to identify or solve, e.g., engineering, education, managing, knowledge management, sociological problems (Messoudene, 2018; Nakagawa; 2018; Slim et al., 2018; Livotov et al., 2019). As a result of the analysis of current research work, it can be concluded that selected TRIZ methods and tools are used to solve problems in the area of marketing (Semenova, 2004), the need to consider the role of marketing in engineering creativity, especially relationship marketing, which supports integration of different sources of information (Belski et al., 2019) is indicated. Furthermore, attention is drawn to the diverse problems emerging in TRIZ application in marketing management and the need to conduct research that may lead to their solution (Zouaoua et al., 2010). Research is also being conducted in which TRIZ combines with uncertainty methods such as Grey Relation Analysis (Lin et al., 2011) or Fuzzy Logic (Su and Lin, 2008) and indicates TRIZ application to deal with volatility, uncertainty, complexity, and ambiguity in the world (Kiesel and Hammer, 2018). The innovative aspect of the concept of Contradiction Finding and Classification proposed in this paper is the application of the principles and fundamental operation of quality, methods of Grey System Theory and the Theory of Correlation and Tgression and the methods of the Theory of Inventive Problem Solving for improving the quality of marketing communication.

3 Marketing communication system

In an etymological sense, the term “communication” derives from the Latin *communicare* (i.e., to be in a relationship with, participate in, associate with). Goban-Klas (2001, p. 43) indicates that for some authors communication denotes all forms of information transfer, both between people and between animals and machines. In this work, the approach used in social sciences, especially in sociology, is adopted, and the scope of marketing communication is limited to the transmission of information between people and market players. Marketing communication is the transmission of marketing information between entities on the market (Mantura, 2012; Wiktor, 2013). In our research, the Internal Marketing Communication of the company is considered which, taken individually occurs under the name of the Marketing Communication Process. This process illustrates the transmission of marketing information between the organizational units of the company. The marketing communication process is mapped by a specific arrangement of elements such as (see Lasswell, 1968; Westley, MacLean, 1957; Mantura, 2012): entering the marketing communication process (i.e., source of marketing information, reality components, market objects), the subject of action in the marketing communication process (i.e., organizational units of the enterprise, which are characterized by a specific semiotic system, a conceptual thesaurus and knowledge), tools of action in the marketing communication process (i.e., marketing communication channel and marketing communication tools, means of communication), object of action in the marketing communication process (i.e., marketing information, content, message), result of actions in the marketing communication process (i.e., the message of marketing information received), the exit from the marketing communication process (i.e., the recipient's reaction, and the qualitative change in the market situation). Internal Marketing Communication occurs in a specific organizational culture of the company. Specifying the term organizational culture, for research purposes of this work, the approach according to E.H. Schein (2004) is adopted. He indicates that the essence of organizational culture is a set of basic beliefs that have been established or adopted in order to solve the difficulties faced by the organization, adapting to external conditions and internal integration. Treating the organizational culture as a product of social interaction, Schein distinguishes its three levels: basic assumptions (which form the foundation for other cultural components, define the essence of existence, human nature, reality and the perception of truth), norms and values (which constitute a set of principles of everyday activities of group members, which are shaped by the impact of dominant values and thanks to them, the group members know how to cope in specific situations), and artefacts (which are manifestations of culture, but do not constitute its essence). The basic assumptions are defined, e.g., by the attitude to the environment, explanation of the nature of reality, beliefs about human nature, human activity, interpersonal relations. Standards and values are determined by, among others, values and norms declared, values and norms observed. Artefacts are determined by language artefacts, behavioural artefacts, and physical artefacts.

4 The quality of the marketing communication system

According to the basics of Qualitology, the work adopts an epistemological (descriptive) definition of quality and the axiological criterion of the value of objects, defining the valued (relative) quality of objects. In this approach, the quality is expressed in a set of features, and the quality of an object is a set of features belonging to it (Mantura, 2010, p. 49). Determining the quality of any object consists in recognizing, postulating and formulating a set of features belonging to it. The quality of the object is described by a finite set of features. The quality of the object is treated in a holistic approach, i.e., it is expressed by a set of features that belong to it and their structure. In fact, the features are identified on objects only in the form of specific own conditions/states. The state of quality of the object determines at least one state of each feature belonging to it. Conceptualization of features belonging to the object and their states in the Value Relation (Rv) with a defined system of human needs, goals and requirements is the basis for transforming the quality of the object into a valued (relative) state of the object's quality. The general and universal criterion of quality evaluation is the effectiveness of satisfying the set of needs, achieving goals and meeting human requirements (Mantura, 2010). The overall marketing communication quality model is presented in Figure 1.



