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INTELLIGENT TECHNIQUES FOR ANALYSING FINANCING PROCESSES OF SMALL AND MEDIUM ENTERPISES

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INTRODUCTION

The development of new, highly efficient, intelligent methods for the analysis of creditworthiness, and the processes of financing, especially for SME's, can be considered a scientific issue. The actuality of the problem is conditioned by the current trends in the introduction of technical and technological methods in financing, and in particular the increasing importance of internal automatization of the financing processes. These trends are reflected in many researchers desire to use the latest developments in the design of highly efficient, but sophisticated data processing algorithms from SME's behavior in local business environment. Modern smart methods require, processing of large data streams, using all available information for the observation of the biggest stake of legal entities in the country – Small and Medium size enterprises SME's.

These trends are reflected in the desire of researchers to use the latest developments in the design of highly efficient but sophisticated data processing algorithms derived from close monitoring of the financial sector. Present day intelligent methods require the processing of large data streams, using all the available information for the observed area.

Recent studies on the development of the country's economy, and in particular the progresses of SMEs over the past few years show a decline in development. The recovery and restructuring of the economy goes through the rebuilding and modernization of industries that create long-term value.

The continuous development of already established SMEs in some of the analyzed sectors of the economy is supported by the identified potential for above average growth. The initially appointed favorable sectors, subject of investment will be the main focus for future investments of each JEREMIE Fund, but will not limit the exploration of other options depending on market developments.

In recent years, wider application of intelligent methods in creditworthiness analysis and financing approach modeling are found being used, in order to extract the necessary data, to further optimize and improve potential lading processes. Each individual monitoring process is actually a collection of separate sub processes that are

ran in parallel over a spread of time. Utilization of financial modeling tools, including Generalized Nets, has been proven in practice as an adequate and correct method for improving and upgrading the complexity in overall landing processes.

This greatly complicates the detection of regularities in the functioning of the monitored system. Another approach, the subject of research in the dissertation work - InterCriteria Analysis, exploits two mathematical formalisms defined by Krassimir Atanassov: the algebraic apparatus of indexed matrices (IM), when it is necessary to apply algebraic operations on matrices of different dimensions and intuitions) as a mathematical tool for treating uncertainty.

The purpose is from a matrix that contains data on the measurements or estimates of “m” number of objects, evaluated by “n” number of evaluating criteria, as a result of binary comparisons by objects and by criteria it blurred the correlation pairs between each of the two criteria and gave the name, respectively, "InterCriteria Analysis - ICA". In the ICA approach, the raw data for processing are put within an index matrix M of m rows $\{O_1, \ldots, O_m\}$ and n columns $\{C_1, \ldots, C_n\}$, where for every p, q $(1 \leq p \leq m, 1 \leq q \leq n)$, O_p in an evaluated object, C_q is an evaluation criterion, and $e_{O_pC_q}$ is the evaluation of the p-th object against the q-th criterion, defined as a real number or another object that is comparable according to relation R with all the rest elements of the index matrix M.

A sufficiently high correlation between a decision maker (LA) indicated by an "unfavorable" criterion with a "favorable" criterion is obtained when the corresponding’s to these two criteria (in order and pillar) in the matrix is higher than a predefined threshold for intuitionist fuzzy affiliation and lower than a predefined threshold for intuitionist fuzzy incongruity (thresholds are numbers in the range [0, 1]).

IRMs are used for binary comparisons and assessments of the behavior of objects by criteria, as well as for determining the values of correlation thresholds between criteria and tolerance thresholds that are required in the decision-making process.

IRMs are an essential tool of the method, since they describe both input arrays with values of multiple objects against multiple criteria, and output arrays with calculated degrees of correlation between each pair of criteria. Research in the field of

IRM operations can also be reflected in the enhancement of the capabilities and performance of the algorithms incorporated in the InterCriteria Analysis method.

The proposed approach calculates the degrees of dependence between all possible pairs of criteria, which means that they can be distinguished as already known in the literature and other established dependencies, and to discover completely new, unknown so far dependencies, and hence a completely new scientific knowledge is generated and its usefulness is designed.

In this dissertation, original results related to the research of contemporary paradigms in the field of intelligent systems have been obtained, using analytical and experimental models. The main focus of dissertation work is the analysis of the considerable variety of research and existing methods that have to determine the approaches, methods and algorithms to be tested on particular classes of subjects. The main efforts to achieve the results sought are directed at different elements of the SME financing process in the spirit of global trends.

Current dissertation aims to develop, with the support of modern tools and intelligent systems, highly efficient intelligent methods in creditworthiness analysis, and further application of modern tolls, to better assist local small business entities, especially SME's in financing processes. To achieve this goal, the following tasks are formulated:

- to systematize the existing intelligent methods for the analysis of creditworthiness and financing processes through the JEREMIE initiative;
- to apply intelligent techniques to analyze the mechanism under which the first tier of a banking institution operates, for financing small and medium-sized businesses;
- to apply intelligent techniques to analyze the effectiveness of the internal financial structural units of different banks, such as levels of the decision-making hierarchy;
- to apply intelligent techniques for analyzing various types of hybrid credit products that are appropriate for the needs of small and medium-sized businesses;

- to apply intelligent data analysis techniques for micro, small, medium and large economic entities in the EU-27, evaluated by different economic indicators;
- to apply intelligent techniques to analyze the financing mechanism of the EU budget for small and medium-sized enterprises;

The dissertation work is structured in an introduction, three chapters and a conclusion, showing the actual results of the implementation of the methodology for the analysis of the Creditworthiness in SMEs financing.

Actual results of the optimization process have been published and presented in few international conferences. In the list of publications, used for the preparation of the dissertation, are included articles, which took place in *Notes on Intuitionistic Fuzzy Sets (NIFS), ISSN 1310-4926, e-ISSN 2367-8283*, *2th International Symposium on Business Modeling and Software Design – BMSD'12, Geneva, Switzerland, 3th International Symposium on Business Modeling and Software Design – BMSD'13, Noordwijkerhout, The Netherlands, 4th International Symposium on Business Modeling and Software Design – BMSD'14, Luxembourg, Grand Duchy of Luxembourg, 5th International Symposium on Business Modeling and Software Design – BMSD'15, Milan, Italy, 12th International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets – IWIFSGN'13, Warsaw, Poland*, *17th International Conference on Intuitionistic Fuzzy Sets, Notes on Intuitionistic Fuzzy Sets, Sofia, Bulgaria* and *International Workshop on Advanced Control and Optimisation: Step Ahead – ACOSA'14, Bankya, Bulgaria*.

All publications are referenced and indexed in world-renowned databases of scientific information, which comply with the requirements of the law for the development of academic staff in the Republic of Bulgaria.

CHAPTER 1

AN OVERVIEW OF THE INTELLIGENT METHODS FOR AN ANALYSIS OF COMPLEX PROCESSES

The Artificial Intelligence (AI) occurs as a scientific field in the first decade after the Second World War, [50, 74, 75, 76, 87, 88, 89]. The term 'artificial intelligence' itself was adopted during a historical summer seminar in Dortmut (USA) in 1956, organized by John McCarthy (author of the LISP programming language), which was attended by another 9 prominent scientists in the field, including Marvin Minsky (with a huge contribution in the field of neuron networks, frame structures and the theory of knowledge presentation), Claude Shannon (author of the information theory), Allen Nuel and Herbert Siman (authors of the first computer program, capable of proving theorems, called 'Logic – Theoretic'), Arthur Samuel (who wrote the first programs for machine self-study) and another four of the 'fathers' of artificial intelligence.

From its occurrence artificial intelligence (AI) unites the research in various scientific fields, focused on the analysis of human intelligence, using the methods of informatics (computer science), mathematics and engineering. At the same time, human intelligence is an exceptionally vast field of research in scientific disciplines such as neurophysiology, psychology, linguistics, sociology and philosophy. There is exceptionally strong impact on the development of artificial intelligence by the fields theory of management and cybernetics (especially after the works of Norbert Winer), the decisions theory (of Von Neumann and Morgenstern), the research of operations (of Belman), which develop in parallel at that time. There is a dominant impact of the quickly developing computer technology, especially in the field of the programs supply, where the operational systems are created, the programming languages, the instruments for writing the programs.

Although the leading experts globally do not share the same opinion with respect to the formulation of artificial intelligence as a scientific field, however, two definitions reflect its main specifics.

‘AI is part of informatics, directed at the establishment of intelligent computer systems, i.e. systems that have characteristics, which we associate with the intelligence of human thinking – understanding natural languages, training, judgements, problem solving, etc.’ [74].

‘AI is the art of creating machines, which perform functions, requiring intelligence upon the performance thereof by people’ [76].

The first definition indicates the ambition for resemblance with certain aspects of human thinking, whereas the second definition indicates resemblance of the rational human actions.

The development of artificial intelligence indicates that the leading researchers sought ‘resemblance’, and not copying human intellect. A confirmation of this statement is the ambition to fly, which was realized successfully only when the Rite brothers and other researchers and engineers (Liliental, Zhukovski) stopped imitating the flying of birds and resorted to studying aerodynamics and applied a different approach (the immobile wing and propeller).

The history of the development of artificial intelligence is full of periods of great hopes and standstill, explained by the level of the achieved results, and the financing of research [75]. The main achievements of the classical artificial intelligence have been enumerated below:

— The NASA Remote Agent Program is the first program for automatic and autonomous planning and drawing up schedules of the forthcoming actions of spaceships in the distant space. It also has capacity to detect, isolate, diagnose and correct irregularities in the course of the occurrence thereof.

— A famous example is the win of the chess program Deep Blue of IBM in a competition with the world champion Gari Kasparov, which ended 3,5:2,5. Kasparov shared that he felt ‘intellect of new type’ against himself. The value of the IBM shares after the match increased by 18 billion US dollars.

— The DART system (Dynamic Analysis and Replanning) during the crisis in the Persian gulf in 1991 provided automated preparation of plans for delivery and drawing up shipment schedules at the same time for 50 000 cars. The methods of

planning, based on artificial intelligence, allowed the calculations to be carried out for a few hours, while the old methods would need several weeks.

— The legendary expert systems Dendral and MYCIN of the Stanford University demonstrate considerable capacity for analyzing and synthesizing new molecular structures and diagnosis of infectious diseases of the cardiovascular system.

— Many computer programs have been proposed for the understanding of natural language, translation and problem solving.

These are only a few of the brightest examples of the practical achievements of AI. The theoretical results are more considerable and are related to the use of mathematical methods (e.g. mathematical logic), optimization theory, management theory, decisions theory, as well as to the establishment of new methods, which impact on the mentioned scientific fields. Among the huge number of AI methods there are a few, which are important for the practical applications [50]:

1. Expert systems those are important, only if domain knowledge is used, in contract to the initial attempts for general valid presentation of knowledge.

2. Judgement mechanisms, which produce accurate or reliable conclusions based on the meaning of the knowledge base and the use of a certain strategy for searching and logical operations (formal logic, approximate methods).

3. Case-based reasoning or CBR, where it is assumed that similar decisions are taken in similar situations.

4. Knowledge management, which builds up an overall system for problem solving in the specific area based on a huge volume of human knowledge and experience.

Such system has been shown on Figure 1.1. [50] and contains the following main elements:

— Knowledge base, which represents an expert system.

— Judgement mechanism, which manages the processes of the logical conclusions and the mental conclusions in the system.

— Database, which contains and lays out the collected information, necessary for the knowledge base.

— User interface.

— Interface to data base.

— A module for collecting knowledge, which builds up structured knowledge based on the specific knowledge of the expert from the respective field and the conceptual knowledge and techniques of the knowledge engineer.

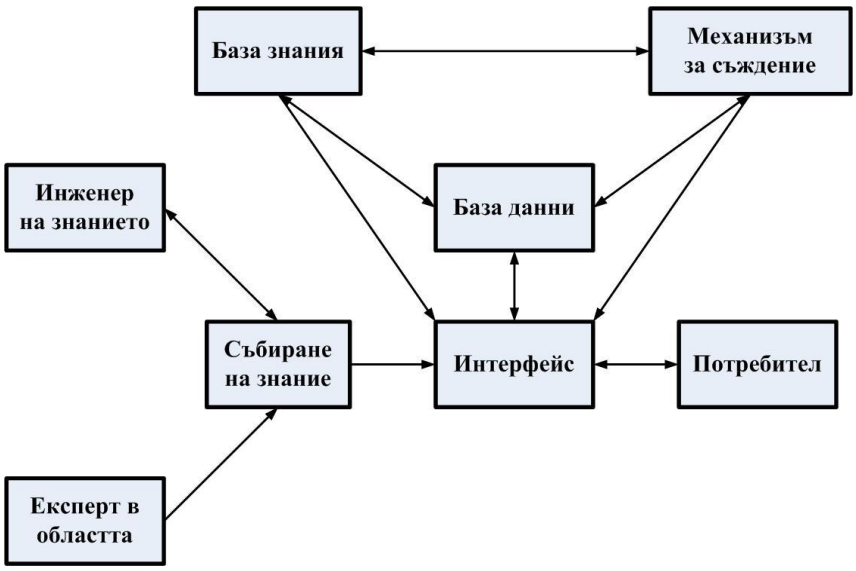

Figure. 1.1. Principle scheme of the knowledge management system

A critical moment for the success of the knowledge management system is the efficient reorganization of the expert knowledge of the field into the general knowledge base.

The increasing industry interest in the AI products started in the middle of the 80s of the previous century – about 25 years after the pioneer achievements mentioned above. This achievement in the real business is due to the following factors:

1. Gradually development of the software infrastructure for the application of artificial intelligence in the real world: from the popular product Level 5 Object for the creation of small expert systems (with less than 100 rules), through Nexpert Object, suitable for larger expert systems, to probably the most contemporary instrument for building up expert systems G2, having wide proliferation globally. This product does not require special knowledge of programming and cognitive engineering (knowledge engineering).

2. The knowledge of the specific fields of application is collected, structured and preserved. This is important for the efficient use of the company “know-how”, considering the retirement of the leading experts or their transferring in another organisation. This knowledge is useful for the exploitation experts, and for the developers of expert knowledge.

The knowledge is presented in a natural language, which deploys the field of the possible applications.

3. Development of the possibilities for interpretation of the behaviour and the decisions of the expert system – it gives explanations (upon request) of the process of the logical conclusions and the basis of the recommendations given.

4. Separating the knowledge from the judgement mechanism. This is an important achievement, because it allows to develop standard shells for the expert systems, which may be used in various fields of the applications.

The popularity of the applications of the classical methods of artificial intelligence in industry reaches its peak at the end of the 80s and the beginning of the 90s of the previous century. The increased number of implementations allows from the stage of pioneer enthusiasm, where the main task is to demonstrate the capacity for work of the main ideas and methods, to go to a sober analysis of the main three aspects of the application of artificial intelligence – methodological, infrastructure and related to people. There are a number of difficulties and shortcomings of the classical artificial intellect, which limit its wide application in a number of fields in the last 15 years.

The difficulties of *methodological character* are related mainly with the following problems:

— It is difficult to reach completeness, reasonableness and no contradiction of the rules used. The incorrect knowledge is hard to ascertain and correct. Knowledge in the form of rules depends mainly on the qualities of the expert. The situation is aggravated additionally, when one has to coordinate the opinions of several experts. Seeking consensus via averaging sometimes is not the best strategy, because it is possible one of the experts to be rights, and the others – not.

— There are considerable difficulties in deploying the scope of the expert system via new rules and internal relations.

— The classical expert systems are built up with static rules. They do not have built in instruments for training, which would allow them to be modified by automatically adding or correcting rules. This places the expert system in a position not to react adequately to the changes in the environment. Besides, there are situations, in which the changed operational condition require time for the operators to make an attempt and establish their rules, which the knowledge engineers introduce in the expert system.

There are a number of difficulties of *infrastructure* character:

— High price of the developments. Even with the use of a contemporary framework for expert system of the type G2, the time for development is several months.

— The high price of the maintenance of the expert systems. Due to the need to use expert with the highest qualification, even in the years of their greatest popularity (the end of the 80s and the beginning of the 90s), the price of the annual maintenance of the expert system is within USD 250 000 –500 000.

Often the underestimated *human factor* is a source of considerable difficulties. Thus, for example, the quality of the expert systems is determined predominantly by the quality of their knowledgebase. The collection of knowledge itself is a complex and contradictory procedure, because the best experts are much occupied and often are not prone to transfer their knowledge on the grounds of prestige and security for their workplace.

