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Identifying the Relationship Between Business Model and Competitiveness Using Rough Set Theory

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Abstract:

Purpose: *The purpose of this paper is to show the possibility of using Rough Set Theory to identify the relationship between a business model and company competitiveness.*
Design/Methodology/Approach: *Rough Set Theory operates on large data sets and allows for the reduction of irrelevant data and the induction of decision rules that discover recurrence and dependencies in data. The discovered rules can become the basis for making business decisions.*
Findings: *The relationship between a business model and company competitiveness can be identified through Rough Set Theory, and the results can take the form of clear and easily interpretable decision rules, if the premise, then the conclusion.*
Practical Implications: *The identified decision rules can provide a rationale for the design or development of organizations, thus, enhancing the chance of success by relying on correctly validated company behavior. The proposed approach can also be used to identify relationships in other business environments or address diverse variables, such as other aspects of competitiveness.*
Originality/Value: *The study will verify the usefulness of Rough Set Theory for building a rule base for decision-making regarding the construction of business models that offer a chance to boost the companies' competitiveness.*

Keywords: *Rough Set Theory, business model, competitiveness.*

JEL codes: *M210, M130, L220.*

Paper Type: *Research Paper*

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1. Introduction

Progressive globalization and virtualization of the world economy brings about the need to increase the competitiveness of companies, which nowadays often determines the very existence of companies, rather than their profits. Increasingly important has become the question: what configuration of the business model increases the likelihood of enhancing the competitiveness. However, it seems that a universal answer to a problem so posed is not possible. The diversity of economic conditions allows us to suspect that in different situations this relationship will take different forms.

Hence, it seems that a more appropriate direction of work is trying to answer another question, i.e., how to identify this type of dependence? The sought approach should allow for its application in different business environments and refer to their specific conditions. This line of thought leads to the hypothesis that the relationship between a business model and competitiveness can be examined with the use of the rough set theory. The purpose of the paper is to exemplify the proposed approach in a selected group of economic entities.

2. Research Methodology

The article uses the theory of rough sets, promulgated by Pawlak (1982a; 1982b). The rough set theory is an answer to the problem of "imperfect" knowledge, which has been in the interest of philosophers as well as logicians and mathematicians for a long time. Moreover, in connection with the development of computing techniques, including the field of artificial intelligence, it has also aroused interest among computer scientists.

From a logical point of view, the rough set theory is a mathematical approach to fuzzy concepts, while from a practical point of view, it is a new method of data analysis that allows, among other things, for finding relationships between data, redundant data reduction, determining the weights of individual data components, and for generating decision rules from data (Greco, Matarazzo, and Slowinski, 2016). At the same time, Pawlak (1981) points out that data analysis should be treated as a special case of inductive reasoning, which, starting from certain partial facts about the reality under study, by way of generalizations aim to discover knowledge about a world wider than the one constituting the starting point for the inferences. These efforts are targeted at drawing probable (possible) conclusions, and hypotheses are verified by means of experiments.

Depending on the accuracy of measurement of the reality under study, the objects in question can be considered to be either different or indiscernible from one another. Often, however, excessive precision of a measurement is not necessary, and instead of differences, it is the similarities between the studied elements that are more valuable. "Elements about which we have identical information are similar and form

so-called elementary sets. These form the basis of reasoning in the rough set theory. The sum of any elementary sets is called a discernible set. Sets that are indiscernible are called rough sets. Of course, discernible sets can be uniquely characterized by attributes of their elements, while rough sets cannot be characterized in this way. Therefore, in the rough set theory, the notions of lower and upper approximation of a set are introduced, which make it possible to characterize any indiscernible (rough) set by means of two discernible sets - its lower and upper approximation (...) the essence of the method consists in introducing two membership functions $\subseteq$ and $\overline{\in}$, which stand for *positively belongs* and *possibly belongs*, respectively." (Pawlak, 1981).

