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Information Systems Architecture and Technology: Proceedings of 40th Anniversary International Conference on Information Systems Architecture and Technology – ISAT 2019

Part III

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Preface

We are pleased to present before you the proceedings of the 2019 40th Anniversary International Conference Information Systems Architecture and Technology (ISAT), or ISAT 2019 for short, held on September 15–17, 2019 in Wrocław, Poland. The conference was organized by the Department of Computer Science, Faculty of Computer Science and Management, Wrocław University of Science and Technology, Poland, and the University of Applied Sciences in Nysa, Poland.

The International Conference on Information Systems Architecture and Technology has been organized by the Wrocław University of Science and Technology from the eighties of the last century. Most of the events took place in Szklarska Poręba and Karpacz—charming small towns in the Karkonosze Mountains, Lower Silesia in the southwestern part of Poland. This year 2019, we celebrate the 40th anniversary of the conference in Wrocław—the capital of Lower Silesia, a city with a thousand-year history. A beautiful and modern city that is developing dynamically and is a meeting point for people from all over the world. It is worth noting that Wrocław is currently one of the most important centers for the development of modern software and information systems in Poland.

The past four decades have also been a period of dynamic development of computer science, which we can recall when reviewing conference materials from these years—their shape and content were always created with current achievements of national and international IT.

The purpose of the ISAT is to discuss a state-of-art of information systems concepts and applications as well as architectures and technologies supporting contemporary information systems. The aim is also to consider an impact of knowledge, information, computing and communication technologies on managing of the organization scope of functionality as well as on enterprise information systems design, implementation, and maintenance processes taking into account various methodological, technological, and technical aspects. It is also devoted to information systems concepts and applications supporting the exchange of goods and services by using different business models and exploiting opportunities offered by Internet-based electronic business and commerce solutions.

ISAT is a forum for specific disciplinary research, as well as on multi-disciplinary studies to present original contributions and to discuss different subjects of today's information systems planning, designing, development, and implementation.

The event is addressed to the scientific community, people involved in a variety of topics related to information, management, computer and communication systems, and people involved in the development of business information systems and business computer applications. ISAT is also devoted as a forum for the presentation of scientific contributions prepared by MSc. and Ph.D. students. Business, Commercial, and Industry participants are welcome.

This year, we received 141 papers from 20 countries. The papers included in the three proceedings volumes have been subject to a thoroughgoing review process by highly qualified peer reviewers. The final acceptance rate was 60%. Program Chairs selected 85 best papers for oral presentation and publication in the 40th International Conference Information Systems Architecture and Technology 2019 proceedings.

The papers have been clustered into three volumes:

Part I—discoursing about essential topics of information technology including, but not limited to, Computer Systems Security, Computer Network Architectures, Distributed Computer Systems, Quality of Service, Cloud Computing and High-Performance Computing, Human–Computer Interface, Multimedia Systems, Big Data, Knowledge Discovery and Data Mining, Software Engineering, E-Business Systems, Web Design, Optimization and Performance, Internet of Things, Mobile Systems, and Applications.

Part II—addressing topics including, but not limited to, Pattern Recognition and Image Processing Algorithms, Production Planning and Management Systems, Big Data Analysis, Knowledge Discovery, and Knowledge-Based Decision Support and Artificial Intelligence Methods and Algorithms.

Part III—is gain to address very hot topics in the field of today's various computer-based applications—is devoted to information systems concepts and applications supporting the managerial decisions by using different business models and exploiting opportunities offered by IT systems. It is dealing with topics including, but not limited to, Knowledge-Based Management, Modeling of Financial and Investment Decisions, Modeling of Managerial Decisions, Production and Organization Management, Project Management, Risk Management, Small Business Management, Software Tools for Production, Theories, and Models of Innovation.

We would like to thank the Program Committee Members and Reviewers, essential for reviewing the papers to ensure a high standard of the ISAT 2019 conference, and the proceedings. We thank the authors, presenters, and participants of ISAT 2019 without them the conference could not have taken place. Finally, we

thank the organizing team for the efforts this and previous years in bringing the conference to a successful conclusion.

We hope that ISAT conference is a good scientific contribution to the development of information technology not only in the region but also internationally. It happens, among others, thanks to cooperation with Springer Publishing House, where the AISC series is issued from 2015. We want to thank Springer's people who deal directly with the publishing process, from publishing contracts to the delivering of printed books. Thank you for your cooperation.