Here, $flm1, flm2, \dots, flm10$: the features belonging to marketing information; $fCh1, fCh2, \dots, fCh4$: the features belonging to the marketing communication channel; Rv : Value Relation; Rw : Relation of Impact; Rk : Correlation between the states of individual features belonging to the communication channel and the states of features belonging to the marketing information.

Fig. 1. The qualitative model of marketing communication (Source: own elaboration).

Value Relation refers to the relationship between the state of marketing communication quality and usability in achieving the goals and functions of marketing in the company's

organizational culture. According to the paradigm of systemic thinking adopted in the work, the goal of the existence of a given system (i.e., marketing communication of a company) is determined by the objective of its environment, the supersystem it belongs to (i.e., the supersystem of marketing in the organizational culture of the company). Relation of Impact expresses the so-called causality ratio (cf. Kotarbiński, 1975) between elements occurring in the form of causes and elements occurring in the form of effects. In this paper, referring to the basics of information theory, it is assumed that the state of the quality of marketing information is influenced by features belonging to the marketing communication channel. The adequacy of these assumptions has been empirically verified in the authors' earlier research work, concerning the development of Integrated Marketing Communication Quality Management Method in the industrial company. The qualitative model of marketing information was tested by thirty industrial companies and the relation between the marketing communication channel (i.e., frequency of using a specific form of marketing communication channel, such as, advertising tools, public, sales activation, direct marketing, personal sales, personal promotion and partnership with market entities, or internal marketing communication tools) and the states marketing information quality was confirmed (Majchrzak, 2018). In this paper, the marketing communication channel is defined only by the methods of internal marketing communication, such as, personal meetings, phone calls, e-mail messages, interactive multimedia communication. Correlation allows to recognize whether the change (increase / decrease) in the state of features belonging to the communication channel is accompanied by the change (increase / decrease) in the state of features belonging to marketing information. Recognizing the direction of correlation makes it possible to check whether a given feature belonging to organizational units or marketing communication channels is a feature of a minimizing nature (the smaller the value the better) or the maximizing (the higher the value the better) in relation to a given feature belonging to marketing information. In order to identify the problem of qualitative contradictions in the marketing communication system, the selected elements were determined in accordance with ENV model (Element, Name of the property, Value of the property), which is a universal model adopted in OTSM-TRIZ for representing any kind of problematic situation (Cascini, 2012). The results of modeling the quality of marketing information and the marketing communication channel based on the ENV model are summarized in Table 1. The research assumes the interrelation between the specified elements of the marketing communication system. It is assumed that changing one part of the system has a negative effect on other parts of the system (Altshuller, 1994). The problem of contradictions in the marketing communication system is determined using the model of a contradiction, consists in at least three parameters (Khomenko et al., 2007), where:

1. Evaluation Parameters (EP), constituting a measure of system satisfaction requirements, refer to the state of the at least two features of marketing information;
2. Control Parameter (CP) whose value impacts, with opposite results, both the Evaluation Parameters, refers to the state of features of the marketing communication channel.

Table 1. Qualitative modeling of marketing communication according to ENV model.

| Element | Name | Values |
|---|---|--|
| Marketing Information (<i>Im</i>) | Features belonging to marketing information, such as: f_1^{Im} (amount), f_2^{Im} (understandability), f_3^{Im} (relevancy), f_4^{Im} (completeness), f_5^{Im} (free of error), f_6^{Im} (security), f_7^{Im} (timeliness), f_8^{Im} (accessibility), f_9^{Im} (believability), f_{10}^{Im} (ease of operation) | States of features values: 5 (very favorable), 4 (favorable), 3 (average), 2 (unfavorable), 1 (very unfavorable). |
| Marketing Communication Channel (<i>Ch</i>) | Features belonging to marketing communication channel, such as: f_1^{Ch} (personal meetings), f_2^{Ch} (phone calls), f_3^{Ch} (e-mail messages), f_4^{Ch} (interactive multimedia communication). | Frequency of use: 5 (very frequent) 4 (frequent), 3 (medium), 2 (rare), 1 (very rare). |

Source: Own elaboration based on Lee et al., 2002.