The language of the set theory is used to describe "approximate operations on sets, as well as exact operations on rough sets. (...) The proposed approach is based on an imperceptible relation that glues together all objects that could not be distinguished by available means of observation (measurement) or expression (language)" (Pawlak, 1982b).

The final effect of applying the rough set theory are decision rules, which also draw attention to their much better fit to the human mind than it is the case with "black box" techniques, represented for example by discriminant functions or neural networks. The rules offer an explicit representation of knowledge, which contributes to better understanding and clarification of the decision problems under consideration. The importance of this issue is evidenced by the fact that the comparison of the two approaches has its own term: data fit versus mental fit (Weihs, Sondhauss, 2002).

3. Research Study

In order to obtain empirical data, a research tool was constructed in the form of a survey questionnaire. It included questions about the business model and competitiveness. Based on the assumption of progressive specialization and cooperation of companies and business virtualization, the dimensions of the business model were adopted basing on A. Mowshowitz's model of virtual organization. He is considered to be the author of the concept of virtual organization. At the same time, his exchange mechanism (Mowshowitz, 1999; 2002; Mowshowitz and Kawaguchi, 2004) is one of the first, if not the first approach to the virtual organization (and a proposal for its management) that was implemented in the majority of models created later (Veber, 2009). The latent dimensions of the business model along with their metrics are outlined in Table 1.

Competitiveness is viewed in multiple dimensions. Eleven determinants of competitiveness have been found. In this paper, only one of them has been chosen for the analysis, namely the cost of producing products or services in comparison to the competition. In this work, competitiveness is viewed through the prism of this particular determinant.

Table 1. *Conditional attributes included in the decision table*

Attribute symbol	Names of attributes - measurements (broken down by dimensions of business model they describe)
Specialization	
q1	we focus on our core competencies (knowledge and skills)
q2	our strengths distinguish us from our competitors
q3	we are highly willing to cooperate
q4	we see cooperation as an opportunity to offer customers attractive products/services, thanks to responding quickly to customer needs and/or at a relatively low cost and/or outstanding quality
Temporality and loose coupling	
q5	cooperation is ad hoc in nature, limited by the duration of the tasks for which it has been established
q6	the composition of a group of cooperating parties changes dynamically depending on market opportunities/demand
q7	we cooperate with many companies at the same time
q8	cooperation takes place in a dispersed environment, in the course of cooperation the process of value creation (e.g. ideas, products, services) occurs in different places
q9	when cooperating with contractors, we operate without formal contracts or, if there are any, we agree only on the general terms of contract, while the details of their implementation are agreed upon informally (verbally, by e-mail, etc.)
q10	we treat the cooperating parties as partners
Trust	
q11	we clearly demonstrate our competences (skills, abilities) to our contractors and offer them high quality standards (solutions, products, services)
q12	we abide by what we have agreed to, even if it is temporarily to our disadvantage.
q13	we are ready to trust our partners in new situations
q14	we are open, honest and willing to share information with our contractors
ICT	
q15	we use electronic communication channels within the company (e.g., e-mail, text/audio/video messaging, newsgroups)
q16	we use electronic communication channels (e.g., e-mail, text/audio/video messaging, newsgroups) to work with our contractors
q17	use electronic tools for work coordination within the company (e.g., shared schedules, shared planning and scheduling tools, shared databases or knowledge archives)
q18	we use electronic tools for work coordination with our contractors (e.g., shared schedules, shared planning and scheduling tools, shared databases or knowledge archives)
q19	use electronic tools inside our company to support cooperation (e.g. shared remote editing of documents, remote presentations, remote "white board" to transfer written texts and drawings to the contractors' computer screens)
q20	we use electronic tools to support cooperation with contractors (e.g. shared remote editing of documents, remote presentations, remote "white board" to transfer written texts and drawings to the contractors' computer screens)
q21	we use mobile Internet access (from outside the company's premises)
q22	we use remote access to the company's database from outside the office

Source: *Own elaboration.*

Using the research tool described above, PAPI interviews were conducted with the top management of 51 micro and small enterprises that were members of the Stowarzyszenie Klaster ICT Pomorze Zachodnie (West Pomeranian ICT Cluster Association). The choice of the environment provided contacts with companies related to modern technologies. Simultaneously, following the research assumption, the surveyed objects included businesses similar in some respect, which was supposed to help increase the chance of capturing reliable regularities. Eventually, 47 fully completed questionnaires were obtained that provided the basis for the analysis.