September 2019

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Topic: **On the Need of an Explainable Artificial Intelligence**

Contents

Models of Financial and Investment Decisions

The Influence of Strong Changes of Chosen Macroeconomic Factors on Some Parameters of the State of Organization

Tadeusz Gospodarek(✉) and Sławomir Pizoń

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Abstract. This paper describes the problem of relations between some macroeconomic indexes and microeconomic financial indicators of an organization during rapid and disastrously changes in the surroundings. The analysis of these relationships was carried out for ten Polish transport companies operating on international market, covered the period of the financial crisis 2008–2011, when catastrophic changes of macroeconomic indicators have taken place. Particularly interesting is impact of some changes of the GDP, PMI and IFO indexes on the economic state of organizations from logistic and transport sector. They are the most flexible, continuously adapting themselves to conditions arisen temporarily in the business environment. Changes of their economic state are mainly characterized by the ROE, ROS, ROA and the income ratio values. We propose a relational model of macro and micro economic indicators enabling optimization of organization's behaviour under conditions of critical changes in macro environment. We conclude that there exists a rational forecast of determining the economic state of an organization resulting from the analysis of changes in some macroeconomic indexes.

Keywords: Macro-micro relation · Economic state · Financial factors · Prediction model · Quantitative approach · Relations force measure

1 Introduction

It is an interesting problem of relations of some global macroeconomic factors and microeconomic indicators related to a financial position of organizations which must be monitored continuously. The research question in this paper is: how some strong changes of macroeconomic indicators and global indexes as GDP, PMI and IFO affect changes of some micro indicators as ROA, ROE and ROS along time. The changes of macroeconomic parameters may arise during economic crisis or critical changes of economic situation derived from natural or social disasters and some political decisions. In all cases, observations of these changes allow to build relations to microeconomic states defined by some local variables. These local parameters are mainly related to key performance indicators of an organization (Parmenter 2010; Gospodarek 2015). It is possible to obtain some macro-micro relations synchronized in time and find those where the reaction of micro indicators on macro changes will give useful information from the decision-making point of view on micro level. Of course, it is

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necessary to estimate the term "strong changes" if anyone would like to build an adaptive model of suggested behaviours in micro scale. Estimations may be based on scenarios derived from what if (Rizzi 2009, Gospodarek 2018) or sensitivity analysis (Pannell 1997).

The choice of macro indicators for prediction purposes should be based on availability of source data for comparison and their influence on national economies. Therefore, the GDP is one of the most important, because it is a basic measure of the overall size of a country's economy. Suitable data have been collected by International Monetary Fund for 189 countries for a couple of years (Monetary 2018).

The next chosen index in our research is the purchasing managers' index PMI related to evaluation of current situation on the market and presented as a survey of evaluations of 400 purchasing managers in the manufacturing sector on seven different fields: production level, new orders from customers, speed of supplier deliveries, inventories, order backlogs and employment level. PMI data are collected and offered by Markit Group (Markit 2019). These data offer the base for prediction of changes of some microeconomic indexes.

In this paper IFO means Business Climate Index (IFO 2019), leading indicator for economic activity in Germany prepared by the IFO Institute for Economic Research in Munich. Three data series are compiled from raw scores and grouping in three fields: business climate, current business situation and business outlook.

There are some other very useful and interesting business data surveys, as: The Global Competitiveness' Report (GCI) of the World Economic Forum (WEF 2018), Global Innovation Index (GII) of the Cornell University, INSEAD and WIPO (WIPO 2018), Doing Business of the World Bank (World Bank 2019). But they have too complex structure and be too much synthetic for models based on financial data of organizations. Looking for some relations of macro-micro indicators, the rational reduction of multi-pillar-based data (e.g. GCI Index) and too much processed and interpreted data (e.g. Doing Business Report) is a crucial aspect of scientific methodology, because further generalization may affect crude relations of source data.

Quantitative analysis of some global data along a finite period when minimum one catastrophic change has been observed was the occasion to verify the influence of some macro on some micro economic indicators. It also allows to explain a dynamic of changes before the moment of crisis or catastrophe, and after, during the recovery processes. Some changes of macro values during 2006–2014 period are presented on the Fig. 1. One can see catastrophic changes of the GDP for the Eurozone during 2008–2010 period. The amplitude of decreasing is near 2% of absolute measure (60–100% relatively), what had to influence on all economies in the EC and therefore on the related macro indexes e.g. intracommunity trade, household available income, freight transport. As the logical consequence, some changes in micro state indicators determining the financial position of organizations should take place. It was observed that very sensitive aspects of European economy during the crisis time had been domestic trade and transport. Also, a disposable income has been changed along the GDP, but in a moderate scale (see the Fig. 1). These facts suggest that observations of financial indicators of firms from logistic and transport sector would be the rational choice for experimental data analysis for hypotheses about existing measurable relations between macro and micro economic factors. Based on available macro and micro data, we have

observed that since 2004 the logistic sector reacts very quick and sharp on some economic changes in the surroundings.