Regardless of the high scientific level of the theoretical works in artificial intelligence, which more and more transform into strong mathematical evidence and are based on secure experimental data, and not on intuition [50], the classical artificial intelligence, especially in its applied field, has a serious competitor in terms of the direction that appeared in recent years, with the name “computational intelligence” [76]. It makes an attempt to overcome some of the shortcomings of the classical artificial intelligence.

1.1. Computational intelligence.

In the last two decades there appeared gradually a new scientific field, which was termed “Computational intelligence”, one of the most popular definitions of computational intelligence in the respective academia is of the following type:

“Computational intelligence is a methodology, including calculations, showing possibilities for training and/or for coping with a new situation, so that the system is comprehended as having one or more attributes of judgements, such as summary, opening, association and abstraction.”, [3].

1.2. Main approaches in computational intelligence.

The scientific approaches, used in computational intelligence, are equally accessible for artificial intelligence, but the guidelines and the objectives in the development thereof differ. The majority of them are rooted in the classical artificial intelligence, but some are standalone scientific disciplines.

The main approaches in computational intelligence are:

1. Fuzzy Systems.
2. Artificial Neural Networks.
3. Support Vector Machines.
4. Evolutionary calculation.
5. Swarm Intelligence.
6. Intelligent agents.

Fuzzy systems emulate the inaccurate character of human knowledge. They resemble the approximate conclusions of a man, using fuzzy terms, but in a quantitative way. This makes it possible for computers to use fuzzy logic, which is very close to the real indefinite world, than accurate logic, [66, 67, 100, 1001].

Neural Networks are one of the main methods for training in computational intelligence. The obtained knowledge in the Artificial Neural Networks is presented by the numerical values of the weights in the structural relations.

Reference vectors are the second method of training in computational intelligence. They are the result of the fast development of the statistical theory of training. The main advantage of this method in comparison to the known statistical approaches is that it produces a result, which is optimum in terms of complexity of the

structure and accuracy, upon limited data. In the reference vectors method the obtained knowledge is presented via its most informative elements, called reference vectors.

The evolutionary calculations give a solution to a complex problem with a procedure, similar to the natural evolution. Only the "best" individuals "survive" in the direct sense at every stage of the decision. The main approaches here are the method of genetic algorithms (GAs) and genetic programming (GP).

Swarm intelligence uses the advantages of the collective behaviour of computer modelled individuals, imitating the social behaviour of animal colonies (ants, fish, birds).

Intelligent agents – these are autonomous software units with capacity for independent formation of behaviour in a dynamically changing environment. They will be treated in greater detail in the next section.

[50] presents the following definition of the term "Applied computational intelligence":

"Applied computational intelligence is a system of methods and infrastructure, which deploys human intelligence via training and presenting new models, relationships and structures in the complex dynamic environment for the purposes of solving practical problems."

Finally, it can be concluded that **the applied methods of the classical artificial intelligence use human knowledge, whereas these of computational intelligence try to create the conditions for efficient interaction between man and computer, which leads to increasing human intelligence**.

1.3. Intelligent systems.

"**Intelligent systems**" is a term, having a wide scope and not accepted in a straightforward fashion. The magazine "Intelligent Systems" of the biggest professional organisation globally - Institute of Electrical and Electronics Engineers - IEEE is focused mainly on informatics, while in the numerous international scientific forums devoted to the intelligent systems, there is much wider understanding in the direction of interdisciplinary and multidisciplinary approach. There is special emphasis on the term "intelligent", whose content corresponds to a great extent, in terms of sense and scope, to the terms and techniques, considered above. However, the term

"systems" has a domineering importance. "System" means not only structural characteristics (elements, relationships, interactions), but also specific realization (including simulation). The examples of intelligent systems are exceptionally varied: intelligent systems for management, intelligent systems for decision taking, intelligent robotized systems, intelligent systems for training, intelligent bioinspired systems, intelligent virtual companies, etc., [53, 61, 62, 64, 65, 68, 69, 70, 82, 95, 97, 98].

In this regard, a main emphasis in the dissertation was the analysis of the considerable variety of researches and the existing methods, which had to determine the appropriate approaches, methods and algorithms, as well as to be tested on certain classes of objects. The main efforts to achieve the results sought were directed at various elements of the overall procedure associated with the selection of appropriate instruments for carrying out the procedures for an evaluation of the researched systems – a comparative analysis, selection and reasoning of its elements, an evaluation of their strengths and limitations, the perspectives for realization in the spirit of the global tendencies.

1.4. Mathematical approaches for complex processes modelling.

In literature there are numerous mathematical means for the complex processes modelling. A great part of the development of these sciences is due to the use of mathematical and statistical means and approaches, as well as approaches and methods in the field of "artificial intellect". In fact, every real process is a set of distinct subprocesses, which take place in parallel in time. This to a great extent obstructs discovering the relationships in the functioning of a given biological system. In this relation the use of mathematical means for modelling and in particular the apparatus of the Generalized Nets (GN) [1, 2, 4, 7, 8, 9, 12, 13, 20, 26, 29, 36, 38, 39] is an exceptionally adequate and correct method. The Generalized Nets modelling makes possible the precise investigation of all parameters of the subprocesses under various conditions and moments of time. Via modelling a set of subprocesses we may receive rich information of the values of the different parameters, related to these processes. Building up models of the parallel processes, which take place in the human body, allows their full and accurate understanding. On the other hand, this leads to the possibility of timely detecting pathological and physiological deviations in the normal

functioning of a given system or a part of the human body. The process of taking a decision in a given treatment and rehabilitation program is of key importance for the favourable outcome, in this direction constructing and simulating various models allows making evaluations of the state, forecasts of the critical moments or situations, to plan the treatment process and the necessary inventory. During the years the GN apparatus was used to model a number of biological processes. The most significant example in this field may be the modelling of the human body and its distinct systems [32, 34, 37, 51, 59, 90, 96].

The present dissertation will use a recently defined new approach for assisting the taking of decisions, called “InterCriteria Analysis - ICA”. With this approach from data sets, obtained via the measuring of many objects according to many criteria, the relations are calculated between them for each pair of criteria in the form of intuitionistic fuzzy pairs of values in the interval [0; 1]. The approach takes into consideration the effect of uncertainty, makes possible to work with sets with missing data, and works not only with numbers, but also with linguistic variables with entered profit. The InterCriteria Analysis has applications in tasks, where measuring according to some of the criteria are slower or more expensive, which in turn delays or makes expensive the whole process of taking decisions. With these problems we need a method to reasonable eliminate these criteria and in this way achieve economy and efficiency.

1.5. Introduction to the theory of the Generalized Nets.

The term “Generalized Nets” (GN) was defined in a report of Corresponding Member Krassimir Atanassov, doctor of technical sciences, doctor of mathematical sciences in 1982, intended for a conference on the Bermuda islands and published in 1984. The first monograph in GN appeared in 1991. The only book in Bulgarian on GN appeared one year later, and in 1993 they published the collection of articles under the edition of Krassimir Atanassov. The collection presents the first applications of GN in various fields: artificial intelligence, chemistry, transport, computer technology, medicine, etc. It has been shown that each abstract system may also be described via GN. The definition of this new class of networks is a summary of all extensions, known at that moment, of the term “Petri Nets”, introduced in 1962 by Karl – Adam

Petri, [52]. GN's are a means for Discrete Event Simulation, which is suitable for modelling not only simple, but also big, complex systems. The Discrete Event Simulation is a method, which is used for modelling the real systems, subject to the decomposition of the set of the logically split processes, which take place independently in time. GN's allow the building up of hierarchical models. Via them one can built up systems of various level of detail, which could be further developed in depth. The main advantage of the Discrete Event Simulation is the modelling of chance events and predicting the results of the interaction between them. The GN models may be used as a quick method for analysing and solving complex problems. They provide reducing the risk and the uncertainty, related to taking important decisions, and increases the security via supporting the decision with data, received from simulation. GN's are an adequate instrument for simulation of discrete events, which is justified by the completeness of their definition. The components of GN cover all aspects of the realisation of the process, which will be depicted. The main strength and benefit of GN are the time components. In a given GN the moments of activating every transition, as well as of the network as a whole may be selected. During the simulation the expectations of the active states of the transitions or of the whole network may be changed. Another advantage of GN is the possibility to specify characteristics of the token, whereas the characteristics themselves are determined by a characteristic function. The main advantages of Generalized Net are:

- Times components – In a given GN model the moments of activating every transition, as well as of the network as a whole may be selected. During the simulation the expectations of the active states of the transitions or of the whole network may be changed.

- Characteristics of the token – Another advantage of GN is the possibility to be specified, whereas the characteristics themselves are determined by a characteristic function.

- Maintenance of hierarchy – Building up the model may go from the general to the special via gradual detailisation. So far the summarised networks have been applied in medicine [32, 37]. A number of models for diagnosing have been developed, for the functioning of the distinct authorities and systems, and of the

human body as a whole, as well as of the modelling of the processes in health institutions.

A Generalized Net consists of, [71]:

- a static structure,
- a dynamic structure,
- temporal components.

The static structure consists of objects called transitions, which have input and output places. Two transitions can share a place, but every place can be an input of at most one transition and can be an output of at most one transition.

The dynamic structure consists of tokens, which act as information carriers and can occupy a single place at every moment of the GN execution. The tokens pass through the transition from one input to another output place; such an ordered pair of places is called transition arc. The tokens' movement is governed by conditions (predicates), contained in the predicate matrix of the transition.

The information carried by a token is contained in its characteristics, which can be viewed as an associative array of characteristic names and values. The values of the token characteristics change in time according to specific rules, called characteristic functions. Every place possesses at most one characteristic function, which assigns new characteristics to the incoming tokens. Apart from movement in the net and change of the characteristics, tokens can also split and merge in the places.

The temporal components describe the time scale of GN execution. Temporal conditions control the transitions' moments of activation and duration of active state. Various other tools for fine tuning of the GN functioning are provided in the form of priorities of separate transitions, places and tokens, as well as capacities of places and transitions arcs.

As specified in the GN models assist the researchers in studying the logic of the processes, related to diagnosing and treatment, the medicine students and the trainees, who acquire diagnostic skills, as well as upon the checking of the knowledge of students with simulations in real time.

GN may use and send information from and to expert and/or information systems, as well as to contact specialised medical computer equipment via a suitable

interface. This assists the process of diagnosing via a confirmation of the opinion of the expert or supplementing the decision with an expert evaluation. [71] presents a set of GN models, which will allow the development of specific modelling software, with the aim of assisting the process of diagnosing. Till the present moment many different types of GN models in medicine have been built up, such as:

- GN models of the human body – modelling physiological processes. The live organisms are characterised with a variety of processes, which stem in parallel. Some of them, taken independently, have already been described with the help of specific mathematical means, mainly with those of the theory of systems. But these means do not succeed in reflecting the adequate parallel realisation of the processes. [32] discusses the set of parallel endocrine processes. These processes concern the production of insulin by the pancreas, introduction of artificial insulin, the use of the two types of insulin in the organism, as well as with the possible new conditions for the production of insulin by the pancreas. The paper [32] reviews the GN model of the muscular skeleton system and its relation with the remaining systems in the human body.

- GN models for diagnosis of illnesses in urgent medicine, behavioural medicine, genecology, urology, neurology, nephrology, pharmacology, etc. Before the development of GN models for diagnosis of illnesses, they used elements of the theory of graphs for taking a decision. As a whole these structures have the type of two-dimensional graphs – an initial knot (root, which represents the reception of a patient with certain symptom(s)), with two knots, which represent the alternatives (the patient has or does not have the presence of a certain symptom), whereas each bow leads to a knot, related to two new knots, again representing the presence or absence of symptoms, etc. This graph allows investigating the steps, through which the process of diagnostics passed, but does not allow going at the same time in more than one direction. If several possible paths are researched at the same time, respectively – if more than one research are made at the same time, time can be saved upon diagnosing. The GN apparatus presents this possibility.

The wide application of the summarised networks in complex systems is evident from the survey made. The possibility for modelling the financing processes

and the system of the creditworthiness, via the GN apparatus, are basis for constituting more complex models. The modelling of the specific structure and the review of the processes of its interaction with the remaining structures and systems of the financing changes is significant for a detailed and full understanding of the logical nature of the investigated object. On the other hand, the development of such models would help to find deviations from the normal functioning of the modelled structure or system, as well as the reason for these breaches.

1.5.1. Definition of transition and Generalized Nets.

During the years the definition of GN changed several times with the aim of improvement. The present definition dates back to 2007, [20]. The GN is made up of transitions. Graphically each transition is represented by two elements - ○ and |.

Each transition to GN should have at least one entry and one exit position (Figure 1.2) [1, 2, 4]. The graphical symbol of the position is (○). Each of the positions of GN may have not more than one bow for entry and as much as one bow for exit. The incoming bow is termed “exit bow” for the transition, while the leaving bow is termed “entry bow”. The entry positions are always situated on the left side of the transition, while the exit positions– on the right side. For each transition there may be m entry and n exit positions, where $m \geq 1$ and $n \geq 1$. When no bow enters one entry position, it is called network entry. Respectively, the network exit is the exit position, from which no bow goes out.

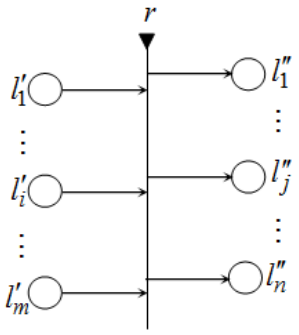

Figure. 1.2. Presentation of a transition in GN

In each position of GN there may be token, which pass from one position to another. The graphical symbol of the nucleus is a point. When the token reach a

certain number in the entry position, it will be possible for them to move to the exit positions. The process of the token's passing from the entry to the exit position is called transition activation. Each nucleus, entering the network, receives an initial characteristic. Upon passing to a new transition the nucleus receives a new characteristic and this process is repeated until the nucleus gathers its history. Each position from GN has its capacity.

The transition condition is an indexed matrix, containing as much rows as are the entry positions of the respective transition and as much columns as its exit positions. For the sample transition from Figure 1.2 the indexed matrix will have the size $m \times n$. Its elements are predicates, which receive logical values ("*true*" or "*false*"). Each entry and exit position is related to a predicate, which if it receives "*true*" value, the token of the respective entry positions will be able to move to a certain exit position. Otherwise, in case of "*false*", the token will remain in the same entry position.

In order to present the indexed matrix it is necessary first to define the sets I and R, whereas I is a fixed set of indices, and R is the set of the real numbers. Then, for indexed matrix with indexed sets K and L ($K, L \subset I$ and $K = \{ k_1, k_2, \ldots, k_m \}$, $L = \{ l_1, l_2, \ldots, l_n \}$), the following is obtained:

$$\left[K, L, \left\{a_{k_i, l_j}\right\}\right] = \begin{array}{c|cccc} & l_1 & l_2 & \ldots & l_n \\ \hline k_1 & a_{k_1,l_1} & a_{k_1,l_2} & \ldots & a_{k_1,l_n} \\ k_2 & a_{k_2,l_1} & a_{k_2,l_2} & \ldots & a_{k_2,l_n} \\ : & \ldots & \ldots & \ldots & \ldots \\ k_m & a_{k_m,k_1} & a_{k_m,l_2} & \ldots & a_{k_m,l_n} \end{array}, \quad (1)$$

Where $a_{k_i,l_j} \in R$ for $i \in [1, m]$ and $j \in [1, n]$.

The transition of GN is defined via ordered set of seven of the type:

$Z = <L', L'', t_1, t_2, r, M, \square>$,

where:

- $L' = \{ l'_1, \ldots, l'_i, \ldots, l'_m \}$ – final not empty set of entry positions of the transition;

- $L'' = \{ l''_1,..., l''_j,..., l''_n \}$ – final not empty set of exit positions of the transition;

- t_1 – moment of activating the transition;

- t_2 – duration of the active state of the transition;

- r – a condition of the transition, which determines which token may pass from its entry positions to its exit positions.