Source data describing the respondents' business models and enabling the assessment of their competitiveness, approached through the prism of the production costs of products or services compared to the competition were included in the original information table representing the objects in the universe under study, in accord with the theory of rough sets. The values describing the business model were conditional attributes, while the competitiveness was a decision attribute. Then, by reducing the measurement precision, discretization was performed to obtain a secondary information table. As mentioned earlier, too high a measurement precision causes each of the examined elements to be different from the others.

Reduced precision contributes to the identification of similarity and repeatability, hence to the identification of rules. Discretization consisted of assigning the original values to one of 3 groups - low (1), medium (2) and high (3). As recommended, in the course of that process, an effort was made to keep the groups similar in size. On the way to search for the relationship between the business model and competitiveness, a set of reducts was obtained. Despite operating with a smaller number of features of objects belonging to the universe, the reducts condition the decision set to the same extent as the complete set of conditional arguments contained in the secondary decision table. It permits to significantly reduce the number of analyzed features and contributes to the simplification of the decision rules.

The inclusion of selected features in the reducts proves their important role in assigning the objects they describe to abstraction classes, which in this case means their influence on competitiveness (low, medium, high). Attention was focused on the reducts with the smallest number of conditional arguments. Subsequently, an attempt was made to induce decision rules taking into account satisfaction levels, including certainty factor of rules and their support ratio - aided by as many examples as possible corresponding to both the conditional and decision parts of the rule. The obtained set of rules was subjected to interpretation and discussion.

4. Discussion

Attention is drawn to the rule taking the form:

If q4=1 & q7=1 & q10=3 & q19=2, then d=2; [5, 5, 50.00%, 100.00%] [0, 5, 0] (1)

Given the names of the metrics denoted by the symbols of the rule conditional arguments (Table 1) and taking into account the employed discretization of their values, as well as the decision attribute (d), the rule can be read as:

- if a company to a small degree (or not at all) sees in cooperation an opportunity to offer customers attractive products/services by responding quickly to customer needs and/or at a relatively low cost and/or with outstanding quality (q4=1),
- if it does not cooperate with many companies at the same time (q7=1) and to a large degree treats its contractors as partners (q10=3),
- if it to an average degree uses electronic tools inside the company to support cooperation (q19=2),

then it reaches a medium level of competitiveness (d=2).

The support ratio for the analyzed rule is at level 5, which means that it is supported by five examples from the decision table - because for that many companies the conditional arguments and the conclusion took identical values. In other words, the rule describes the behavior of five (out of 47) companies of the population under study.

In the universe under scrutiny, there were 10 objects with the value of the decision argument equal to 2. Comparing the support ratio for the rule and the number of examples with the conclusion equal to 2 (belonging to a given abstraction class denoting the average level of competitiveness), the support ratio of 50.00% (5/10) was revealed. This means that the rule describes the relationship between the business model and competitiveness present in half of the companies achieving average competitiveness.

At the same time, the certainty factor (the relationship of the rule support ratio and its coverage), or the rule confidence, is equal to 1 (100%), so in each case described by the premise (conditional arguments) the conclusion (decision) takes the same value. All of the companies declaring the indicated values of their business model metrics achieve the same level of competitiveness. It is therefore a certain rule.

The second rule that is worth noting takes the form:

If q3 = 1 & q4 = 1 & q10 = 3 & q19 = 2, then d = 2; [3, 3, 30.00%, 100.00%] [0, 3, 0] (2)

It operates with the same arguments except for replacing q7 with q3=1. It is not true that we are highly willing to cooperate. And in this case the indicated combination of business model features leads to an average level of competitiveness (d=2). This is a certain rule, i.e., all of the companies declaring the indicated values of the business

model metrics achieve the same level of competitiveness. However, it has a lower support rate at 30.00% - 3 out of 10 companies with an average level of competitiveness declare such a composition of the business model.