The aim of this paper is to create the model of quantitative changes of some financial micro indicators of the organization's state related to changes of the selected, well elaborated and commonly accessed economic macro indexes. As the result, suitable model of usable relations macro-micro will be presented and discussed for a set of transport organizations from Poland offering services on the European market. The authors try to answer two scientific questions.

1. Which relations of micro and macroeconomic indicators are particularly useful for building short-term scenarios of keeping the economic stability of organizations?

2. How to simulate the economic position of an organization when strong changes of some macro indicators derive?

Both questions are important for adaptative managing (Gospodarek 2018) and strongly depend on the changes in the surroundings. Especially transport firms are vulnerable because of strong competitiveness on the market, small margin base in their pricing strategies and serious engagement of resources for leading business.

2 Characteristic of the Financial Micro State

There are three basic financial statements of an organization: income statement, balance sheet and cash flow statement (Deloitte 2018, IFRS 2019).

The income statement indicates the organization's profits over a defined period (monthly, quarterly or annually) represented by EBT or EBITDA value for the whole organization or its structural part. It answers the question "how profitable the analysed business is" and reports on five areas: sales (revenue), costs of creating and delivering goods or services, operating expenses, financing costs (interest expense), tax payments. For each area, it is possible to define synthetic indicators as a measure of effectiveness or accuracy.

Balance sheet represents equality between total assets (what the organization owns) and a sum of outstanding debt and the owner's equity. It indicates an organization's financial position in terms of the assets owned and how these assets have been financed. The time-based difference between balance sheets is equal to the income statement in the analysed period. Together with the value of revenue, it is the base of dividing companies on categories: micro, small and large. From balance sheet, it follows a lot of consequences for controlling parameters and indicators related to the ratio of income to engaged capital and resources.

At last the cash-flow statement answer the fundamental question "where did the cash come from and where did the cash go". It is very important aspect of management, because from the experience it follows, that cash flow problems are a major reason for organizations failing especially small ones—even at times when the business seems to be profitable. In accounting systems, there are a difference between the income statement and the cash-flow one. The balance sheet is based on accrual accounting whereas the cash-flow one is realized on cash-basis account. Therefore, profits and cash flows usually are not equal. More details about "how to" in relation to the financial statement

calculations are available from International Accounting Standards (Deloitte 2018) and International Financial Reporting Standards (Deloitte 2018, IFRS 2019).

From the managing point of view, the set of precisely tailored key performance indicators (Parmenter 2010; Gospodarek 2018) is the most important for making tactic and strategic decisions under uncertainty, and for realizing continuous adaptation of an organization to different changes in the surroundings. In practice, management uses IT support for measurement the feed-back aspects for optimization of the economic state of the organization. As the nowadays standard the ERP class integrated IT systems support monitoring of the defined set of KPI's according to strategic model and goals definition. Among the set of KPIs these related to financial report described by Dupont's model of controlling are crucial (Gospodarek 2015 and 2018).

All the above areas on micro level depend on the situation in the business surroundings, characterized by macro parameters, and they can't be separated as isolated entities for quantitative analyses (as it is possible in physics). It is the main idea of this research, and abduction inferring for the hypothesis, that it is possible to predict the behaviour of some financial indicators of the firm, when significant changes in the related indexes macro are detected. And that some relations may be useful for decision making in advance.

3 Source Data and Analyses

We have carefully selected ten logistic organization from Poland operating on international market, mainly EC countries. All of them had been stable organizations of average and big class since 2004 (date of Polish membership in EC) and obligated to prepare annual financial reports according to international accounting standards (Deloitte 2018). These reports are available from court files. For these firms, we have retrieved financial reports for the period 2006–2012, where big changes in macroeconomic data had been observed between 2008–2010.

We have also collected suitable information from Polish Governmental Statistic Office GUS and Eurostat as source data of macro level. We've also used reports offered by the World Bank, Markit, WIPO, etc. All the selected data (micro and macro) were synchronized in time, elaborated according to the assumed analytical model, compared and statistically verified as derived from the same population or not and in the case of relational macro-micro aspects, if they are important or not based on statistical criteria.