It is formed via an indexed matrix of the type:

$$r = \begin{array}{c|ccccc} & l''_1 & ... & l''_j & ... & l''_n \\ \hline l'_1 & r_{1,1} & ... & r_{1,j} & ... & r_{1,n} \\ : & ... & ... & ... & ... & ... \\ l'_i & r_{i,1} & ... & r_{i,j} & ... & r_{i,n} \\ : & ... & ... & ... & ... & ... \\ l'_m & r_{m,1} & ... & r_{m,j} & ... & r_{m,n} \end{array}, \quad \text{for } i \in \{1,2,...,m\}, j \in \{1,2,..,n\} \qquad (2)$$

$r_{i,j}$ is a predicate, which corresponds to i^{th} entry position of the transition and j^{th} exit position of the transition. If the predicate is true (has value "*true*") it is possible that the nucleus passes from i^{th} entry position to t^{th} exit position. The predicates may not depend on future events.

- M – indexed matrix of the capacity of the bows is of the following type:

$$M = \begin{array}{c|ccccc} & l''_1 & ... & l''_j & ... & l''_n \\ \hline l'_1 & m_{1,1} & ... & m_{1,j} & ... & m_{1,n} \\ : & ... & ... & ... & ... & ... \\ l'_i & m_{i,1} & ... & m_{i,j} & ... & m_{i,n} \\ : & ... & ... & ... & ... & ... \\ l'_m & m_{m,1} & ... & m_{m,j} & ... & m_{m,n} \end{array}, \qquad (3)$$

$i \in \{1,2,...,m\}, j \in \{1,2,..,n\}$

$m_{i,j}$ are natural numbers, which determine the capacity of the bow from i^{th} entry position of the transition to j^{th} exit position of the transition;

- □ – an object, of a type, similar to Boolean expression. In this identifiers participate the identifiers of all entry positions of the transition, related to the logical

operations "*and*" ($\wedge$) and "*or*" ($\vee$). When the value of the type, calculated as Boolean expression is "*true*", the respective transition may be activated, otherwise - Not.

If the Boolean expression is of the type: $\wedge(l_{i_1}, l_{i_2},\ldots, l_{i_u})$, then this means that in every entry position $l_{i_1}, l_{i_2},\ldots, l_{i_u}$ there should be at least one nucleus each.

If the Boolean expression is of the type: $\vee(l_{i_1}, l_{i_2},\ldots, l_{i_u})$, then this means that at least in one of the entry positions $l_{i_1}, l_{i_2},\ldots, l_{i_u}$ there should be at least one nucleus.

After the term "transition" has been defined, as a main constituent of the summarized network, the term "summarized network" may be defined. We define a ranked set of four as **Generalized Nets**:

$$E = <<A, \pi_A, \pi_L, c, f, \theta_1, \theta_2>, <K, \pi_K, \theta_K>, <T, t^\circ, t^*>, <X, \Phi, b>>, \quad (4)$$

If:

- A – the set of all transitions in the network;

- π_A – function, which specifies the priorities of transitions, i.e., π_A: $A \rightarrow N$, where: $N = \{0, 1, 2,\ldots\} \cup \{\infty\}$;

- π_L – function, which specifies the priorities of the positions, and L is the set of all positions of the Generalized Nets;

π_L: $L \rightarrow N$, where $L = \mathrm{pr}_1 A \cup \mathrm{pr}_2 A$ and $\mathrm{pr}_i X$ denotes the i^{th} projection of the n-measure set X, $n \in N$, $n \geq 1$, $1 \leq k \leq n$. In general:

$$pr_{i_1, i_2, \ldots, i_s} X = pr_{i_1} X \times \ldots \times pr_{i_s} X = \prod_{j=1}^{s} pr_{i_j} X,$$

where: $1 \leq i_1 < \ldots < i_s \leq n$, n is the size of X and s is a natural number.

- c – function, which determines the capacity of the positions, i.e., c: $L \rightarrow N$;

- f – function, which determines the probability value of the predicates (for the GN used here, the function f assumes values "*false*" or "*true*", or the elements of the set {0,1});

- θ_1 – function, which determines the next moment of time, in which the transition may be activated. The value of this function is recalculated at the moment, in which ends the active state of the transition $\theta_1(t) = t'$, where $t = pr_3 Z$, $t' \in [t, T+ t^*]$;

- θ_2 – function, which determines the duration of the active state of a given transition Z and its value is calculated at the moment, in which the transition $\theta_2(t) = t'$ is activated, where $t = pr_4Z$ and $t' \in [0, t^*]$;

- K – the set of token in GN;

- π_K – function, which specifies the priorities of the token, i.e. $\pi_K: K \rightarrow N$;

- θ_K – function, which specifies the moment of time, in which a certain nucleus can enter the Generalized Nets, i.e. $\theta_K(\alpha) = t$, where $\alpha \in K$, $t \in [T, T+t^*]$;

- T – the moment of time, in which the Generalized Nets starts functioning. The moment T is determined according to a fixed time scale;

- t° – elementary time step of the fixed time scale;

- t^* – duration of the functioning of the Generalized Nets;

- X – set of the initial characteristics, with which the token enter the network;

- Φ – characteristic function, it determines the new characteristic of the nucleus upon its passing from the entry position of a transition to an exit position;

- $b: K \rightarrow N$ – function, which specifies the maximum number of characteristics, which a nucleus may receive during its movement in the Generalized Nets. If for nucleus σ $b(\sigma)=1$ is complied with, then this nucleus will enter the network with *initial characteristic (null characteristic).* After that it will "remember" only *its last (current)* characteristic. If $b(\sigma)=k$ ($k<\infty$), then the nucleus σ "remembers" its last k characteristics. The initial (zero) characteristic is always preserved. If $b(\sigma)=\infty$, then the nucleus σ remembers its all possible characteristics.

The description of a given GN may not contain all its components. In this case, in the places of the missing components "*" is specified and the network is called "reduced".

The statical part of a Generalized Nets is determined by the elements of the set $pr_{1,2,6,7}A$, i.e. by the entry and exit positions of the network, by the indexed matrix of the bows and by the type of transitions. The dynamic character of the network is determined by the token of GN and by the conditions of the transitions. The time character is determined by the time components T, t°, t^* and by the elements of the set $pr_{3,4}$ A. Final, the components Φ, X and b play the role of memory of GN. The distinct

functions are also related to these four components of GN: functions π_A, π_L, c – with statical structure; f, π_K – with dynamic elements, and θ_1, θ_2 and θ_K – with the time parameters.

Above summarized networks they have defined sets of operations and operators, which modify the structure of the GN.

1.5.2. Methodology for building up a generalized net.

Upon modelling via GN it is necessary to carry out a number of preparatory activities. It is necessary that the real process, which will be modelled, be well-known, in order to correctly reflect its characteristics in the model. On the other hand, the modelling technique needs sufficient information, in order to reflect the process adequately. Consequently, before resorting to the modelling via GN, one has to determine a number of characteristics, related to building up the graphical structure of the network, the information, which the token carry and they movement in the network, the functioning of the network in time, etc. The methodology of building up GN includes the stages of building up the static structure of the modelled process, reflecting the dynamics of the modelled process, describing the functions of the modelled process in time, determining the data, which are of interest for the modelled process, etc.

1.5.3. Determining the static structure of the Generalized Nets.

Building up the static using Generalized Nets (GN), considers the issues, related to the transitions, the positions, the conditions for activating the transitions, etc. Initially one has to determine the distinct events in the system, which is modelled. Within each event some activities that represent a fragment of the overall functioning of the real system are carried out. The modelling of each event is reflected via a transition to GN.

The duration of a certain event in the real system is reflected in the summarized network via performance of the necessary conditions to activate the transition: presence of sufficient token in the entry positions of the transition, which models the respective event, presence of predicates with "*true*" value in the matrix of predicates, presence of free positions in the exit positions of the transition. Each event has to be described in detail, whereas the following are determined for this purpose:

- priority of the event with respect to the other events;
- according to absolute time scale the first moment, in which the event occurs is determined;
- determining the formula for the calculation of the next moment in time, in which the event occurs;
- duration of the event;
- determining the formula for the calculation of the event duration;
- defining the initial states of the event. At each initial state one entry position of the transition, which presents the event, is compared. The entry positions are ranked according to priority and their capacity is determined;
- determining the entry positions, in which there should be token, in order to activate the transition;
- defining the end values of the event. At each final state one exit position of the transition, which represents the event, is compared. For the exit positions one also determines their priority and capacity, as well as the characteristics, which the token, going to them, should receive;
- determining the conditions, under which a nucleus may pass from entry to exit position of the transition;
- determining the number of token, which may pass from the entry to the exit position within one activation of the transition.

1.5.4. Reflecting the dynamics of the modelled process.

The dynamics of the modelled process is reflected in GN via the presence of token in its positions. The movement of the token in the network reflects the realization of the real processes in the modelled system. Each real process represents a totality of subprocesses, which occur sequentially or in parallel in time. When the reviewed totality of subprocesses contains one element (subprocess), the need to use GN ceases to exist. The use of GN is meaningful, when the totality of the subprocesses consists of at least two elements. Via GN one may see how the distinct subprocesses develop in time and what conflict situations may occur as a result of this. GN's make possible the detailed review of the modelled totality of subprocesses.

A time scale may be associated with GN, and on this scale with the help of the global time components one takes into consideration the development of the modelled process in time. If for the modelled process it is significant that this process starts its functioning at a certain moment of time and has certain duration, then the description of GN should include the global time components. For this purpose one has to determine the elementary time step, with which time increases from the initial moment (start of the functioning of the network) to the final moment (termination of the functioning of the network).

1.5.5. Modifications of the Generalized Nets.

Via correcting or adding various components in the description of the GN, various modifications of the GN are obtained. If some of the components of the network are missing, a special class of the GN, called *reduced Generalized Nets are* obtained. On the other hand, upon adding new components a number of *deviations of the Generalized Nets* are defined.

If, for example, for the modelled process it is not important that it starts at a certain moment in time, and that it has certain duration, then it is convenient to use reduced networks. In this case the transitions in the network may be depicted without specifying their time characteristics t_1 and t_2. Considering that the network should as minimum contain: transitions, which have the respective entry and exit positions (components L' and L''), token, which reflect the ongoing processes in the modelled system, as well as a condition of the transition (component r), specifying the conditions for moving the token, *the reduced Generalized Nets* looks as follows [1, 2]:

$$E' = \langle A', K, X, \Phi \rangle, \tag{5}$$

The transitions may have the following form:

$$Z' = \langle L', L'', r, M, \square \rangle \tag{6}$$

or

$$Z' = \langle L', L'', r \rangle. \tag{7}$$

Regarding the reduced networks it can be stated that they are simpler in terms of their formal description, because they contain less components, but here they have more complex graphical structure. This is so because the objects existing in the network should receive information, which in principle is specified by other components. The token have to be more in number, have to receive more characteristics, etc.

The addition of various components to GN gives new possibilities for modelling. The various classes of GN deviations have been defined. It has been proven that each class is a conservative deviation of the ordinary network, i.e. each such deployed network may be presented via an ordinary GN. Some of the important *deviations of GN* are:

- *Intuitionistic fuzzy GN of type 1* – values in the set [0, 1] with degree of correctness $\mu(r_{i,j})$ and degree of incorrectness $\nu(r_{i,j})$, for which is in force $\mu(r_{i,j}) + \nu(r_{i,j}) \leq 1$ may be specified as conditions of the transitions;

- *Intuitionistic fuzzy GN of type 2* – these are *Intuitionistic fuzzy GN of type 1*, but the difference is that instead of token they have "liquids", passing on the network bows and gathering in the network positions;

- *Intuitionistic fuzzy GN of type 3* – such as *Intuitionistic fuzzy GN of type 1*, but with the supplement that the function Φ gives two values to each nucleus as current characteristic: the first coincides with the characteristic of the nucleus in the sense of GN, and the second is a ranked pair of the set [0, 1], which is equal to probabilistic value of the predicate, which missed the nucleus in the current position. Each GN is *Intuitionistic fuzzy GN*, for which $\mu(r_{i,j}) = 1$ and $\nu(r_{i,j}) = 0$;

- *Intuitionistic GN of type 4* – these are *Intuitionistic fuzzy GN of type 3*, but the difference is that instead of token they have "liquids", passing on the network bows and gathering in the network positions;

- *Intuitionistic GN of type 5*;

- *Colourful GN* – in this type of networks the token and the bows are in different colours and each nucleus may pass only on the bow with the same colour. Evidently each ordinary GN is a colourful GN, for which the possible colour of the token and the bows is only one;

- *GN with global memory* – with these networks a component is added (accessible for all components of the network), conditionally called “global memory”. It serves as a store of the data, which are received during the functioning of the network, and via them it is possible to determine various parameters (values of predicates, characteristic functions);

- *GN with an alarm clock* – a new time component is introduced and this component specifies the minimum duration for the calculation of the values of the predicates. After expiry of these values the predicates receive new values from preliminary specified indexed matrix, and the characteristics of the token are obtained by an additional preliminary specified characteristic function. The deployment assists in the solution of insoluble situations, related to limitations on the time to determine the values of the predicates or of the characteristic functions;

- *GN with optimization components* – via optimization procedures the way, in which token pass from the entry to the exit positions of the transitions, is determined. They may be used for management and/or optimization of sufficiently slowly passing real processes, modelled via these types of networks;

- *GN with a complex type of the transitions* – these are networks, which allow more than one bow to enter/exit in/from their position;

- *GN with conditions for stopping* – include additional conditions (logical expressions). The transition description includes an additional component, which if it receives “true” value, the transition stops functioning;

- *GN with token, which may assume variables as characteristics* – they are used to solve optimization problems, concerning the modelled processes;

- *Reverse GN* – the token may move in the reverse direction via certain areas in the network – from exit to entry;

- *GN with token with a lifetime* – the characteristics of the nucleus, which “died“, are transferred to another;

- *GN with numerous bows*, entering and leaving the positions;

- *GN with limited global capacity of the positions*;

- *GN with token with volume*;

- *GN with characteristic of the positions*.

1.6. Intuitionistic Fuzzy Sets (IFS).

The theory of the Fuzzy Sets (FS) was defined by Lotfi Aliasker Zadeh in 1965 as a mathematical apparatus for an adequate description of the inaccuracy and uncertainty in nature [100, 101]. A proof of the increasing interest in these were the developments, defined subsequently: L-FS (L-Fuzzy Sets) of Goguen [66], FS with interval values (Interval Valued Fuzzy Sets) of Gorzalczany [67], "coarse" (rough) sets of Pawlak and intuitionistic fuzzy sets (IBS) of Krassimir Atanassov [10, 16, 17, 18, 19, 25, 27, 28, 40, 44].

A represents intuitionistic fuzzy sets (IFS), the description of which is of the following type [10]:

$$A = \{\langle x, \mu_A(x), \nu_A(x)\rangle / x \in E \ \}, \tag{8}$$

where *E* is a fixed set, the function $\mu_A : E \to [0,1]$ specifies the respective degree of belonging, and the function $\nu_A : E \to [0,1]$ specifies the respective degree of not belonging of the element $x \in E$ to the set $A \subseteq E$ and for each $x \in E$ the following is complied with:

$$0 \le \mu_A(x) + \nu_A(x) \le 1. \tag{9}$$

The function π_A is described by the mathematical expression:

$$\pi_A(x) = 1 - \mu_A(x) - \nu_A(x), \tag{10}$$

Which specifies the degree of uncertainty of the element's belonging $x \in E$ to the set *A*. Evidently, FS is a special case of IFS, where $\pi_A(x) = 0$ for each $x \in E$.

1.7. Indexed matrices.

In practice it is a frequent tendency that the so called intercriterial tasks for taking a decision appear. The criteria and the available data are heterogeneous and various, and they have been obtained through the measurement or evaluation of the

objects compared to the criteria. Sometimes the measurement or the evaluation of some of the criteria may turn out slow, expensive, resource intensive, etc. In such cases the decision taker will benefit from being able to ignore upon future decision taking all or part of these 'unfavourable' criteria without a significant loss of accuracy. For this purpose it would be beneficial to ascertain sufficiently high and predictable relation between the specified "unfavourable" criteria and other among the set of criteria, which are faster, cheaper and easier to measure or evaluate. It is assumed that ignoring (without a significant loss of accuracy) of one part of the criteria upon taking a decision, on the basis of established relation between these and other criteria, may lead to a significant acceleration or becoming cheaper of the entire process of decision taking, which is always favourable, and in certain cases may be vital.