Because of the shortness of the rule, which contributes to its easy interpretation, it is worth pointing out the rule:

If q3 = 3 & q7 = 3, then d = 1; [4, 4, 23.53%, 100.00%] [4, 0, 0] (3)

If a company is highly willing to cooperate (q3=3) and cooperates with many companies at the same time (q7=3), then it achieves a low level of competitiveness (d=1) viewed from the perspective of the products/services production cost.

The rule is supported by almost ¼ of entities with low competitiveness (23.53%). At the same time, the certainty factor of the rule (100.00%) indicates that each of the companies in the studied population whose business model has such features achieves low competitiveness.

It should be added here that the organizations under study operating in the ICT sector are rather open to cooperation and see many benefits in it. In the face of high demand for their products and services and simultaneous shortage of qualified employees, they do not compete on costs and price. In many cases they compete for employees and other aspects of competitiveness by agreeing to bear high costs of operation. However, the analysis of other aspects of competitiveness goes beyond this study and has been the subject of other publications by the author.

The collection of the revealed rules did not contain a certain rule with high competitiveness and a satisfactory level of support ratio, hence the need to employ possible rules. In these rules not all the coverage (i.e. their compliance with the premise) supports the rule (i.e. lead to the same conclusion).

A noteworthy example of this type of rule is:

If q4 = 1 & q7 = 1, then d = 2; [10, 7, 70.00%, 70.00%] [2, 7, 1] (4)

This rule is a simplification of the rule (1) operating with only two conditions. 10 objects in the universe are consistent with the premise, 7 of them also have a consistent conclusion (70.00% certainty), the competitiveness of 2 of them is low while 1 is highly competitive. So we can say that in the universe under scrutiny the behavior described by the conditional part in 70% leads to medium competitiveness. At the same time, 70.00% of companies conforming to the conclusion (medium competitiveness) are characterized chose the business model described by the conditional arguments.

Looking for an answer what configuration of the business model leads to high competitiveness in its assumed aspect, we can refer to the rules:

If q4 = 2 & q19 = 2, then d = 3; [9, 7, 35.00%, 77.78%] [2, 0, 7] (5)

and

If q3 = 2 & q4 = 2, then d = 3; [10, 7, 35.00%, 70.00%] [2, 1, 7] (6)

Both are possible rules with 77.78% and 70.00% confidence, so this is the percentage of entities conforming to the premise that reach the level of competitiveness indicated in the rule (d=3). Both describe the behavior of 35% of highly competitive companies.

5. Conclusion

The proposed procedure is aimed at identifying the configuration of the business model that enhances the probability of higher competitiveness. The author proposes to employ the rough set theory. The implementation of the procedure allowed for the reduction of empirical data describing the business model by those that had little impact on competitiveness, and then for the discovery of decision rules.

In a clear and comprehensive way these rules reveal which elements of a given business model and the values they take contribute to low, medium or high competitiveness in its assumed aspect. Thus, according to the author, the hypothesis that the relationship between the business model and competitiveness can be investigated using the rough set theory can be considered as confirmed.

It should be emphasized that the recommendations presented in the form of decision rules were established only for the given business environment. It should be expected that the rules obtained for different environments will take a different form reflecting the specific conditions of these environments.

Hence, the obtained rules and their interpretation indicate the possibility and usefulness of basing inference in the area of this study on the rough set theory. When reducing redundant data, it should be borne in mind that the reduct is defined only for the objects described in the decision table, and its usefulness in selecting features for the classification of new objects is not clear. Thus, any extrapolation or generalization of the obtained rules should be accompanied by caution and a critical eye.

However, it is recommended to employ the procedure proposed in this paper in similar research into other populations, taking into account their features included in decision tables. The study can also be repeated to deal with aspects of competitiveness other than in this paper.

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