For confirmation of importance of the assumed changes between annual macro data and the related different micro factors derived from the source data, the Wilcoxon-Mann-Whitney rank-sum test was applied (Ruland 2018; Gospodarek 2018). It is non-parametric test which allows to verify the hypotheses regardless the type of statistic data distribution. The null hypothesis that it is equally likely that a randomly selected value from one sample will be less than or greater than a randomly selected value from a second sample. The sample of 10 items is statistically representative for such kind of comparisons (Gospodarek 2018). It is simple and effective tool nearly as efficient as the t-test for normal distributions.

Hypotheses that the variances from the sample based on the selected organizations are equal on significance level $p = 0{,}05$ were confirmed with Snedecor's F-test of

equality of variances (Taboga 2017). The null hypothesis that two normal populations have the same variance was assumed. It was useful in comparative analyses of some micro data between time periods.

Due to behaviour of micro and macro indicators along time, analyses were performed in three ranges: 2006–2008 (period just before the crisis); 2008–2010 (crisis period); 2010–2011 (period of recovery from the crisis).

Table 1. Analysed macro indicators in the period 2006–2011

Macro indicator	2006	2007	2008	2009	2010	2011
GDP (Euro zone)	3,2%	3,0%	0,4%	−4,4%	2,1%	1,6%
GDP Poland	6,2%	7,2%	3,9%	2,6%	3,7%	5,0%
CPI	1,0%	2,5%	4,2%	3,5%	2,6%	4,3%
Reference interest rates National Bank of Poland	4,0%	5,0%	5,0%	3,5%	3,5%	4,5%
PMI Industrial Poland	53,3%	50,7%	38,3%	52,4%	56,3%	48,8%
IFO EC (Euro zone)	15,1%	3,3%	−52,0%	−26,4%	−2,6%	31,5%

Illustration of macro indicators changes from Table 1 is presented on Fig. 1.

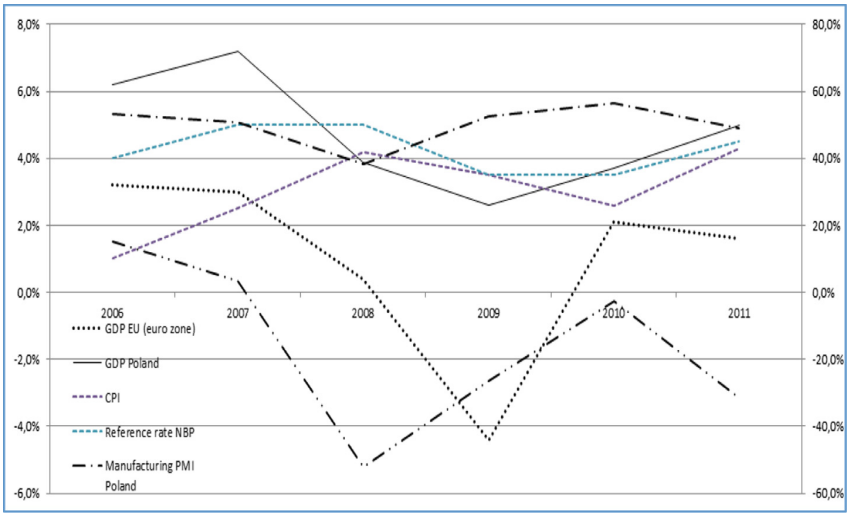

Fig. 1. Source data: EUROSTAT, GUS, NBP, Markit Group and IFO Institute

As one can see, some interesting relation of IFO and GDP were observed in the period 2008–2009 when the changes of IFO had been ahead of the GDP minimum (the deepest crisis) almost on a year. It may suggest that IFO and GDP should be valuable indexes for building the relations macro-micro. PMI was also relatively decreased on

1,5% to its minimum value in 2008, but it had been not so sensitive in reaction on crisis situation as IFO.

4 Relations Macro - Micro

For quantitative evaluations of the strength of micro-macro relation presented in this paper, the Coefficient of Dependence's Relative Force (CDF) was introduced. It may be interpreted as a ratio of relative changes of a macro variable and a micro one, according to Formula 1.

$$CDF = \frac{\frac{x_{ti} - x_{ti-1}}{|x_{ti-1}|}}{\frac{M_{tj} - M_{tj-1}}{|M_{tj-1}|}} \quad (1)$$

where, x_{ti} *– represents a given micro parameter in i-th period,*
M_{tj} *represents a given macro index in j-th period respectively.*

The CDF may be positive (when increasing of a micro variable is correlated with increasing the related macro index) and it may be negative (when positive changes of micro are correlated with negative changes in macro and reverse). It is the useful measure but not very sensitive. Rational inferring needs supporting analyses of the source differences (xti – xti-1 and Mtj – Mtj-1). It is also necessary for correct interpretation of a CDF's sign.