The term Indexed Matrix (IM) was introduced in 1984 by Corresponding Member Krassimir Atanassov, doctor of technical sciences, doctor of mathematical sciences in [11, 14]. During the last 25 years some of their properties were studied, but were mainly used as an additional instrument for the description of the transitions of the Generalized Nets (GN), intuitionistic fuzzy relations and graphs with edges and as a whole in some algorithms for taking decisions [21, 22, 23, 24, 31, 33, 79]. During the last 30 years some of their properties were investigated and summarized in the book of Krassimir Atanassov "Towards an Augmented Matrix Calculus", [15]. The paper [31] deploys and summarises the existing types of indexed matrices, the operations with them, and some of their properties, specifics and applications were studied.

Let I be the determined set of indexes and R be the set of real numbers. Via an indexed matrix with sets of indices K and L ($K, L \subset I$) we will note:

$$\left[K, L, \left\{a_{k_i,l_j}\right\}\right] \equiv \begin{array}{c|cccc} & l_1 & l_2 & \ldots & l_n \\ \hline k_1 & a_{k_1,l_1} & a_{k_1,l_2} & \ldots & a_{k_1,l_n} \\ k_2 & a_{k_2,l_1} & a_{k_2,l_2} & \ldots & a_{k_2,l_n} \\ \vdots & \ldots & \ldots & \ldots & \ldots \\ k_m & a_{k_m,l_1} & a_{k_m,l_2} & \ldots & a_{k_m,l_n} \end{array} \quad (11)$$

where $K=\{k_1, k_2, ..., k_m\}$, $L=\{l_1, l_2, ..., l_n\}$, for $1 \le i \le m$, and $1 \le j \le n : a_{ki,lj} \in R$.

For the indexed matrices (IM) $A=[K, L, \{a_{k_i,l_j}\}]$, $B=[P, Q, \{b_{p_r,q_s}\}]$ the defined operations for summing and multiplication are analogous to the ordinary matrix operations, as well as to other specific operations.

1.8. Method of InterCriteria Analysis.

The method of InterCriteria Analysis was introduced in [30]. It is based on two mathematical formalisms – the apparatus of the indexed matrices for the processing of data batches with various sizes, and intuitionistic fuzzy sets as a mathematical instrument for the treatment of uncertainty.

Let M be an indexed matrix, built up in the following way:

$$M = \begin{array}{c|ccccccc} & O_1 & ... & O_k & ... & O_l & ... & O_n \\ \hline C_1 & a_{C_1,O_1} & ... & a_{C_1,O_k} & ... & a_{C_1,O_l} & ... & a_{C_1,O_n} \\ \vdots & \vdots & & \vdots & & \vdots & & \vdots \\ C_i & a_{C_i,O_1} & ... & a_{C_i,O_k} & ... & a_{C_i,O_l} & ... & a_{C_i,O_n} \\ \vdots & \vdots & & \vdots & & \vdots & & \vdots \\ C_j & a_{C_j,O_1} & ... & a_{Cj,O_k} & ... & a_{C_j,O_l} & ... & a_{C_j,O_n} \\ \vdots & \vdots & & \vdots & & \vdots & & \vdots \\ C_m & a_{C_m,O_1} & ... & a_{Cm,O_k} & ... & a_{Cm,O_l} & ... & a_{Cm,O_n} \end{array} \quad (12)$$

where for each p, q ($1 \le p \le m$, $1 \le q \le n$):

- C_p is criterion;
- O_q is object;
- $a_{Cp,Oq}$ is the evaluation of the q-th object against the p-th criterion.

Each such evaluation is determined as a real number or another object, which is commensurate with regard to the relation R with the remaining a-objects, so that for each i, k, l is determined $R(a_{Ci,Ok}, a_{Ci,Ol})$. Let $\overline{R}$ be the dual relation of R in the sense that if R is satisfied, then $\overline{R}$ is not satisfied and vice versa. For example, if "R" is the relation "<", then $\overline{R}$ is the relation ">" and vice versa.

Let $S_{i,j}^{\mu}$ be the number of cases, in which $R(a_{Ci,Ok}, a_{Ci,Ol})$ and $R(a_{Cj,Ok}, a_{Cj,Ol})$ are satisfied at the same time. Let $S_{i,j}^{\nu}$ be the number of cases, in which $R(a_{Ci,Ok}, a_{Ci,Ol})$ and $\overline{R}(a_{Cj,Ok}, a_{Cj,Ol})$ are satisfied at the same time.

Since the total number of comparison in pairs between the objects is $\frac{n(n-1)}{2}$, it is evident that:

$$S_{i,j}^{\mu} + S_{i,j}^{\nu} \leq \frac{n(n-1)}{2} \tag{13}$$

For each i,j, such that $1 \leq i < j \leq m$, and for $n \geq 2$ we determine:

$$\mu_{C_i,C_j} = 2\frac{S_{i,j}^{\mu}}{n(n-1)}, \quad \nu_{C_i,C_j} = 2\frac{S_{i,j}^{\nu}}{n(n-1)} \tag{14}$$

For each two criteria C_i and C_j these two values may be used to build up intuitionistic fuzzy pair $\langle \mu_{C_i,C_j}, \nu_{C_i,C_j} \rangle$. This pair plays the role of intuitionistic fuzzy evaluation of the relation between the two criteria.

The matrix M may be transformed into another indexed matrix M^*, which shows the relationships between all criteria:

$$M^* = \begin{array}{c|ccc} & C_1 & \ldots & C_q \\ \hline C_1 & \langle \mu_{C_1,C_1}, \nu_{C_1,C_1} \rangle & \ldots & \langle \mu_{C_1,C_q}, \nu_{C_1,C_q} \rangle \\ \ldots & \ldots & \ldots & \ldots \\ C_q & \langle \mu_{C_q,C_1}, \nu_{C_q,C_1} \rangle & \ldots & \langle \mu_{C_q,C_q}, \nu_{C_q,C_q} \rangle \end{array} \tag{15}$$

The last step of the algorithm is to determine between the criteria pairs.

Let $\alpha, \beta \in [0; 1]$ be such numbers that $\alpha + \beta \leq 1$. Regarding the two criteria C_k and C_l it is assumed that they are in:

- (α, β)-positive consonance, if $\mu_{C_i,C_j} > \alpha$ and $\nu_{C_i,C_j} < \beta$:
- (α, β)-negative consonance, if $\mu_{C_i,C_j} < \beta$ and $\nu_{C_i,C_j} > \alpha$:

- (α, β)-dissonance, otherwise.

In detail, according to the table presented below the relations between the criteria are termed “strong positive consonance”, “positive consonance”, “weak positive consonance”, “weak dissonance”, “dissonance”, “strong dissonance”, “weak negative consonance”, “negative consonance” or “strongly negative consonance”.

If each evaluation a_{CpOq} is intuitionistic fuzzy pair of the form $\langle \alpha_{C_p,O_q}, \beta_{C_p,O_q} \rangle$, then the method of InterCriteria Analysis may be applied in a similar way.

Table 1.1. Relation between the criteria

Degree of relation	***Type of consonance***
[0; 0,05]	Strongly negative consonance (SNC)
[0,05; 0,15)	Negative consonance (NC)
[0,15; 0,25)	Weak negative consonance (WNC)
[0,25; 0,33)	Weak dissonance (WD)
[0,33; 0,43)	Dissonance (D)
[0,43; 0,57)	Strong dissonance (SD)
[0,57; 0,67)	Dissonance (D)
[0,67; 0,75)	Weak dissonance (WD)
[0,75; 0,85)	Weak positive consonance (WPC)
[0,85; 0,95)	Positive consonance (PC)
[0,95; 1]	Strongly positive consonance (SPC)

Let $\langle a,b \rangle$ and $\langle c,d \rangle$ be two intuitionistic fuzzy pairs. The following relations may be determined between them:

$\langle a,b \rangle \leq \langle c,d \rangle$ if $a \leq c$ and $b \geq d$,

$\langle a,b \rangle \geq \langle c,d \rangle$ if $a \geq c$ and $b \leq d$,

$\langle a,b \rangle < \langle c,d \rangle$ if $a \leq c$ and $b > d$ or $a < c$ and $b \geq d$ or $a < c$ and $b > d$,

$\langle a,b \rangle > \langle c,d \rangle$ if $a \geq c$ and $b < d$ or $a > c$ and $b \leq d$ or $a > c$ and $b < d$,

$\langle a,b \rangle = \langle c,d \rangle$ if $a = c$ and $b = d$.

The paper [35] describes the mathematic formalism, which stands behind the idea of InterCriteria Analysis. Formulas have been presented to determine the two intuitionistic fuzzy pairs in intuitionistic fuzzy evaluations of the proximity between the distinct studied criteria and different scale for determining the relations between the pairs of criteria have been discussed. In [40], this research continues with the interpretation of intuitionistic fuzzy pairs simultaneously according to the degree μ of belonging and the degree ν of not belonging within the interpretation triangle. Paper [44] presents the results of the implementation of InterCriteria Analysis in the version with their interpretation in the interpretation triangle.

At present, in the context of InterCriteria Analysis problems of various problematic areas are presented: applications in various fields of the economy and industry, applications in metaheuristic techniques, applications in neuron networks [5, 6, 41, 42, 43, 45, 46, 47, 48, 49, 54, 55, 56, 57, 58, 60, 63, 71, 72, 73, 77, 78, 80, 81, 83, 84, 85, 86, 91, 92, 93, 94, 102, 103, 110].

CHAPTER 2

ANALISING FINANCING PROCESSES OF SMALL AND MEDIUM ENTERPISES

2.1. Statistical data analysis.

Most recent statistics of the Eurostat on SMEs (2012) report that the EU of 28 states (EU28) has more than 22.3 SMEs which are a staggering 99.8% of all companies. Taken together, SMEs generate 67.1% of all jobs and make a 57.5% contribution towards the creation of wealth. Other additional factors that could be taken into account when segmenting the SME clients are the legal form of the company, accounting practice (single and double entry), audited financial statements, which are important factors, when comes down to potential financing.

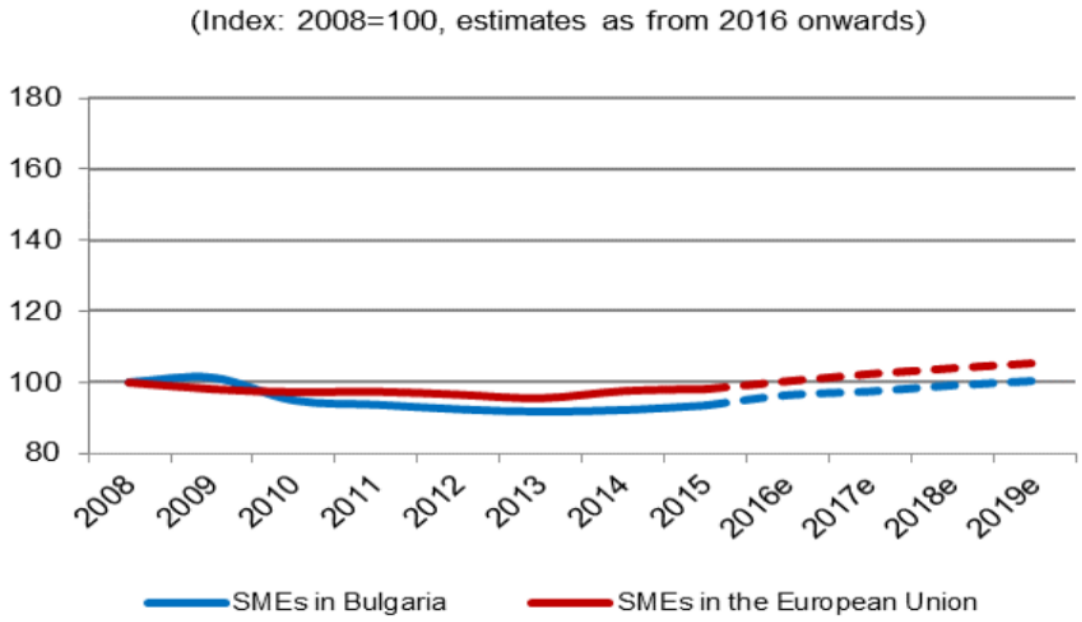

Figure 2.1. Number of persons employed in SMEs

As all throughout Europe, likewise in Bulgaria, SMEs are the backbone of non-financial business economy. Local SMEs represent 65.2% of all value added businesses, and 75.4% of employment providers, which is well above the EU average of 56.8% and 66.4%, respectively. Bulgarian SMEs employ approximately 4 and a half

people, against 3.9 in the EU as a whole. During the spread of 2011-2017, local SMEs generated sharp value added growth of 60.5%. The increase was notably strong in micro firms, with value added rising by 83.9% within the same period. After a prolonged downturn starting with the 2009 crisis, SME employment bottomed out in 2013, gradually rising afterwards, contributing to moderate overall growth of 4.1% in 2011-2017. Most recently, in 2016-2017, SME employment increased slightly, by 1.1%, and SME value added rose, by 3.6%. In 2017-2019, SME value added is forecast to increase by 15.1%. Likewise, SME employment is predicted to increase, by 3.1% within the same period, corresponding to around 46 500 new jobs.

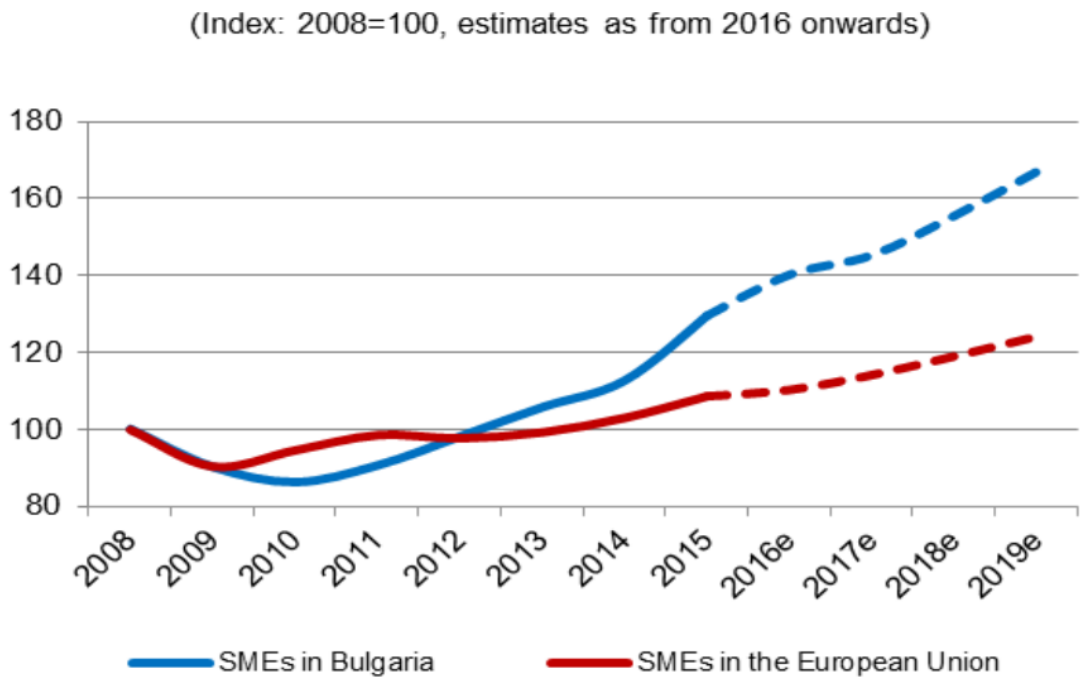

Figure 2.2. Value added of SMEs

As part of EU, the implementation of Small Business Act in Bulgaria, aim to support and provide equal business opportunity to small and medium-sized enterprises (SMEs). The introduction of a number of policy measures and principles, ranging from entrepreneurship and responsive administration to internationalization, is done with the fundamental objective to monitor and improve SME's business and existence. Annually published SBA fact sheets, aim to improve the understanding of recent

trends and national policies affecting SMEs. Bulgaria's Business Act profile, shows a performance that is below the EU average in several areas. In particular, the results show that the country's weakest performance is in the areas of entrepreneurship, responsive administration, environment and skills & innovation. State aid & public procurement, access to finance, single market and internationalization perform in line with the EU average. However, Bulgaria's strongest performance is in the area of second chance*, where the country has scored above the EU average in both the current and previous reference period. Since 2008, the country's performance in access to finance and second chance has improved.