Contradiction occurs when two Evaluation Parameters are coupled in such a way that the attempt of improving any of them determines the worsening of the other (Cascini, 2012), which is shown in Figure 2.

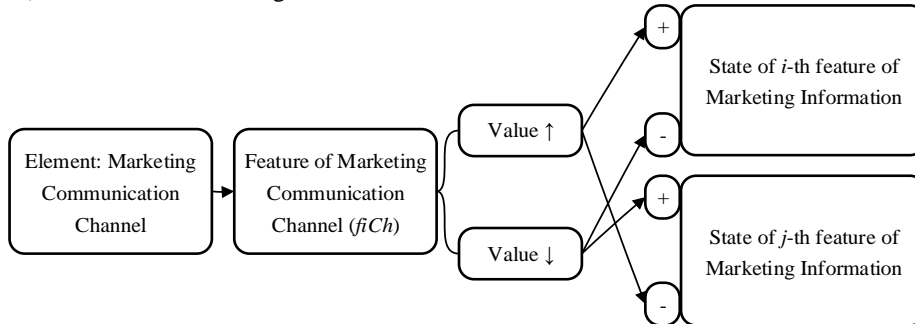


Fig. 2. OTSM model of TRIZ contradiction in the marketing communication system (Source: own elaboration).

When developing the concept of Contradiction Finding and Classification, the set of contradictions between the various features of the marketing communication channel and the features of marketing information is defined first. Then, the contradictions according to their importance are classified for positive changes in the quality of marketing information in a comprehensive approach.

5 Stages of contradiction finding and classification

Contradictions between specific elements of marketing communication are identified by recognizing the Relation of Impact and Correlation between the various features of the marketing communication channel and marketing information. Another method of contradiction finding based on functional analysis was presented, e.g., in the problem product from the function of the product (Yang et al., 2018). In order to recognize the implementation of the influence, the method of studying Grey Relations of the Grey Systems Theory was used (Liu, Lin, 2006). This method allows to check whether and what is the strength of the impact of particular system factors (*CP*: control parameters) on specific system characteristics (*EP*: evaluation parameters) (Liu, Lin, 2006, p. 120). The level of impact of system factors on the nature of the system is identified by calculating the ratio of the absolute (total) impact ε_{ij} . The coefficient of impact ε_{ij} between the vectors of variable factors, X_i , and the characteristics, Y_j , of the system was chosen due to its following properties, significant in the study of the impact relationship between the specific elements of the marketing communication system (Liu, Lin, 2006, p. 112; Cempel, 2014, p. 15):

1. $0 < \varepsilon_{ij} \leq 1$;
 ε_{ji} is only related to the geometric shapes of X_i and Y_j , and has nothing to do with the spatial positions of X_i and Y_j or in other words, moving horizontally does not change the value of the absolute degree of grey incidences;
2. any two sequences are not absolutely unrelated, that is ε_{ji} never equals zero,
3. the more X_i and Y_j are geometrically similar, the greater ε_{ij} ;
 when X_i and Y_j are parallel, or Y_j^0 vibrating around X_i^0 with the area of the parts with Y_j^0 on the top of X_i^0 being equal to that of the parts with Y_j^0 beneath X_i^0 , $\varepsilon_{ij}=1$;
4. when any one of the data values in X_i or Y_j changes, ε_{ij} also changes accordingly;
5. when the lengths of X_i and Y_j change, ε_{ij} also changes accordingly;
6. $\varepsilon_{ii} = 1$, $\varepsilon_{jj} = 1$;
7. $\varepsilon_{ji} = \varepsilon_{ij}$.

In studies on grey relationship, different types of sequences of variable factors and system characteristics were specified, including: behavioural sequence (sequence of variables versus system observation conditions, e.g., evaluation of the same variable by different experts, in different conditions), behavioural time sequence (evaluation of the same variable determined at different times), behavioural criterion sequence (e.g., different system characteristics are evaluated by various experts), behavioural horizontal sequence (e.g., the value of a given characteristic is determined for different objects) (Liu, Lin, 2006, p. 88). The individual calculation activities carried out in the method of testing grey relationships between control and evaluation parameters are explained below.