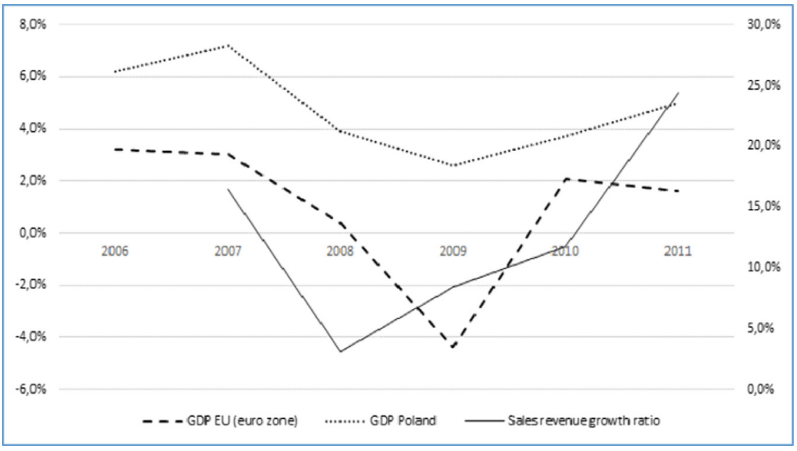

Fig. 2. The pace of changes in sales revenues compared to Poland's GDP and GDP for the Euro zone [source data: Eurostat]

Changes of income rate (IR) of the analysed organizations in respect to GDP of Poland and EC are presented on Fig. 2: The IR changes in relation to the GDP of Poland and EC countries were derived quicker with similar intensity as changes of

GDP. It can be noticed that in the period 2007–2008 there was a significant decrease of the rate of changes in sales revenues and GDP ratios. At the same time, GDP indicators continued to decline in 2009, while the rate of change in sales revenues began to increase. It results from the capacity of transport and logistic companies to adapt to the surroundings changes and favourable external conditions.

The values of CDF for the relations presented on the Fig. 3 are presented in Table 2.

Table 2. The CDF values for the micro macro relation income/GDP

CDF of ΔIR/GDP	Period of analysis		
	2007–2008	2009–2009	2010–2011
Poland	1,77	−5,16	2,05
EC	0,94	−0,14	1,39

In the analysed periods, the significant positive relationship between GDP changes and the rate of change in sales revenues occurred in 2007–2008, in the initial phase of the crisis. Faster rebound of the rate of change in sales revenues than the GDP causes negative values of coefficients of the relative dependence in 2008–2009. However, in the later period 2010–2011 (beginning of recovery), the dependence is again strong and takes a positive direction. Therefore, only the relationship existing in the initial phase of the crisis may be considered for further analyses. The decline in GDP causes a drop in the rate of sale. GDP growth until the end of the analysed period (2009–2011) is related to increase the rate of sale.

Similarly, to the above, the following relations of the income to different macro indicators have been considered. The results are presented in Table 3, and Fig. 3.

Table 3 Considered relations of income changes (micro) with some macro indicates. The differences between the average values in pointed periods were confirmed statistically as important with Snedecor's test of variance equality at 95% level.

Relation of macro indicators and the ratio of the ROA changes	Compared periods	CDF value
GDP Euro zone	2007 and 2008	0,94
GDP Euro zone	2009 and 2011	1,39
GDP Poland	2007 and 2008	1,77
GDP Poland	2009 and 2011	2,05
CPI	2007 and 2008	−1,19
Interest rate (National Bank of Poland)	2006–2007 and 2007–2008	−3,25
PMI industrial Poland	2006–2007 and 2007–2008	16,63
IFO (Euro zone)	2006–2007 and 2007–2008	1,04

From the Fig. 3 some conclusions may derive. Big changes of GDP in Euro zone and Poland between 2007 and 2008 also 2009 and 2011 are correlated with decreasing of the ratio of income changes. The level of significance measured by the CDF value was 0,94 – 2,05. The influence of CPI index on the ratio of income changes between 2007 and 2008 shown negative tendency represented by the CDF value. The most important changes of the CDF value are observed for PMI changes. It is interesting, that the IFO index had no such spectacular correlation estimated by the CDF value.