The phrase Second chance* refers to ensuring that honest entrepreneurs who have gone bankrupt get a second chance quickly. Bulgaria performs well over the EU average in this area. This is also the area in which it performs the best out of all Business Act principles. Little or no movement has been registered across most indicators since the previous reference period. The time to resolve insolvency remains higher than the EU average with 3.3 years against 2 years in the EU. The fear of failure rate trend remains positive since it has dropped from 25% in 2016 to 20.9% in 2017, thus Bulgaria is ranked among the best-performing countries in the EU.

Since 2008, policy progress in this SBA area has been limited. The government adopted the 'Amendment to the Commerce Law' to stabilize companies before being declared insolvent. This amendment envisages the creation of pre-court insolvency procedures for companies in economic and financial distress. It aims to allow entrepreneurs to negotiate a restructuring of obligations, therefore creating the conditions necessary for their recovery.

Bulgaria still needs to address the length of time it takes to resolve insolvency. Moreover, additional policy efforts are needed to establish help-desks to provide guidance to companies on how to prevent insolvency and support those companies already in the process of bankruptcy.

During the current reference period, no new significant measures were adopted under the 'second chance' area.

Bulgaria's profile in regards to SBA execution, shows a low performance in several areas, concerning SME's. In particular, the results show that the country

performs weakly in the areas of skills & innovation, entrepreneurship, environment, and responsive administration. Single market, state aid & public procurement, access to finance and internationalisation perform in line with the EU average. The country has improved in the access to finance and 'second chance' principles, while its performance under the single market principle has deteriorated since 2008. Bulgaria's strongest performance is in relation to 'second chance', where the country scores above the EU average.

Since 2008, Bulgaria has made policy progress in implementing the recommendations of the Small Business Act. During the current reference period approximately 20 new measures were introduced, addressing majority of the policy areas under the Small Business Act. No new policy measures were introduced during the current reference period in the country's highest performing area, 'second chance'.

The areas where the Bulgarian government was most active, also visible from the results, include the 'Think Small First' principle, responsive administration, access to finance and internationalisation. Efforts have also been made with regard to skills & innovation and entrepreneurship. During the current reference period, Bulgaria strived to respond to the Small Business Act recommendations, achieving promising, but still limited results. A number of additional measures have been implemented, particularly addressing administrative burdens affecting SMEs. However, many such measures are still in the initial stages of implementation or have yet to achieve expected results. Serious additional policy efforts are required to elevate the skill base of the Bulgarian workforce, to develop innovations, to promote entrepreneurship, to apply environmental policies and to continue implementing the principles of the single market.

As previously mentioned, local government plays a strategic role in improving communication with the business, and especially with SME's. The introduction of the principle „Think Small First" has a general purpose of being a guiding principle for all policy- and law-making activities. Main focus of the exercise is certain requirements, which policymakers have to consider in best interest of SMEs', especially in the early stages of the policymaking process. The principle also calls for newly designed legislation, administrative rules and procedures to be made simple and easy to apply.

Since it was first introduced, moderate progress has been made on the application of the 'Think Small First' principle. Efforts have mainly focused on reducing administrative burdens and simplifying administrative procedures through the introduction of e-services. Over the years, Bulgarian Council of Ministers adopted a Decision, which obliges all administrative bodies to propose follow up measures to reduce administrative requirements by implementing the once-only principle.

The introduction of measures for systematically implementing the 'SME Test' as part of the impact assessment processes, are an encouraging sign that the government is trying to meet the needs of small businesses. However, the application of these measures is still limited. In this regard, the recent introduction of regulatory impact assessments of legislative and administrative acts has been a major achievement.

It is expected that the combined application of the regulatory impact assessments, improved e-services and the principle of tacit consent resulting from the changes in the Administrative Procedural Code will lead to significant improvements in the business environment.

Under the 'National Strategy for Promotion of the SMEs' 2014-2020, a new project has been started, aiming to provide tools for assisting SMEs in Bulgaria with regulatory compliance.

The SRS Service supports the project, as the beneficiary of it is Ministry of Economy and, as assistance provider, the audit company PwC was chosen. Several outcomes have been provided already, but the main results are expected toward the end of 2019.

However, SMEs remain in an unfavorable position in the dialogue between government, business and trade unions. SMEs, for example, are still not represented on the National Tripartite Cooperation Council. This is mainly because SMEs' representative organizations currently do not meet the strict requirements in terms of the number of members to be considered nationally representative organizations.

To implement further the 'Think Small First' principle, Bulgaria needs to put more effort into promoting the role of the SME envoy among stakeholders. In

addition, the country still needs to establish a common start date for all new legislation and amendments relevant to SMEs.

The combined application of the regulatory impact assessment, improved e-services and the principle of tacit consent resulting from the changes in the Administrative Procedural Code (adopted in June 2018) is expected to improve the business environment. In addition, as a result of an amendment to the Rules of Procedure of the Council of Ministers Administration a Regulatory (Scrutiny) Board has been established.

In 2018, the Report on the activity of the Administrative Reform Council for 2017 and the Annual report on Implementation of the Impact Assessments were published. Several meetings of the ongoing working groups that aim to support better SME evaluation within the impact assessment were held.

During the transition of 2011-2017, as with the overall non-financial business economy, in terms of value added, in wholesale and retail trade, SME's input grew up to 58.7%. In contrast, SME employment declined by 2.7%. Bigger companies significantly outperformed SMEs, with their value added and employment growth, increasing by 75.5% and 17.0% respectively. The large gains in value added in the sector as a whole are primarily thanks to the generally positive economic climate in Bulgaria, typified by rising incomes and consumer spending. As for example, in 2017 per capita, income in Bulgaria was 8.1%, which is a figure, higher than the one result from 2016. Nevertheless, the subdued development of employment in this sector, especially in SMEs, is largely related to the transformations, currently taking place in the retail trade. Online retail sales, are becoming more and more prevalent, although Bulgaria is still lagging behind the rest of Europe in terms of online shopping. However, new technologies have also affected traditional in-store shopping: retail traders face consumer pressure to provide cashless and contactless payment options, as well as mobile device payment systems, all of which require access to modern and risk-free payment networks. The operational and training costs of adopting this technology are more of a barrier for small and micro firms than for large retail companies. Nonetheless, these technological trends have the potential to pave the way

for cost reductions and productivity gains for SMEs. However, they are likely to result in reduced demand for labor.

Table 2.1. Eurostat statistics sourses

Class size	Number of enterprises			Number of persons employed			Value added		
	Bulgaria		*EU-28*	Bulgaria		*EU-28*	Bulgaria		*EU-28*
	Number	Share	*Share*	Number	Share	*Share*	Billion €	Share	*Share*
Micro	309 050	91.5 %	93.1 %	586 140	29.7 %	29.4 %	5.5	21.3 %	20.7 %
Small	23 734	7.0 %	5.8 %	474 078	24.0 %	20.0 %	5.8	22.4 %	17.8 %
Medium-sized	4 316	1.3 %	0.9 %	427 087	21.6 %	17.0 %	5.5	21.5 %	18.3 %
SMEs	**337 100**	**99.8 %**	**99.8 %**	**1 487 305**	**75.4 %**	**66.4 %**	**16.8**	**65.2 %**	**56.8 %**
Large	649	0.2 %	0.2 %	485 486	24.6 %	33.6 %	9.0	34.8 %	43.2 %
Total	**337 749**	**100.0 %**	**100.0 %**	**1 972 791**	**100.0 %**	**100.0 %**	**25.7**	**100.0 %**	**100.0 %**

The numbers in the table above are estimates for the period 2017-2019, and are based entirely on figures from the database statistics of Eurostat. The structural business statistic covers the spread between the years 2008-2015. The data summarizes directions in business economy, which includes industries such as construction, trade, and the services sector. Not included in the analysis are enterprises in agriculture, forestry and fisheries and the largely non-market service sectors such as education and health. Utilization of Eurostat statistics is an advantage to the point that provides harmonized and comparable data across EU-28.

One of the most dynamic sectors of the economy for SME's in Bulgaria during recent times is **Information and communication**. The sector is responsible for the highest employment contribution, in actual more than 34% to overall SME job creation in 2011-2017. The gap between the level of employment between 2011 and 2017 is shorter than 48% difference. The SME value added growth was also remarkable, at 93.5% within the same period. Computer programming and consultancy, the most significant subsector, has also been a major driver of growth. International demand for Bulgarian IT services is still the main factor behind the sector's success. By 2016, the proportion of ICT firms engaging in export activity had climbed to 70.6%. Moreover, in terms of the domestic economy, digital technologies (such as block chain and cloud technologies, enterprise resource planning and customer relationship management software) are increasingly being integrated into the

production processes of a wide range of other sectors, including finance, insurance and healthcare.

Business registrations fell by 2.2% in 2016-2017, falling to 52 790 in 2017. Furthermore, deregistration rose sharply, by 20.7%, within the same period. However, the number of businesses that deregistered in 2017 - 2150 - is still small compared to the overall number of registrations in the same year.

At the same time, a relatively large proportion of Bulgarian firms has shown high growth in recent years. In 2015, 2 835 firms, or a portion of 10.7% of all firms in the business, registered with at least 10 employees, were classified as high-growth firms. By comparison, in the EU as a whole, only 9.9% of all firms were high-growth firms in the same year. In Bulgaria, the biggest proportion of high-growth firms is in transportation and storage, at 13.9%, exceeding the EU average of 12.0%. High-growth firms are also particularly prevalent in administrative and support services, at 13.2%. However, this is lower than the EU average of 14.0%.

The recent SME growth is expected to continue over the coming years. In 2017-2019, SME value added is forecast to increase by 15.1%. Likewise, SME employment is predicted to increase, by 3.1% within the same period, corresponding to around 46 500 new SME jobs.

Continuing sector analysis, reach underperforming once, especially manufacturing, which was heavily hit in the above discussed period, not only in terms of value growth but also in the overall employment contribution. In the beginning, due to decreased internal and external demand, out of date business processes and weak financial management, the liquidity reserves of the sector decreased significantly. The situation created good opportunities, at low-to-reasonable valuations enabling investors to extract maximum return on potential investment projects. As a sign of overall economy recovery was noticed in some industries, manufacturing sector was able to wipe out some of the generated unproductivity.

The Bulgarian government expected GDP to rise by 3.7% in 2011, as foreign institutions and banks were more moderate and forecasted an average annual growth of 1.5%. Even though prognoses for a new recession in Europe are close to becoming a reality, overall expectancy is that after 2013 a partial recovery and additional growth

of the export goods demand from Western Europe will be anticipated. Combined with recovery of local consumption and resumed capital inflows this should result in an average GDP growth of 5.0% yoy over the next 10 years.

Manufacturing output growth is forecasted to be faster than GDP growth over the next decade. Manufacturing output is expected to rise by 9.6% in 2012 and on average by 7% yoy over the next 10 years.

As a result, the share of manufacturing output in GDP is projected to rise from 18.0% in 2009 to 20.9% by 2014 and rise to 21.1% by 2019. Over the same period, the share of service sector output in GDP is expected to fall from 63.4% in 2009 to 61.0% in 2014 and rise to 61.5% in 2019.

Table 2.2. Oxford Economic Forecasting, [104]

Forecast by Sectors							
	2004-2008	**2009**	**2010f**	**2011f**	**2012f**	**2013f**	**2014-2019f**
Agriculture	**-4.3%**	**-4.2%**	**2.6%**	**2.6%**	**2.6%**	**2.6%**	**2.6%**
Production	**5.6%**	**-8.1%**	**2.0%**	**8.8%**	**9.6%**	**8.0%**	**5.8%**
Extraction	*1.5%*	*-18.6%*	*4.8%*	*6.6%*	*7.6%*	*6.5%*	*4.7%*
Manufacturing	*6.7%*	*-8.2%*	*3.5%*	*9.6%*	*10.3%*	*8.2%*	*5.8%*
Utilities	*2.4%*	*-4.8%*	*-3.5%*	*6.3%*	*7.0%*	*7.5%*	*5.8%*
Construction	**12.4%**	**-6.4%**	**-8.9%**	**5.5%**	**9.1%**	**8.7%**	**6.3%**
Services	**6.9%**	**-1.7%**	**-1.5%**	**1.6%**	**4.6%**	**6.6%**	**5.9%**

According to analysist expectations, the timing for investment in Bulgarian SME's growth from the manufacturing sector is perfect for the following reasons:

- Rising external demand for the manufacturing sector is already visible in the increase of exports which surpassed pre-crisis peak levels. The decrease in local demand is slowing down to zero, and the reverse trend is already visible in the past year, along with pick up process expected to continue in 2012. This means that the economic cycle will support the investments.
- Most of the companies in the targeted industries have been privatized or established in the period 2001-2007, which makes them attractive for different kinds

of growth investments categorised mainly into 2 types: a) expansion – e.g. in production or product range, b) developing the company to the next level – e.g. vertical or horizontal integration or new markets strategy.

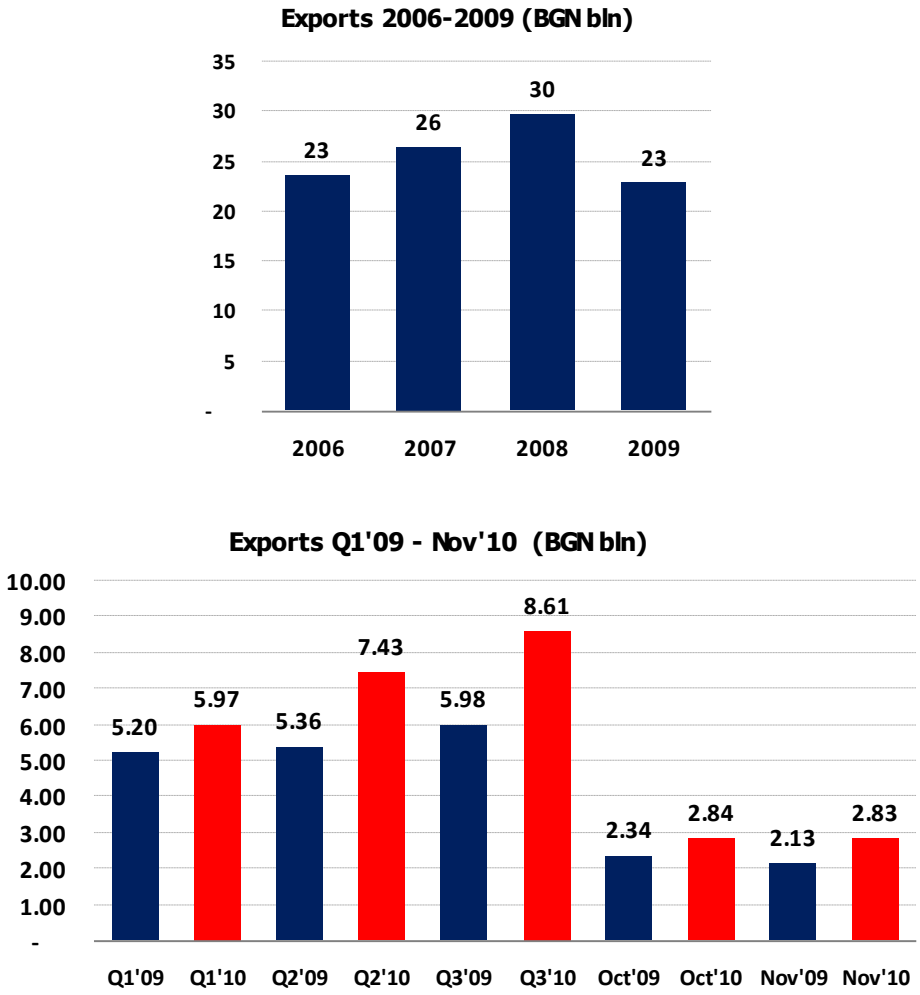

Figure 2.3. Database statistics of Eurostat

The service sector growth prior to the credit crunch was dominated by financial services, telecommunications, and real estate related activities. This led to disproportionate allocation of capital and investments leaving other promising segments of the sector underinvested, such as energy efficiency and healthcare. A great potential is sees for above average growth coupled with demand for capital in those industries.