Operation 1. Determining the sequence of variable factors, X_i , and characteristics, Y_j , of the system:

$$\begin{aligned}
X_1 &= [x_1(1), x_1(2), \dots, x_1(n)], \\
X_2 &= [x_2(1), x_2(2), \dots, x_2(n)], \\
X_3 &= [x_3(1), x_3(2), \dots, x_3(n)], \\
X_4 &= [x_4(1), x_4(2), \dots, x_4(n)]. \\
Y_1 &= [y_1(1), y_1(2), \dots, y_1(n)], \\
Y_2 &= [y_2(1), y_2(2), \dots, y_2(n)], \\
&\vdots \\
&\vdots \\
&\vdots \\
Y_{10} &= [y_{10}(1), y_{10}(2), \dots, y_{10}(n)].
\end{aligned}$$

Here, X_1 : vector of variable feature states, f_1^{Ch} (personal meetings), X_2 : vector of variable feature states f_2^{Ch} (telephone conversations), X_3 : vector of variable feature states f_3^{Ch} (e-mail messages), X_4 : vector of variable feature states f_4^{Ch} (interactive multimedia communication). Furthermore, Y_1 : vector of variable feature states f_1^{Im} (amount), Y_2 : vector of variable feature states f_2^{Im} (understandability), Y_3 : vector of variable feature states f_3^{Im} (relevancy), Y_4 : vector of variable feature states f_4^{Im} (completeness), Y_5 : vector of variable feature states f_5^{Im} (free of error), Y_6 : vector of variable feature states f_6^{Im} (security), Y_7 : vector of variable feature states f_7^{Im} (timeliness), Y_8 : vector of variable feature states f_8^{Im} (accessibility), Y_9 : vector of variable feature states f_9^{Im} (believability), and Y_{10} : vector of variable feature states f_{10}^{Im} (ease of operation).

Operation 2. Transformation of the observation vectors against the zero starting point operator (Liu, Lin, 2006, p. 102):

$$\begin{aligned}
X_i D &= (x_i(1)d, x_i(2)d, \dots, x_i(n)d), \\
Y_j D &= (y_j(1)d, y_j(2)d, \dots, y_j(n)d), \\
x_i(k)d &= x_i(k) - x_i(1), \\
y_j(k)d &= y_j(k) - y_j(1).
\end{aligned}$$

Here, $X_i D$: the image of the i -th observation vector of the system behavior transformed with respect to the operator of the zero starting point, $Y_j D$: image of the j -th observation vector of system behaviour transformed against the zero starting point operator, i - system factor (i.e., control factor), j : system characteristics (i.e., evaluation factors).

Operation 3. Calculation of behaviour measures of system observation vectors by adding, subtracting and the quotient of their values (Liu, Lin, 2006, 104):

$$\begin{aligned}
|s_i| &= \left| \sum_{k=2}^{n-1} x_i(k)d + \frac{1}{2} x_i(n)d \right|, \\
|s_j| &= \left| \sum_{k=2}^{n-1} y_j(k)d + \frac{1}{2} y_j(n)d \right|,
\end{aligned}$$

$$|s_j - s_i| = \left| \sum_{k=2}^{n-1} [y_j(k)d - x_i(k)d] + \frac{1}{2} [y_j(n)d - x_i(n)d] \right|.$$

Here, $|s_i|$: measure of the behaviour of the i -th factor of the system, $|s_j|$: a measure of the behaviour of the j -th system characteristic; $|s_j - s_i|$: measure of the behaviour of the i -th factor systems relative to the j -th characteristic of the system.

Operation 4. Calculation of the value of the impact coefficient ε_{ij} between specific factors and system characteristics (Liu, Lin, 2006, 103):

$$\varepsilon_{ij} = \frac{1 + |s_i| + |s_j|}{1 + |s_i| + |s_j| + |s_j - s_i|}.$$

Here, ε_{ij} : coefficient of absolute level of impact between the i -th factor of the system, and j -th system characteristic. The coefficient of the absolute level of influence, ε_{ij} , takes values within the range of variability $[0,1]$. The higher the value of the coefficient, the greater the impact of the i -th factor of the system on the j -th characteristic of the system.

Operation 5. Adding the values of impact coefficients ε_{ij} for each of the system's factors and ordering the system's factors in relation to the strength of their impact on the system's characteristics (cf. Liu, Lin, 2006, 130). This leads to the ordering of features belonging to the communication channel in relation to the strength of their impact on the state of features belonging to marketing information.

Example:

$$f_1^{Ch} > f_4^{Ch} > f_3^{Ch} > f_2^{Ch}.$$

Thus, the feature f_1^{Ch} (personal meetings) has the greatest impact on changes in the quality state of marketing information.