As an example of interesting relation macro and micro the dependence of the ROA on the GDP may be presented as on the Fig. 4. It means that if the ROA for diagnostic organizations will decrease, then after some time one can observe decreasing of the GDP. Therefore, the GDP is not appropriate indicator for prediction the ROA changes. It may be simply explained. The increasing/decreasing of the GDP is a consequence of the ROA changes.

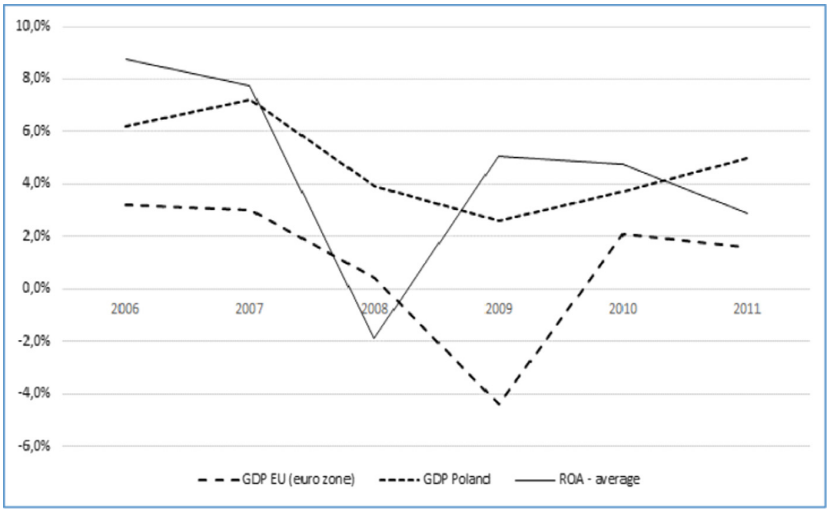

Fig. 3. Changes of ROA in relation to changes of GDP Poland and Euro Zone.

In case of PMI or IFO the relations macro-micro will be useful for prediction of the micro behaviour based on macro changes (Fig. 4).

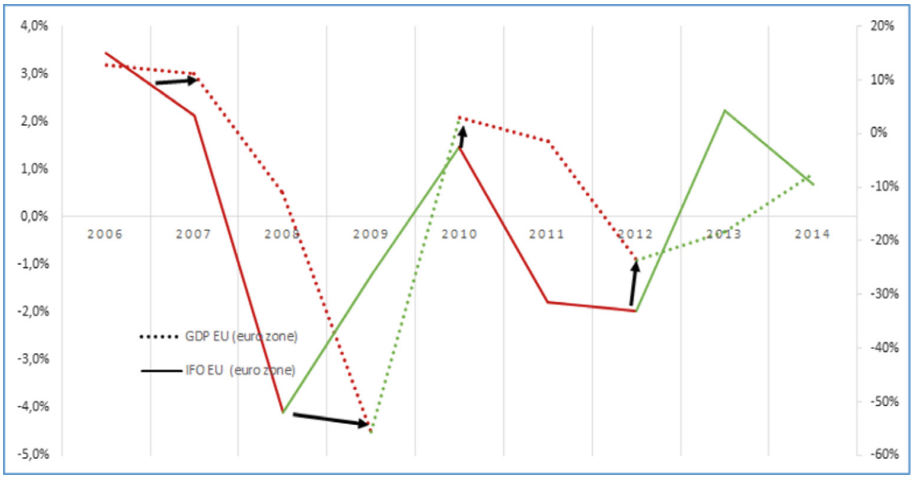

Fig. 4. Changes of GDP EU in relation to changes of IFO.

The first symptoms of prosperity decreasing were observed in 2007 according to decreasing the PMI industrial for Poland and the IFO for Euro Zone. Significant decreasing of the ROS for transport firms was observed in 2008, where adaptative processes in micro had been insufficient in relation to the changes in macro indicators. It is interesting how the values of the Coefficient of Dependence's Relative Force (CDF) were changed during the 2008–2011 period. This data is presented in Table 4.

Table 4 Considered relations of the ROS (micro) with some macro indicates where differences between the average values in pointed periods were confirmed statistically as important with Snedecor's test of variance equality at 95% level.