- Energy Efficiency

The Energy Efficiency space is an attractive investing segment due to the enormous lag of Bulgaria to achieving EU-wide standard and the active supporting policies implemented over the last years. The government, in line EU targets and initiatives, has provided financial and legislative incentives for improving energy affiance, lowering overall energy consumptions and increasing renewable energy in the total consumptions mix. The country occupies one of the places in terms of energy intensity in Europe with energy intensity coefficients of the GDP standing approximately 90% above EU averages.

The latest Energy Strategy drafted by the government in line with European 20/20/20 goals envisages reduction in green-house emissions, raising the share of RES contribution to 16% of the final consumption, and reducing energy intensity of GDP by 50% by 2020. The interim target for reducing energy intensity of GDP is 25% reduction by the year 2013. The state plans to reduce the energy intensity of GDP from 913 toe/M€05 in 2005 to 456 toe/M€05 by 2020. According to different estimates, the country needs to invest approximate BGN 4.2-4.5 billion to reach the outlined targets and to lower the overall energy intensity of the economy. The achievement of the targets requires implementations efficiency and savings solutions and investments in industry (38% share in total consumption), households (21.8%), transportation (28%), and services (9.4%) and it has opened a market niche for business with above average growth opportunities.

Energy efficiency in Bulgaria is a segment, which is below the average in the EU, not only because it has not received the much needed improvement, but also because priority development was given to targeted industries that are generally energy intensive.

The market of energy efficiency solution providers and services companies is relatively fragmented and consists primarily of SMEs in earlier stages of development, thus offering ample opportunities for investment in innovative technology applications, engineering companies, and complex service providers specialized in the household and industry projects.

Prioritized SMEs in terms of energy efficiency improvement will be businesses, focusing on investments into new machinery, equipment, technologies of higher-energy class, and reduced emissions, along with companies looking for energy efficiency achievement by switching fuel consumptions (gas, etc.).

- Healthcare

Following a series of reforms Bulgaria has adopted a mixed healthcare model (similarly to Austria) combining elements of the Beveridge system and a social insurance system by the Bismarkian model. The country now has universal, mostly state-funded, healthcare system. Healthcare expenditure come from taxes, pay-roll based social security contribution to the National Health Insurance Fund, out-of pocket household payments and private insurance. Bulgaria has below average healthcare spending/GDP ratios in the EU (7.3% in 2009; 6.9% in 2010) coupled with demographic trends which are increasing demand for healthcare services. The country has a total dependency ratio, defined as people in age 0-15 and 65+ to employment groups, of approximately 45% and an aged dependency coefficient of 25% which are both expected to increase in the medium and longer term. Healthcare spending increased by a CAGR rate 12.95% in the period 2005-2010 and it is expected to grow at comparable rate.

Private and public health care providers are treated equally and according to the Law for the Health Insurance organizational relations between purchasers and providers are based on a contract model which functions as a binding agreement and it regulates the relationships between the health care providers (public and private) and the purchaser National Health Insurance Fund (NHIF). In terms of total healthcare spending the absolute amount in 2009 and 2010 were approximately BGN 5.35 billion and BGN 6.4 billion, respectively. According to data of the World Health Organization approximately 55-60% of the total spending comes from social security funds, exclusively the NHIF, and the state budget while 40% comes from private contributions including a large proportion of out-of-pocket expenses.

Outpatient medical care is almost privatized as primary care and dental care are fully privatized and specialized care is privatized in about 65%. All of pharmacies are also privatized. Private sector activity in the inpatient care segment, including general

and specialized hospitals, emergency medical care centres (EMCC), transfusion haematology centres (THC), dispensaries, nursing homes and hospices, which provide acute care, chronic and long-term care, and rehabilitation services, is also rising and the number of newly created private inpatient practices increased gradually from some 32 in 2003 to approximately 75 now, or 25% of the total count. The number of beds in the private hospitals is about 2500 (or 6% of all hospital beds) compared to an average rate of approximately 20% for the EU27 or on average 30 beds per one hospital, with only 5 exceeding 100 beds and being multi-profile. The rest of the private hospitals are small specialized ones – surgical, obstetric and gynaecological, ophthalmological and cardiological.

The positive outlook for private healthcare services providers is further reinforced by the right of patients for choosing a private or public establishment which created opportunities for real competition among the health care providers, especially in regions where alternatives exist. The large share of out-pocket expenses (often un-regulated), the in-adequate healthcare coverage by the NHIF, low service levels and dire infrastructure of public providers, which are chronically underfunded from relying predominantly on the Ministry of Health and NHIF funding, all favour preference of patients for private providers. Private establishments are also benefiting from general improvement of living standards and disposable income growth. Furthermore, rates of services are most often significantly lower by Western standards while quality is at par or better and many foreigners are taking advantage of the disparity by travelling to the country for receiving care from private clinics.

Private sector activity also benefits from the availability of trained specialized personnel. Bulgaria brags approximately 365 physicians per 100,000 inhabitants (EU 27 average of 322) numbering 27,480 practicing physicians in 2010 (16,730 with specialty designation). Despite the high count there is deficit in some specialties (e.g. anaesthetics) and qualified nursing personnel is about 35% lower than EU levels.

Looking back in time more than 70% of investments went into non-productive, highly speculative and cyclical businesses or were triggered by arbitrage opportunities in privatisation deals. Manufacturing and service industries (excl. financial services) did not benefit proportionally from the growth. Looking back in a period of 25 years

Bulgaria has lost more than 50% of its light and heavy industry production and more than 60% of agriculture production, turning from a net exporter into net importer for many goods.

It is believe that the next growth wave in the country will be driven by the rehabilitation and modernization of long-term value creating industries led by the manufacturing sector, which will profit from a boost in the local agriculture sector and foreign demand (e.g. exports are surpassing pre-crisis levels). Modernization of production assets is closely related to the implementation of Government's initiative for energy affiances improvements. Service industries, excluding financial services and telecom, are currently underdeveloped, and will grab higher share of the economy and outperform

The development of these industries will support sustainable growth in the country's economy in general. The segment will be in the main focus for investments in the upcoming future by any structured fund or government initiative, but will not limit the exploration of other opportunities depending on the market developments.

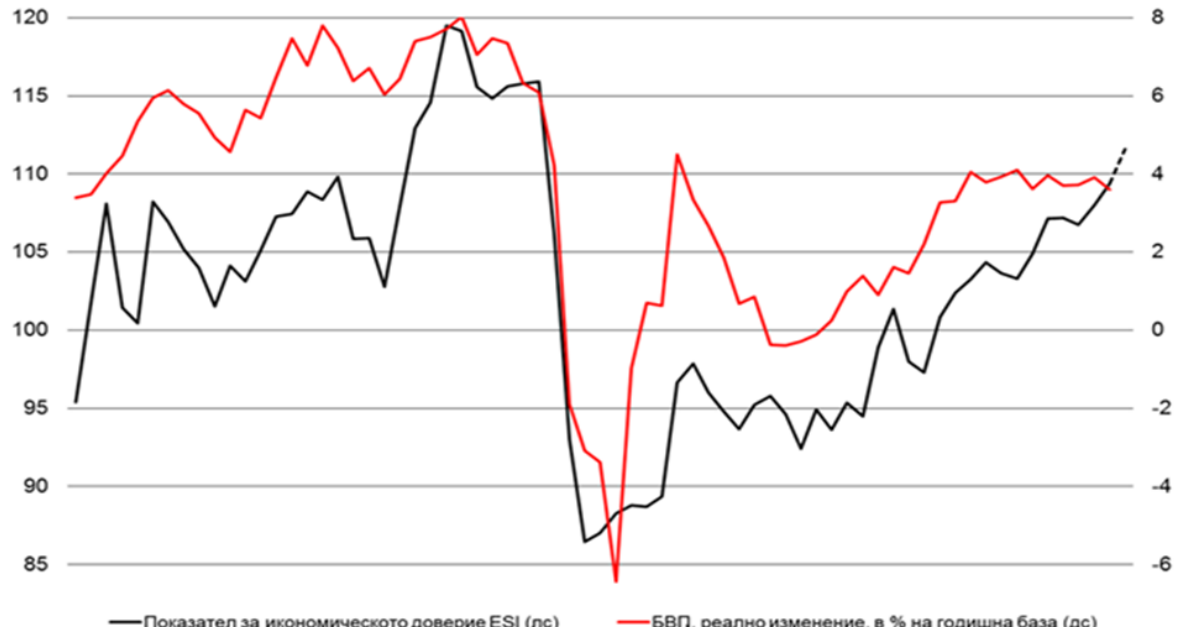

Figure 2.4. Database statistics

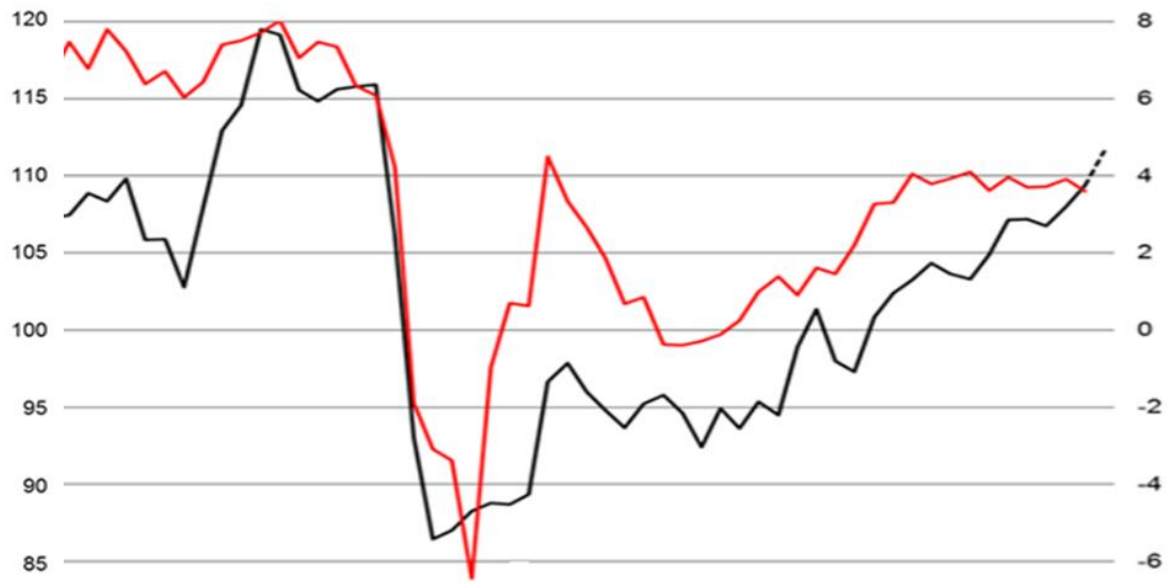

Figure 2.5. Database statistics

Considering the variable economic conditions, to which SME's are exposed, the attitude to external financing changes. A statistical overview of the sector, shows that over the past 20 years, about 21% of enterprises had access and utilized investment loans, 17% had access to working capital funds, and 62% didn't have any access to financing whatsoever. The willingness for comprehensive modification, and internal adjustments in local banking system supported by available EU structured funds, significantly increased the accession of SME's to venture funding. From year 2010 onwards, about 55% of companies are able to reach financing of any type. Premise for that is the inculcation of newer and upgraded screening mechanisms, adopted by financial institutions. Before that, variety of ways are encountered, as most popular source of financing between SME's was owner's resources, followed by illegitimate financing from friends and relatives, and at last EU funds and Bank financing (near 30%). Prior to that period, more than 50% of companies are able to finance new projects, and internal activities with own equity. Limitations and obstacles in financing occur mainly due to the reduced investment intentions of SME's within the last few years. Main reasons for it are lack of economic stability within the country and EU, along with gradual increase of intercompany leverage. The figures show that, intercompany debt over the past 3 years has gone up over 100%. At present time about

83% of all SME's have uncollected receivables (Bulgarian Industrial Association). Repayment of company debt, via bank loan is the first forbidden rule in banking system. At the same time overall global economy, which is deepening in debt, and is not able to generate enough aggregate demand of goods and services, inevitably is contaminates local economy environment. Excessively high levels of debt, carries behind twice as much risk factors, for economy in general. Potential price shock (regardless of origination) would result into expenditure shrinkage, which further and even faster will weaken economy growth, investments and overall employment. Practical example, when a company applies for a bank loan, most important executable documentation is pretty much the content of Balance sheet and P&L. The correlation between receivables/liabilities would give the necessary indicators of debt and overall company performance. As potential loan approval decision is strictly backed by those and other financial ratios, a negative decision on loan application, could be very well expected. Also, an important fact of decision making is the time line. Manually analyzing customer's balance sheet, receivables, inventory, cash flow and other relevant information takas a significant period of time, which could be reduced by automating the process. The practice shows that, for a number of years, an SME borrower is a subject of traditional approach, which means – manual underwriting. Traditional balance sheet, P&L, management and economic data are not easily available for small business. In order to prepare such financial and performance information, potential borrower is obligated to either maintain a sophisticated accounting team, or utilize services of well-organized accounting firm. In both scenarios, to obtain such extensive and correct financial data, is a major concern and a serious financial burden.

In comparison with the other Member States, as focus being access to finance, Bulgaria performs broadly in line with the EU average and is continuously improving since 2008. The main challenge for Bulgarian SMEs is addressing bad debt loss measured as a percentage of total turnover, which has increased from 3.6% in 2016 to 4.1% in 2017. In this indicator, the country performs well below the EU average and is one of the worst performing. On a positive note, Bulgaria scores above the EU average in the 'strength of legal rights' indicator, being one of the best performers. It remains

in line with the EU average regarding the time it takes to be paid, but has dropped since 2014.

SMEs are the backbone of the Bulgarian 'non-financial business economy'. They account for 65.2% of value added and 75.4% of employment, well above the EU average of 56.8% and 66.4%, respectively. Bulgarian SMEs employ 4.4 people on average, against 3.9 in the EU as a whole. Bulgarian SMEs generated sharp value added growth of 60.5% in 2011-2017. The increase was especially strong in micro firms, with value added rising by 83.9% within the same period. After a prolonged downturn starting with the 2009 crisis, SME employment bottomed out in 2013, gradually rising afterwards, contributing to moderate overall growth of 4.1% in 2011-2017. Most recently, in 2016-2017, SME employment increased slightly, by 1.1%, and SME value added rose, by 3.6%. In 2017-2019, SME value added is forecast to increase by 15.1%. Likewise, SME employment is predicted to increase, by 3.1% within the same period, corresponding to around 46 500 new SME jobs.

In therms of adopted skills and innovative techniques and approaches, the country performs well below the EU average in the area. Overall, Bulgaria's performance under this SBA principle has stagnated since 2008, and due to the rank of many indicators, Bulgaria is still among the three lowest performers in the EU. Nearly all scores are below the EU average, except in the percentage of people employed that have ICT specialist skills for which Bulgaria is in line with the EU average. However, the country improved in several indicators between 2014 and 2017. The percentage of SMEs selling online has slightly increased from 5.2% in 2014 to 7.1%. The turnover from e-commerce has also improved from 1.7% in 2014 to 3.5% in 2017. The national R&D available to SMEs has improved marginally since the previous reference period; however, the country's performance is still below the EU average.

Since 2008, moderate policy progress has been made. Relevant policy measures include R&D grant schemes, the development of new and effective technology centres, and support from technology transfer offices. During 2017 and the first quarter of 2018, four important new measures were introduced under the skills & innovation principle:

- The ‘Development of a modern industrial property system that supports the activities from the Patent Office’, under the Operational Programme 2014-2020, addresses the lack of resources SMEs have to cover the significant costs of registering and maintaining patents or other forms of intellectual property rights. It aims to develop an upgraded and integrated IT environment in the Patent Office for the benefit of businesses, which is expected to support the innovation capacity of SMEs.

- The ‘Introduction of credits in the vocational education and training system’ creates valuable educational programmes that are aligned with the European Credit Transfer and Accumulation System and the Vocational Education and Training.

- The ‘Development of innovative products and production’ aims to increase the proportion of companies developing innovative products and production processes and the innovation capacity of companies.

Willingness on behalf of financial institutions on loan provision has improved since the percentage of respondents that indicated deterioration dropped from 2016 to 2017 from 6.5% to 4.1%. For this indicator, Bulgaria is the top performer of all EU countries. In terms of alternative funding, the country is lacking in business angels for new and growing firms and venture capital investments. Moreover, Bulgaria’s performance in equity funding for new and growing firms has declined since 2016 from 3.2 to 2.8 index points. Since 2008, numerous measures have been taken and currently new financial instruments are readily available to SMEs. However, Bulgarian SMEs still face difficulties in obtaining public guarantees and the country’s risk capital remains limited. Moreover, SMEs are lagging behind in terms of accessing alternative sources of funding such as crowdfunding and business angels.