The purpose of the next calculation activities is to recognize the direction of correlation between the states of marketing communication features and the states of marketing information features. To accomplish this goal, the method of analysis of phenomena correlations using the Pearson's linear correlation coefficient was used. The individual computational activities carried out in the method of analysing the phenomena correlations are explained below.

Operation 6. Calculation of the value of the Pearson correlation coefficient r according to the formula (Rutkowski, 2004, p. 30 and p. 99):

$$r = \frac{\frac{1}{N} \sum_j (y_j - \bar{y})(x_i - \bar{x})}{S_y S_x},$$

for

$$S_y = \sqrt{\frac{1}{N} \sum_j (y_j - \bar{y})^2},$$

$$S_x = \sqrt{\frac{1}{N} \sum_i (x_i - \bar{x})^2}.$$

Here, x_i, y_j : particular variables of vectors X_i and Y_j , \bar{x}, \bar{y} : mean values of variables, S_x, S_y : standard deviation of independent variables x and dependent variables y , and N : population size.

The Pearson correlation coefficient r takes values in the range of variability from -1 to 1. The sign of the r Pearson correlation coefficient informs about the direction of correlation. Positive correlation means that the features of the marketing communication channel are the characteristics of the maximal character, and the negative correlation indicates the characteristics of a less-is-better nature in relation to the features of marketing information. The recognized character of features is put together in the so-called Contradiction Matrix.

Example:

$$CM = \begin{array}{ccccc} & f_1^{Im} & f_2^{Im} & \dots & f_{10}^{Im} \\ f_1^{Ch} & \uparrow & \uparrow & \uparrow & \uparrow \\ f_2^{Ch} & \downarrow & \downarrow & \downarrow & \uparrow \\ f_3^{Ch} & \downarrow & \downarrow & \downarrow & \downarrow \\ f_4^{Ch} & \uparrow & \uparrow & \downarrow & \downarrow \end{array}$$

Here, CM : contradiction matrix; \uparrow : the feature of the communication channel of a maximizing character; \downarrow : minimizing in relation to individual features of marketing information.

Thus, referring to the example presented it was recognized, that for features f_1^{Ch} and f_3^{Ch} , there is no opposite correlation with the features belonging to marketing information. Therefore, to improve the quality of marketing information, the value of the feature f_1^{Ch} should be increased and the value of the feature f_3^{Ch} belonging to the marketing communication channel should be reduced. The occurrence of contradictions for the feature f_2^{Ch} and feature f_4^{Ch} was identified:

1. increasing the value of the feature f_2^{Ch} positively affects the state of the feature f_{10}^{Im} , and negatively the state of the features f_1^{Im}, f_2^{Im} ;
2. increasing the value of the feature f_4^{Ch} positively affects the state of the feature f_1^{Im} , f_2^{Im} , and negatively the state of the features f_{10}^{Im} .

At this stage, the results of the Relation of Impact study are taken into account, and the set of ordered features of the marketing communication channel is checked against the strength of their impact on the state of marketing information features (Operation 5). Identified contradictions are classified in relation to the strength of the impact relation of Control Parameters on changes in the value of Evaluation Parameters (cf. Cavallucci et al., 2011; Becattini et al., 2011).