Relation of macro indicators and the ratio of income changes	Compared periods	CDF value
PMI industrial Poland/ROS - av	2008–2010	4,68
PMI industrial Poland/ROS - av	2008–2011	6,41
PMI industrial Poland/ROS - av(t + 1)	2006–2007/2007–2008	28,60
IFO EU (Euro Zone)/ROS - av	2008–2010	2,31
IFO EU (Euro Zone)/ROS - av(t + 1)	2006–2007/2007–2008	1,79
IFO EU (Euro Zone)/ROS - av	2008–2011	4,46

5 Simulations of Some Macro-Micro Dependences

Based on the presented model, some simulations of changes of micro indexes along the macro parameters were performed. These procedures allow to estimate the sensitivity of the CDF model for decision making purposes.

As the most interesting relations, the ROA, ROS and ROE changes depending on the income ratio changes are presented on the Fig. 5. Similar results were calculated for the dependencies of the ROS, ROA, ROE and Income Ratio on PMI.

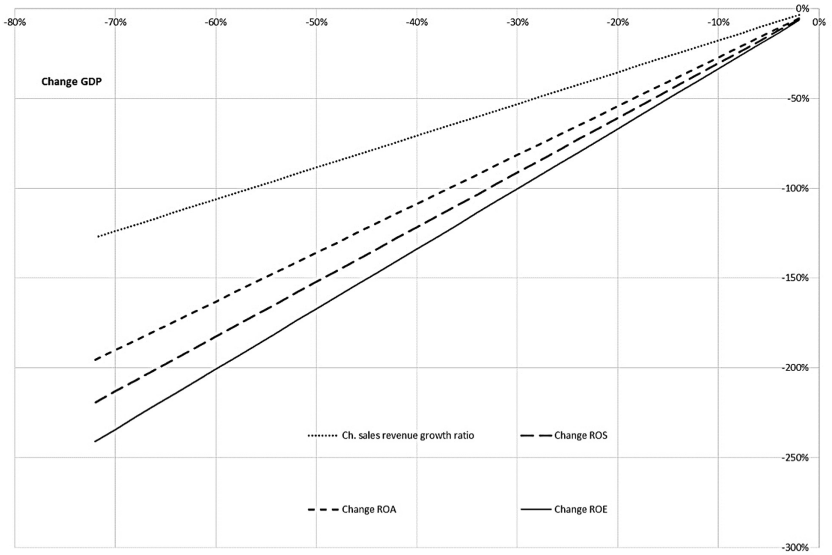

Fig. 5. Simulation of ROS, ROA, ROE and income ratio changes along the changes of the GDP

It may be concluded, that PMI is more sensitive index than GDP, but round 20% change in GDP ratio significantly influences the changes in micro indexes such as ROA, ROE and ROS. Assuming that standard GDP increasing of rational economy is about 3% per year, this 20% of changes is round 0,6% of the GDP increasing. In the case of PMI changes, the 3% decrease causes almost 100% changes in ROE/ROS. So, the relation is far much more valuable for decision supporting. Assuming IFO as the macro index the relations macro-micro are not so sensitive, about 30% of decreasing IFO causes 50% of the described micro indexes. But it is sufficient to support the decisions in micro.

6 Conclusions

The research shows that, just before the crisis starts (decrease of macro indexes), the leading indicators: PMI and IFO and interest rates are changing. In the acute phase of the crisis there is a decline in GDP and an increase in interest rates. The response of microeconomic indicators to changes in macroeconomic indicators takes place in two stages. In the initial, acute phase of the crisis yields are falling and the pace of changes in sales revenues, and a year later the receivables turnover period is extended, and the current assets debt increases. The highest sensitivity of microeconomic indicators

occurs in the case of relations with PMI and interest rates, and the lowest in relations with IFO and GDP. In the case of relations characterized by lower sensitivity of microeconomic indicators to the volatility of macroeconomic indicators, it is necessary to observe a much larger change in the macroeconomic indicator, so that the volatility of microeconomic indicators can be predicted. It allows to avoid premature activities based on random changes in macroeconomic indicators. The existence of relations in the model of relationships characterized by lower sensitivity of microeconomic indicators to changes in macroeconomic indicators increases the stability of the decision-making model.

From the presented results it may be concluded, that there exist the model supporting decision making in micro (organization) level based on the changes of some macroeconomic indexes. Quantitative approach suggests the proposed CDF value defined in this paper as satisfactory measure of the relationship force between some macro and micro indexes. Based on the CDF evaluations it is possible to state the sensitivity of each relation of macro-micro indexes and make a choice suitable pairs for decision purposes. The most valuable are the relationships between the PMI and ROA, ROE and ROS indexes as well as the Income Ratio which is closely related to ROS.