During riecent years, several initiatives have been taken to improve SMEs’ access to finance:

- The ‘Law on Payment Services and Payment Systems’ creates a regulatory framework including specific requirements for payment service providers, especially online, to limit and control the risks associated with the security of payments.

- The ‘On-lending programme under the Juncker Plan’ intends to increase the possibilities for SMEs to access finance with a guarantee facility and counter-

guarantee by the European Investment Fund Programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME).

- The ‘National Guarantee Fund scheme’ provides loan guarantees of up to BGN 1 million. Only new loans to SMEs, including start-ups, are eligible under the programme. These loans are granted for both working capital and investment needs. Loans for implementing projects under the operational programmes and the rural development programme 2014 -2020 are also included.

- Amendments to the Law on European Funds Management’ ensures the financial management principle, and is implemented for national co-financing programmes. It contributes to achieving better financial discipline, protection regarding public contributions and rationalising administrative practice.

Most common, but as previous times mentioned underutilized options of fund raisings, are government financial programs. Less than 5% of the companies had access to that type, due to budget limitation and overwhelming requirements. Non-government organizations landing programs had an input of less than 3% on the overall SME segment. Financing via EU structured funds has significant portion (over 46%) of the whole picture, and considerable number of SMEs are striving and making efforts to the new programing period. Again, access to available programs is a subject of meeting a certain number of criteria’s and requirements, which becomes a major obstacle to certain percentage of SME’s.

Those type of grants are preferable way of financing projects, and gives chance of some start up and all others, to make „the first turn on their business cycle“ with a lower level of risk and debt free. Unfortunately the dependency on EU funding brings an artificial level of comfort, considering that funds are provided as grants to the particular sector of the economy, and are not subject of return if all requirements met. Main obstacle is the programing period of the EU instruments, because once budgets are depleted or timely expired, than internal cash-flow becomes solely dependent on regularity in revenue and proper management. Alternative ways of raising funds by SME’s are via leasing schemes, where at present about 30% of SME’s are able to reach their investment goals, whereas couple of years earlier the figure was close to 45%.

In terms of funds allocation, regardless of origination (loan/own cash), majority of investments made by SME's are into new equipment and machinery (about 35%), re qualification, training and advertisement is the second investment direction (29%), development of present and design of additional newer products (22%), introduction of systems for intercompany management processes (9%).

Alternative ways of raising funds by SME's are via leasing schemes, where at present about 32% of SME's are able to reach their investment goals, whereas couple of years earlier the figure is close to 45%.

Due to worsen economic environment and interbanking debt, weaker turnover and profit results, most SME's are unable to rely on own resources. This is valid to such an extent that the financing with own funds has decreased 10 times and in spite of the difficulties, concerning the receipt of a bank loan, it has turned into the most preferred source of funds.

The most popular source of financing among commercial banks and leasing companies is public procurement. Statistics show that about 15% of SME's take advantage of public procurement. Raising funds via government programs was used by 2.9% of the companies, and access to financing via programs of non-government organizations has a share of 2%. Financing via EU structured funds had an insignificant portion (1.6%) up until few years ago. Nowadays the percentage has increased considerably and 45% of SME's is making efforts to receive the embedded financing and grant schemes, (Bulgarian Small and Medium Enterprise Promotion Agency).

Regardless of the above mentioned statistics there hasn't been any considerable changes in regards to the specific difficulties, with which SME are confronted upon the receipt of a bank loan. Most of which they encounter are:

- Considerableinterest rates and requirements for sufficient loan collateral. Often companies do not dispose with the necessary real estates, and the interest rates are close to the profitability of their assets.
- Lacking or insufficient credit history (valid to an even greater extent for the new companies). The reason for this often is the concealing of tax, despite the decrease in the tax and social security burden in the last years.

- The relatively low economic and legal general knowledge of the owners of SMEs.
- Incapacity for the preparation of a long-term plan for the development of business. This is the result of the unstable economic environment, as well as of the incapacity of SMEs to prepare reliable long-term financial forecasts.
- High fees, “hidden” interest and the heavy paperwork, associated with loan granting/project

The evaluation process of loan applications begins at first level - Branch facility of a financial Institution. Loan projects are initially assessed by at branch level, by manager and supporting team of loan specialist and bank’s representatives. Main focus is the gathering of all necessary information, labeled as objective characteristics. Preliminary research and opinion is based on information provided, so as sent to the headquarters can be filtered and loaded into the automated scoring model.

2.2. Ways of financing, strategies, tools.

JEREMIE is a joint initiative set up in 2007 by the European Commission (Directorate-General for Regional and Urban Policy) in co-operation with the European Investment Bank Group and other financial institutions to enhance cohesion across the EU. The JEREMIE instrument was set up to deploy part of the EU Structural Funds allocated to the regional and national Managing Authorities through new risk finance initiatives for SMEs. In this regard, JEREMIE is a predecessor to the current ESIF-backed programmes managed by EIF under the new 2014-2020 programming period.

JEREMIE offered EU Member States, through their national or regional Managing Authorities, the opportunity to use part of their EU Structural Funds to finance SMEs in a more efficient and sustainable way. JEREMIE's financial resources have been deployed through selected financial intermediaries across the EU, which have provided loans, equity and guarantees to SMEs.

At the end of 2015, EIF managed 13 JEREMIE holding funds for a total of EUR 1.1bn, involving 50 financial intermediaries and resulting in 84 transactions. In the course of 2015, additional commitments were made to the holding funds in Romania (EUR 75m) and Slovakia (EUR 40m) with the implementation period of the

financial instruments being extended into 2016. Furthermore, given the revolving nature of financial instruments, several Member States and regions have entrusted the management of reflows from initial JEREMIE investments to EIF. Accordingly, EIF will redeploy these legacy funds in the respective markets through existing and new financial instruments targeting the support of SME access to finance.

The entrepreneurs below benefited from JEREMIE support which allowed EIF financial intermediaries to give them the necessary kick-start to launch or expand their businesses and carry out their ambitions.

In Bulgaria, the JEREMIE Holding Fund (JHF) is financed by the European Regional Development Fund (ERDF) and co-financed by 15% by the State Budget within the framework of the Operational Programme (OP) "Development of the Competitiveness of the Bulgarian Economy 2007 – 2013". Under this OP, the Ministry of Economy, Energy and Tourism (MEET), has allocated contributions under the Priority Axis 3, including a national contribution, equal to EUR 349 million for the implementation of the JEREMIE Initiative aiming to improve the access to finance for Small and Medium-sized Enterprises (SMEs) through various financial engineering instruments.

Back in 2010, the Government of the Republic of Bulgaria, through the MEET, and the European Investment Fund (EIF) signed the Amended and Restated Funding and Framework Agreements (Amended Agreements) structuring the implementation of the JEREMIE Initiative in Bulgaria.

Part of the Amended Agreements is the investment strategy of the JEREMIE Initiative in Bulgaria. It envisages a balanced mix of equity and debt instruments to address the existing major gaps between supply and demand of financial engineering instruments. On the equity side, the initiative has developed a rich portfolio of instruments addressing all the stages of the life cycle of an enterprise – the Entrepreneurship Acceleration and Seed Financing Instrument for the enterprises in their pre-seed and seed stages, the Risk Capital Fund for the enterprises in their early expansion stages, as well as Co-Investment and Mezzanine Funds targeted at more mature, established companies seeking growth and expansion opportunities.

On the debt side, the initiative supports SMEs through a First Loss Portfolio Guarantee instrument aimed at decreasing the collateral levels and interest rates of loans to SMEs and a Portfolio Risk Sharing Instrument aimed at substantially decreasing the interest rate paid by Bulgarian SMEs. Due to the leveraged structure of the Financial Instruments, in addition to the public funds under JEREMIE (EUR 349 million), it is estimated that an aggregate of EUR 853 million will be directed towards supporting Bulgarian SMEs in the form of equity investments and loans, thus providing Bulgarian SMEs with EUR 2.45 for each EUR 1 of public funding available.

The European Investment Fund (EIF) has signed 5 guarantee agreements with CIBANK, ProCredit Bank (Bulgaria), Raiffeisenbank (Bulgaria), UniCredit Bulbank and United Bulgarian Bank under the Joint European Resources for Micro to Medium Enterprises (JEREMIE) initiative, allowing them to provide up to EUR 400 million of new loans to Bulgarian small and medium enterprises.

On 29th of August 2011, the European Investment Fund launched Call for Expression of Interest No. JER-009/5 to select Financial Intermediaries that will receive resources from the JEREMIE Holding Fund for Bulgaria to implement the following Financial Instrument: Entrepreneurship Acceleration and Seed Financing Instrument.

Further to the signature of five guarantee agreements with Bulgarian banks in July 2011 under the Joint European Resources for Micro to Medium Enterprises (JEREMIE) initiative, EIF progressed with the selection of financial intermediaries under the calls for expressions of interest for the equity products and is currently negotiating a potential commitment with the following private equity fund managers:

Risk Capital Fund

Neveq Capital Partners – an established team in the Bulgarian market, with an investment experience through NEVEQ I, a previous fund of similar size and strategy, raised in 2007.

The new fund has a target size of at least EUR 30m and will focus on seed, start-ups and late stage transactions in Bulgarian technology companies. Investments into individual portfolio companies will typically be in the range of EUR 0.5m – EUR 1.5m per annum.

Growth Capital Fund

Axxess Capital – a new company to manage the JEREMIE growth fund will be set-up by Axxess, one of the largest and most experienced private equity teams consistently focusing on the South-Eastern European lower mid-market. Axxess is headquartered in Bucharest (Romania) and has an office in Sofia (Bulgaria). Since 1994 Axxess has raised and managed three multi-country private equity funds: Romanian American Enterprise Fund established in 1994, the 2005 Balkan Accession Fund and Emerging Europe Accession Fund raised in 2010.

The growth capital fund has a target size of EUR 60m and will provide growth/expansion capital to Bulgarian lower mid-market companies, across a wide range of sectors.

Mezzanine Fund

Bulgaria Mezzanine Capital – a joint venture between Growth Capital Partners AG (GCP) and Rosslyn Capital Partners (RCP). GCP was founded by principles of Mezzanine Management Central Europe (MMCE), the leading mezzanine fund manager in the CEE region created in 2000. MMCE has successfully raised and managed three multi-country mezzanine funds since 2003 focusing on CEE: AMC I in 2003, AMC II in 2007 and AMC III in 2010. RCP was established in 2002 and since then has raised and/or managed five equity funds with more than 30 direct investments, mainly in Bulgaria.

The mezzanine fund with a target size of EUR 60m will provide mezzanine financing for growth expansion, external growth and capital restructurings in the Bulgarian lower mid-market, across a wide range of sectors. The targeted investment size per transaction is EUR 2m – 5m.

The three fund managers have been retained out of the twenty nine applications received under the aforementioned calls for expression of interest. The EIF is in the process of legal negotiation with the intermediaries and will be able to confirm their selection once an agreement has been reached on all the details.

The fund managers have also commenced the process of raising private contributions as well as structuring fund vehicles.

It is expected that the first funds will start the investment process in 2012.

The table below summaries the allocations per instrument within the portfolio of JEREMIE Bulgaria as at 31 December 2014.

Beyond that point, EUR 628 million of loan and equity investment portfolio committed to more than 6,247 Bulgarian SMEs by end-2014, translating into a leverage ratio of 1.8x for each 1 EUR of public funds contributed through the JEREMIE Initiative.

More than 7,300 individual SME financing operations supported.

Absorption of JHF funds stood at 71.5% as of end-2014 – the totality of the JHF funds has been committed to operations.

In 2014, the SME lending activity under the Portfolio Risk Sharing Loan (PRSL) further accelerated with 86% growth of signed SME loan amount YoY. A total of EUR 317m was committed to 2,177 SMEs representing 81% of total budget of the instrument.

Close to full absorption of the original budget of the First Loss Portfolio Guarantee product, together with high market demand by SMES, led to a decision to allocate additional EUR 12m of JHF resources to the instrument in 2014 that along with leverage effect of 5 times is expected to provide additional EUR 60m of guaranteed SME loans in the course of 2015.

- Further negotiations for a financial commitment to the Mezzanine Fund instrument were suspended due to shortening of the prospective investment period; the original budget of EUR 30m for the instrument was reallocated to other operations with financial intermediaries in JHF portfolio.
- Effective start of the two equity funds under the Co-Investment Fund(s) instrument brought the number of equity operations to five in total.
- On 24th of October, 2014 the Government of the Republic of Bulgaria, represented by the Ministry of Economy and Energy and EIF signed an extension of the term of EIF mandate for management of JEREMIE Holding Fund beyond the original deadline 31st of December, 2015. Under the Third Amendment Agreements of the Framework and Funding Agreements, which are set to enter into force on 30th of June, 2015, EIF will continue to act as a sole shareholder of JEREMIE Bulgaria and

to manage the portfolio of underlying operations for the benefit of the Republic of Bulgaria until 31st of December, 2025.

Table 2.3. Allocations per instrument within the portfolio of JEREMIE Bulgaria

Instrument	JEREMIE Allocation	Total budged (incl leverage)
First Loss Portfolio Guarantee	BGN 141.2m	BGN 706m
Portfolio Risk Sharing Loan	BGN 381.4m	BGN 763m
Entrepreneurship Acceleration & Seed Funds	BGN 41m	BGN 41m
Risk Capital Fund	BGN 27.9m	BGN 40m
Co-Investment Funds	BGN 49m	BGN 98m
TOTAL	BGN 640.5m	BGN 1,648m

2.3. Fund focus, including stage and sector (investment criteria).

The individual investments in the fund's portfolio will be selected based on the combination between the mandatory and at least on of the optional criteria:

Mandatory Criteria

- Management team and human resources' potential;
- Profound market and industry knowledge;
- Business model scalability;
- Distinctive competitive advantages;
- Double digit growth potential of the companies revenues;
- Clear Exit Route.

Optional Criteria

- Value-adding opportunities through process optimization, strategy fine-tuning;
- Market scalability of the products (export);
- Potential for horizontal or vertical integration.

The majority of SME companies in Bulgaria experience difficulties in maintaining a normal life cycle and tend to suffer from early maturity and decline without being able to materialize its full potential. There are many reasons for this, with the most common being – poor management and lack of financing. The Fund will aim in this cases at eliminating these factors with different optimization strategies, so the company converges to its natural development path and then seek expansion

opportunities. Companies that have already accomplished this stage of their life cycle will be prepared for the next level.

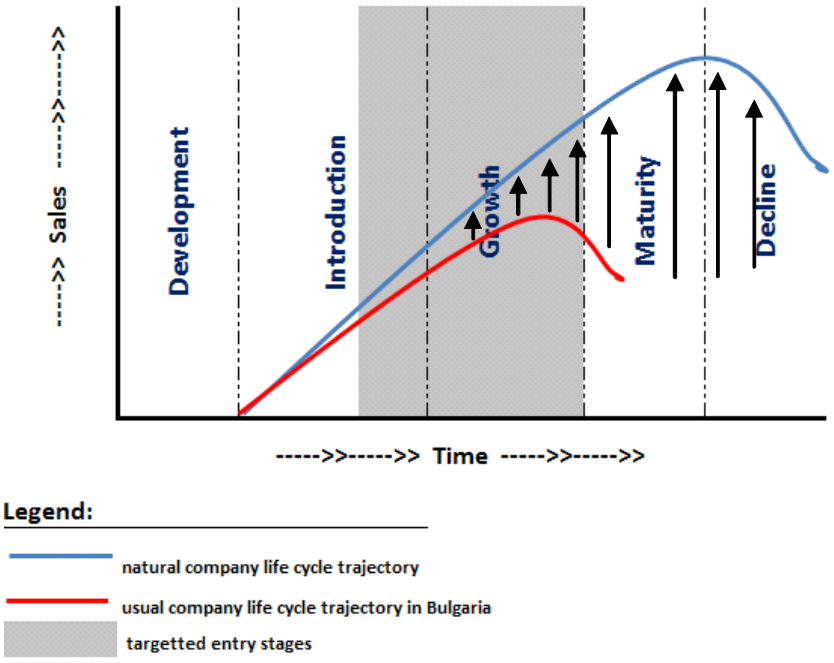

Figure 2.6. Life cycle of SME companies

Business cycle stage of the investment targets:

- *Expansion and optimization*

By providing equity financing, business expansion and optimization can be achieved primarily through the implementation of various strategies: production capacity expansion; new product or a new line of products launch; commercial network development, process improvement and efficiency

More than 80% of the companies are managed with outdated structures, based on personal skills and single person's authority. It is believe that implementation of modern business processes and process management would increase significantly profitability.