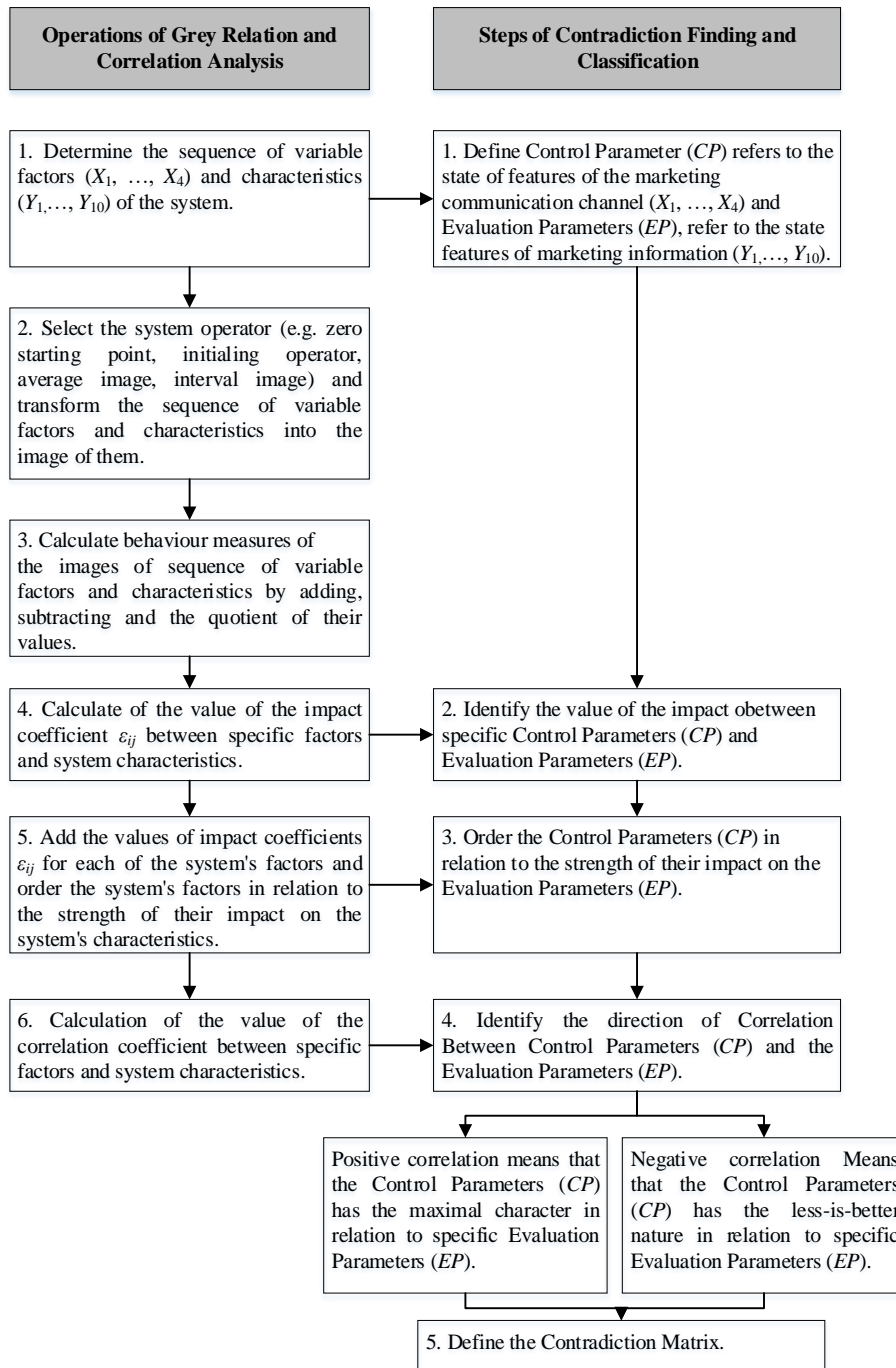


Fig. 3. The course of the operations and steps in contradiction finding and classification in the field of marketing (Source: own elaboration).

When designing qualitative changes, first of all it is considered what should be the state of those control parameters which have the strongest impact on the changes in the evaluation parameters. In accordance with the assumption that those elements of the system which have the greatest impact on changing the desired features of the system should be changed in the first place (cf. Gadd, 2011, p. 104). The course of the proposed operations and the steps applied in concept of contradiction finding and classification in the field of marketing communication quality management is shown in Figure 3. The operations refer to the specified methods of Grey Relation Analysis and Correlation Analysis. The results of specific operations are applied to achieve objectives of proposed steps in contradiction finding and classification. In solving the problem of contradictions, the problem of physical contradictions is first considered and a set of principles of separation applied, and then it refers to a set of appropriately selected inventive principles for solving problems of technical contradictions (cf. Gadd, 2011, pp. 120-134). A specific set of inventive principles is of general nature and should be adapted and applied taking into account the specifics of the problem being resolved (Altshuler, 1975). In solving the problem of qualitative contradictions in the marketing communication system, interpretations of standard inventive principles are used to solve problems in the area of marketing (Retseptor, 2005).