It may be also concluded that based on the presented relationships it is possible to state the rational forecast of economic position of an organization using the PMI and IFO data. From the presented simulations it follows that the sensitivity of CDF model is enough to support the tactic decisions regarding financial state of the organization.

The presented heuristic and structure of quantitative approach based on CDF model, described in this paper offer the method of optimization of the micro state on acceptable level of rationality. Optimum solution is related to dynamics of some macroeconomic factors as the forecast for the micro state estimation for not too far future (tactic level of management).

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Branch and Bound Method in Feature Selection Process for Models of Financial Condition Evaluation

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Abstract. Uncertainty and risk which are associated with company's activity require a special instrument supporting process of the managers' decision making. The objective of the research is to determine the number features characterizing the financial risk – financial condition of companies. A quality of financial condition evaluation depends on the selection of variables (features) and criteria of the assessment. The choice of financial ratios in the study of financial standing of companies is crucial. The article presents the proposal to apply branch and bound method to choose sub-optimal subsets of financial ratios that best describe the subject of the research, which is the company, under the assumption that classification algorithms are used for evaluation function creation. The aim of this study is to present a solution that allows the selection of financial ratios with a very high cognitive value, enabling the building of integrated measures assess the financial condition of the company.

Keywords: Selection of information · Financial ratios · Optimization · Discriminatory models · Branch and bound method

1 Introduction

In the rapidly changing market economies continuous assessment of financial phenomena occurring in businesses, in particular continuous evaluation of their financial condition is expected. Proper evaluation of the processes occurring in the enterprise enables prediction of the financial situation of the company and taking pre-emptive action which could protect the company from bankruptcy [1, 7, 10, 11], it means enables risk reduction of the activity. A primary source of risk in human activities is a feeling of uncertainty connected with future unknown events, due to the fact that decisions are made today and the effects of the decision will be known in the future.

There have been carrying out calculations of financial ratios of public and private companies since the 19th century. As the years passed the development of statistical methods, that were used to predict business failure, were followed. The sixties of the twentieth century were a turning point in the study of the early diagnosis of the symptoms of risk of bankruptcy.

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High volatility of the business environment and high risk of management result in a large number of bankruptcies. The tools of economic analysis allow for the rapid assessment of financial condition of companies and their financial risk [1, 10, 11]. For the past twenty five years many models have been constructed to examine the financial condition of companies and to classify them as "ones with good condition" as the ones with "bad condition" which mean high risk of bankruptcy.

Enterprises can be described by certain characteristics, features that can be financial and non-financial indicators, ratios. The use of synthetic indicators in the assessment process allows the assessment of a company financial standing, this is integrated assessment. Of course, it is clear that not every financial indicator (feature) is equally important in the evaluation of companies, therefore is crucial in this respect to choose (select) financial indicators most valuable, useful and crucial from the point of view of the assessing enterprise.

Multicriterial methods for company condition evaluation – discriminant methods, taxonomic methods, classifications (discrete risk assessments) – require the definition of a size vector (vector of features) that is the basis for assessments [5, 6, 8, 11].

Why some indicators are more often used than others? Various aspects effect the frequency of their use. One of them is the availability of data, for example not all companies are listed on the stock exchange, what means that mostly the market ratios of companies are not known, and therefore should be removed from the set of financial ratios.

In the "bankruptcy" models, Polish and foreign authors, there is a lot of talk about the quality of their assessment of enterprises [11, 12], but not much about the selection of indicators in these models. Dozens of attempts to use models are carried out, estimating their diagnostic quality, but not much about the diagnostic quality of selected indicators. Of course, expert knowledge should be appreciated, but attention should also be paid to the possibility of using the methods already used, e.g. the methods of selecting information and selecting the features for example branch and bound method.

In this paper we propose well known method, branch and bound method, for selecting features for the construction of the synthetic index of company financial condition evaluation using classification methods.

2 Feature Selection for Financial Condition Evaluation

The literature suggests several methods of selection features (indicators) to build discriminatory models [2, 4–6, 9]. Very often correlation matrix is used for features selection, but keep in mind that a strong correlation dependence between x_1 and x_2 does not exclude a weak relationship between x_1 and x_3, as well as between x_2 and x_3.

The second technique is to set yourself up as an expert in the selection of appropriate indicators. Currently, the authors are inspired by these indicators, which are often used to assess the insolvency of companies, something discussed in a number of publications.

A company has specific characteristics (in the assessment of the financial condition it can be financial ratios) that describe the object. These characteristics are expressed by a sequence s of N variables $x_1, x_2, \ldots, x_N$. The larger the N, e.g. the number of features,