6 Conclusion and Outlook

This paper deals with the problems of identifying and classifying contradictions for the purpose of managing the quality of marketing communication of an industrial enterprise. In our developed method, reference was made to the basic principles and operations of Qualitology, i.e., the Principle of Qualitative Mapping, Principle of Systematicity, and Principle of Quality Evaluation. At the stage of qualitative contradictions modeling, the ENV and OTSM models of TRIZ contradiction were used. The Evaluation Parameters (*EP*) in the conducted research refer to the state of the marketing information features, and the Control Parameter (*CP*) refers to the state of features of the marketing communication channel. In order to determine the impact relation between Control Parameter (*CP*) and Evaluation Parameters (*EP*), Grey Incidence Analysis method was used. In order to determine the direction of correlation between Control Parameter (*CP*) and Evaluation Parameters (*EP*), the method of analysis of phenomena correlations using the Pearson's linear correlation coefficient was applied. It has been assumed that when designing qualitative changes, the most important issues is to consider what should be the state of Control Parameters, which have the strongest impact on the changes in the Evaluation Parameters in the overall approach. It was pointed out that by solving the problem of qualitative contradictions, a set of separation principles is applied first, and then it refers to the interpretation of standard inventive principles developed for solving problems in the area of marketing. The course of this research process is shown in Figure 4.

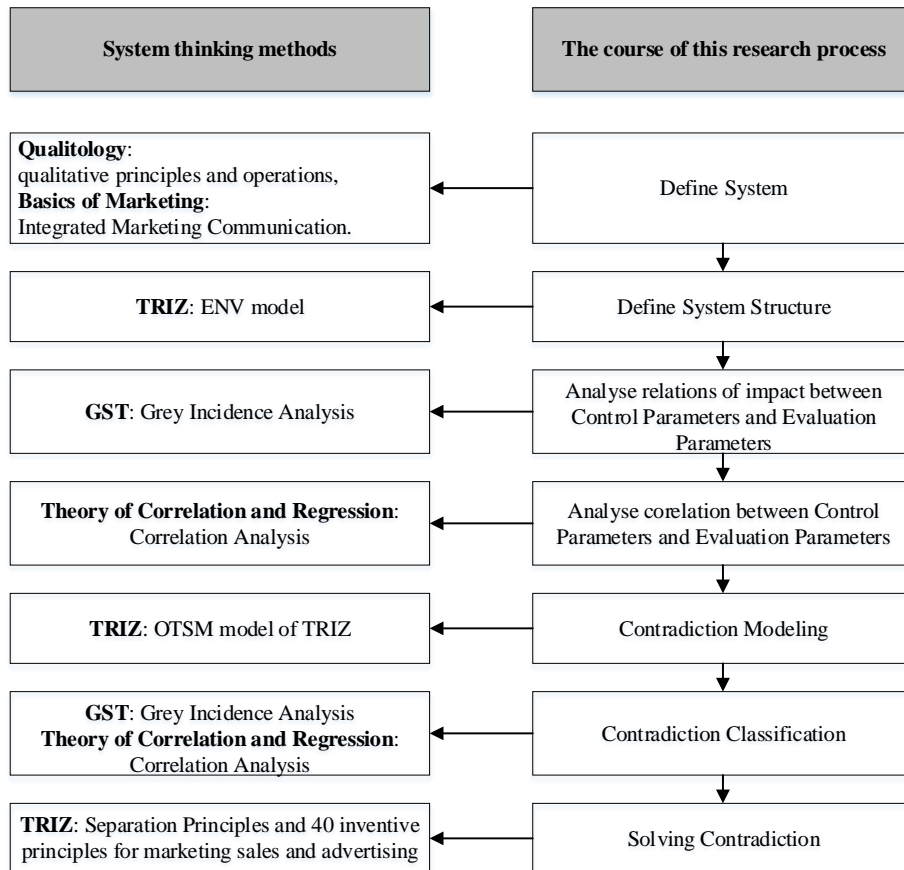


Fig. 4. The course of this research process in contradiction finding and classification in the field of marketing (Source: own elaboration).

The aim of future research is, first, to verify the developed concept, including designing a questionnaire to assess the state of the quality of marketing communication in an industrial enterprise. Second, creating the computer software supporting computational activities at the stage of using Grey System Theory method and a statistical method of analysing the phenomena correlations. Third, integration of the developed method with other commercially available methods of computer-aided problem solving (e.g., Innovation WorkBench). Fourth, application of a mathematical model, such as system dynamics approach methodology of modern Operational Research (Pedomallu et al., 2012a) and methodology and computer simulation modeling technique (Pedomallu et al., 2012b) to improve the classification of the contradiction for its impact on the marketing communication quality. Furthermore, application and verification of proposed concept of contradiction finding and classification in the other fields of industrial companies structure.

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