Optimization of the marketing strategy and establishment of adequate financial management will be in most of the investment cases the other substantial driver for successful expansion.

- *Upgrading to the next level*

The step to the next lifecycle stage of the company will be achieved by providing equity capital and financial structuring of the implementation of one or several of the following strategies:

- Organic growth for companies with interesting and multipliable business models
- Non-organic growth, horizontal integration
- Non-organic growth, vertical integration across the value chain
- Creating regional leaders and consolidation plays

Investment Cases

The described cases represent and summarize a small part of the existing opportunities.

Investment Case 1 – expansion

A mid-size Brewery was established in 1997, after a privatization process. Initial production funding came from in-kind contributions from shareholder's equity, along with mortgaging companies land and real estate property. These sources were sufficient to enable the company to become operational and to establish its range of brand production cycle. Sales experienced a steady growth, but due to the fact that productional capacity was outdated, substantial increase of fuel and electricity consumption was a fact, along with increase of emissions partition. The owners want to create an environment-friendly and efficient production, by implementation of new and modernization of existing machinery and equipment. Improvement of energy efficiency is projected to be at least 16%. For the first three years of implementation, EBITDA is expected to increase as projected at 40%-60%.

Investment Case 2 – expansion and optimization

Freight Transportation company established in 2001 performs services in and beyond the limits of the country at moderate price segment. Utilized assets are fairly new but of a mid-class emissions standard. The SME is considered as regional leader in the segment in terms of performance and quality, but cost of executed services is increasing steadily. By signing several new freight contracts, the Company has a unique chance to increase market share. Stipulations in contracts are the utilization of

newer and energy friendlier assets. Sources for investment in new and efficient assets (trucks) are limited, due to lack of collateral. The expansion of the company is achievable trough a serious investment. Using its current available assets, management values its performance at 2.5 x EBITDA. After expanding by investing into new trucks of higher emissions class and optimization of transportations and toll cost, EBITDA is expected to triple in 4 years.

Fund size and justification.

The size of established Funds under the JEREMIE initiative should be between EUR 45-60 million, thus utilizing the whole amount available from the OP Competitiveness. The amount of the funds should be planned to be at the maximum level in order to fulfil the main targets of each Fund manager, with a main focus on:

- Fund diversification to be aimed at mitigating the various risks.
- Private investor commitment – based on the already confirmed participation by private investors (Banks, Insurance Companies, Mutual Fund and local companies) – the indication should be that the overall commitment of Private Investors will exceed EUR 30 million for each fund.
- Built – in Pipeline- the fund managers will dispose with an immediate pipeline of 15 potential deals with total investment of near EUR 70 million, which should be the base for the first few executed deals in the first year. In our case the pipeline is partially represented by the described investment cases.
- The demand for financial growth instrument in the SME segment is at its peak. Traditional bank financing remains currently hardly accessible for SMEs, due to the ongoing cautious approach by the banks to lend investment loans with longer tenors following the continuing process of deterioration of the banks' loan portfolios. Banks are currently predominantly focusing their efforts in consumer and mortgage lending

Therefore, it is considered that managers of each fund should be in a position to grow private equity portfolio of companies within 3 years surpassing the set target of the growth fund of EUR 60 million.

2.4. Expected number of investee companies, planned investment rate including follow-on policy and envisaged strategy for risk diversification of Fund's capital.

Investing in growth capital in the SME sector involves substantial risk in general and particularly in emerging markets like Bulgaria. A significant portion of this risks results from the lack of business ethics in the market and a legislation, which doesn't support in particular this kind of investments. Several cases from the experience of international PE players in Bulgaria have shown that even a complete loss of the investments is possible due to fraud and weak legal execution. It is believe that the combination between the accumulated experience in each fund's team, combined with previous successful financial deals in the local business environment and the necessary understanding of the peculiarities of the execution of financial deals in Bulgaria will be crucial for mitigating the legislative and fraud risk.

In order to mitigate the business and industry risks, it is necessary to achieve a relative diversification in stages/ types of investment, industries, size and number of portfolio companies. It is believe that each fund needs to be able to invest in no less than eight companies in its total lifetime and not more than twelve at any moment of it.

The main purpose of these funds per definition is to support SME growth and not to takeover companies. Therefore the general intention under the initiative of the fund is to hold not more than 50% of the company's equity. Although, as the mentioned negative experience of other PE investors in the country shows, even as minority shareholder it is appropriate to implement irrevocable control mechanisms over the decisions process of the company's management as guarantee that the invested capital is used for its original goals. Attendance in the management board meetings of each company will be just one of these mechanisms.

Generally the management processes of the companies will be reviewed and if needed adjusted. Preferable to invest in companies that have already existing or are willing to implement modern business and management processes, which are detached and independent from individual talent skills and single persons authority. The latter is unfortunately still the business standard for the majority of SMEs in Bulgaria, and bares a high potential business risk in the cases of disloyalty of this key people.

As funds will be investing in growth, the equity investments as a general rule should be done as a capital increase and not as a partial or full shareholders exit. Exceptions to this rule can be evaluated if one or some of the shareholders hinder the development of the company.

Considering the required experience of each developed structure and the targeted industries, the ideal investment sizes should be between EUR 1.5 million (smaller investments) and EUR 8 million (large). This numbers show the initial investment size. For follow-up capital increases funds are advised to keep special reserves of 10% to 15% of the total fund capital. Ideally, capital injections should be scheduled in tranches tied to performance and/or investment cornerstones.

The general holding period of an investment is projected to be around 5 years, depending on the industry, life cycle of the company and the general economic cycle. Overall targets should be an IRR of 18%. Some of the companies might need to be prepared for acquisition by international buyers due to the natural limitation of the local market. Such companies need to have grown to a size and stage that will make such acquisitions possible.

Additional investment rules have to be made applicable, in order to cover the principles described above:

- A single investment should not exceed EUR 10 million, and if it does, then a decision of the supervisory board will be needed. Single investments below EUR 1.5 million will be not evaluated.
- To assure diversification of companies, Top 4 investments should not exceed EUR 30 million
- To assure diversification in the targeted industries, the limit per single industry will be 30% of one funds capital.
- A balance (50/50) between the two types of investment will be targeted

Each fund is to aim and complete at least 3 deals from different industries and different investment types within the first year of structuring. The investment cases show a generalized summary of some of the existing projects/ deals under the specific pipeline. In the following years, performance speed should be kept at 3-4 deals per year (set as target).

2.5. Strategy for generation of deal flow, adding-value to investee companies post-investment and exit strategy.

Deal Origination

Funds must utilize a two-pronged approach for deal flow generation. The origination will benefit from the commitment of local commercial banks specialized in SME financing, and partners' extensive network and experience in Bulgaria's financial market. Combined network covers majority of Bulgarian SMEs in the targeted size and industries.

- Partners' pro-active engagement
  - Extensive networking capabilities after 80 years of combined investment experience and decision making roles within the financial industry
  - Successful advisory experience in M&A, capital markets attests for a good relationship with locally active investment industry professionals will further enhance the potential for referrals and deal flow generation
  - Maintaining high visibility and contact with local private sector executives and entrepreneurs through participations business association, appearances in specialized conferences and media
- Local Commercial Bank as an alternative source of referrals of potential capital seekers
  - About 80 to 90% of the corporate clients of banks fall under the definition for SMEs
  - Effective nationwide coverage with local and regional points of sale contributing for:
    - optimized opportunity identification;
    - reduced cost of pre-screening investments through "on-the-ground" presence of officers
  - Sector and regional specific experience allowing fast evaluation of investments bearing in mind peculiarities of targeted segments and companies

It is believe that the combination of these factors will allow a faster deal evaluation and generation process compared to the existing PE funds. This will allow

as well a faster deployment of each funds recourses and respective limitation of unused cash positions.

For avoidance of potential conflict of interest between Bank's interest and the purpose of a newly structured fund, a clear investment policy for customers or affiliates of financial institutions should be developed, in order to differentiate functions of both parties. The policy must handle and not allow the funds to invest in cases where this investments will result in direct profit for the commercial banks or will improve each customer exposition, for example by investing capital in a company with a non-performing loan towards any bank.

Investment Process

Structured Funds under the JEREMIE initiative must follow an organized and well documented investment process. The investment process will be aimed at providing exhaustive research on the investment opportunity, thorough due diligence and efficient deal closing corresponding to the strategy and criteria of each Fund. Investment processes are expected to last up to 9 months. The following sections are summarizing the key steps and cornerstones of the deal making points.

- Identification of investment opportunity and preliminary review
  - Business case initial review and formulation
  - Review of business plan including business and market description provided by the investee, financial history and management expertise
  - Series of interviews with business owners, management, and independent industry experts aiming at providing a thorough understanding of the business model, market environment, the viability of the business plan provided and growth prospects
  - Series of interviews/meetings with industry experts
  - Internal discussion within the Fund's investment committee
  - Drafting of an initial investment proposal by the Fund's management stipulating the scope of the transaction and evaluating the investment in the context of the Fund's strategy and investment criteria.
  - Signing of a Memorandum of Understanding outlining the interests of both parties and the relevant aspects that will be shared. The Memorandum of

Understanding aims at preventing possible conflict and disagreements that could threaten the investment process and the transaction at more advanced stages.

- In-depth Investment Analysis and Valuation
  - Company provides all necessary information for assessment and documentation of the business model, operations and organizational structure, legal standing, relationships with customers and key suppliers
  - Initial due diligence: quality of management and operations, on-site visits
  - Identification of key risks pertaining to the company, business model & products, industry, execution of the transaction
  - Generation of pro-forma statements and internally prepared business plan for the purpose of a rigorous valuation. They should encompass various growth scenarios depending on company/project specifics and industry insights
  - Valuation based on DCF techniques, peer-analysis, LBO modeling, industry specific methodology
  - Involvement of industry consultants, legal and financial advisors might be reverted to
  - Detailed summary (Term sheet) including the key consideration from the phase, and expected terms and pricing is prepared for review and approval by the Investment Committee of the Fund and in special cases by the Supervisory Board.
- Negotiation and Transaction Structuring
  - Negotiate terms and pricing
  - Drafting of a preliminary SPA subject to the due diligence process and gaining of Investment Committee and/or Supervisory Board approval
  - Legal and accounting due diligence
  - Signing of a SPA and, Advisory and Supervisory Participation Agreement

The Investment Committee consists of GP's representatives and representatives of the Fund Investors.

The Supervisory Board consists of two representatives from the fund private investors and one representative appointed by JHF.

Post-Investment Policies

Funds will strive to maximize value creation by following policies providing in-direct and direct support to capital beneficiaries. Taking into consideration the business environment in the country and the usual practices of SMEs, structured funds management is convinced that the potential for value-creation is immense and should be addressed adequately. As already several times described in this document even well-run Bulgarian companies often suffer from inefficient management, un-timely access to performance metrics, no monitoring procedures, and lack of access (or unwillingness to rely) to third-party advisory/consulting services. Post-investment strategies for value creation should also be designed as to address the mentioned risks of fraudulent behaviour, and to handle resistance for cooperation.

The points below aim to summarize the major actions that have to be undertaken in the post-investment. The list is not exhaustive and specific measures implemented might include additional policies that pertain to target specific circumstances.

- Appointments to the Board of Directors of the company and the other governing bodies
- Implementing best-in class policies for reporting, financial and operational management, marketing and sales
- Advisory of the financial management of the company, including support in seeking external funding from credit institutions
- Creating of investment committee for efficient capital allocation
- Involvement in the decision making process in strategic areas, including industry experts opinions by third parties.
- Policies for aligning stakeholders interest (management and shareholders) through adequate corporate governance and performance evaluation practices: KPIs for management performance and increasing shareholders' value
- Support in the marketing strategy through the contacts of the fund managers
- Management coaching

Strategies of increasing post-investment value of the investees are considered to be a major part of the investment decision process. Each Fund carefully has to evaluate the potential for value creation from the strategies implementation prior to an investment decision. Careful consideration will be given to their effectiveness, execution risk, and best practice standards for the respective industries.

Investment Exit Strategy

Fund's management has to have significant expertise in M&A and capital markets transactions in Bulgaria and they will employ a broad range of investment exit strategies that have been identified to provide viable exit options. In order to maximize investment return, each Fund will follow predetermined time horizon and exit strategies for each investment. The exit strategies will be stated in the investment agreements signed from both parties (the fund and the beneficiaries) at the time an investment is made. The fund will typically seek exit through one or a combination of the following options:

- Sale to a third party:
  - to a strategic acquirer through a merger or acquisition (M&A)
  - to another private equity firm, (e.g. "secondary sale")
- Initial Public Offering (IPO)
- Sale to other shareholders in the business
- Buy-out by the management team (entrepreneur)

Upon decision for entry, depending on the terms reached, investment agreements will also include standard for the private equity industry drag alone clauses and options. Their design will be case-specific aiming at limiting downside risk, maximizing return potential and avoiding future conflicting interests by shareholders. The use of such instruments is to ensure the timely execution of the investment strategy and align investment objectives of all stakeholders.

The exit strategy adopted by all structured funds for each particular investment has to be reviewed periodically. Fund's management will constantly evaluate existing market dynamics, availability of buyers, and company specific circumstances. The review will be undertaken in relation to ensuring adequate timing and increased return potential. It will also limit downside risk in cases market conditions change in

unfavourable way, or investments fail to perform as per initial expectations and the targets set at the point of entry.

2.6. Financial instruments used and expected returns.

It is believe that given the development stage and nature of the SMEs in Bulgaria the most suitable instruments created by Funds management have to be as plain and simple as possible. Sophisticated financial products generally create mistrust on the local market. Thus each Fund must intend to use for its investment needs primarily direct participation in the companies via investing in common stock and in certain cases through a combination with investments in preferred stock of the company.

Structured Funds under JEREMIE most likely will aim at purchasing a significant portion of a particular company in order to be able to have a larger influence in its governing and to speed up its growth via the experience and know-how of its investment team. Typically Funds will seek to participate via a capital increase aiming at further strengthening the shareholder's equity, and support the continued growth through acquisitions as well as organic growth.

In order to protect its investment each Fund might seek also participation trough preferred stock as it has many advantages including a greater claim of the assets than common stock thus limiting the downside of the investment. Buying preferred stock could include the option of converting them into common stock at any point of time, in which case the owners will lose the right of a dividend, but will gain the ability to participate in the decision making process. Preferred stocks could be flexible in terms of the dividend rates that they hold, which could be adjusted along the way so that it does not interfere with the company's sustainable growth.

In limited number of cases each Fund have to aim at lending different types of hybrid loan products, suited to best fit the business needs of each company. A common type of debt product that Funds will be looking at will be the convertible debt, where the loan is secured via the right to convert it to common stocks at certain predetermined conditions. This will reduce both the risk to each Fund and the requirement to the company to provide collateral, which as have mentioned before

proves to be a major obstacle for the SMEs on their way to receiving a proper financing.

Each structured Fund must target an investment with a clear potential to generate above 30% internal rate of return (IRR). As some of them could be expected to not realize their full potential and reach all financial targets at the predefined time horizon, managers should expect that the overall performance that one Fund will be able to achieve will be equivalent to IRR of 18%.

CHAPTER 3

EXPERIMENTAL RESULTS OF THE SIMULATION ANALYSIS

During the past 15-20 years, a wide range of inspirational methods, government along with EU grant programs, financial institution's products where introduced to local economy, more directly to the biggest stake of legal entities in the country – Small and Medium size Enterprises (SME's). As every beginning in the modern era, things looked more than promising. The first economic boom was supported by the implementation of currency board, followed by Bulgaria's EU accession, western oriented governments, and last but not least the aggressive banking industry supported by relatively cheap credit resource. To a certain extent, the above mentioned factor created a relatively friendly business environment. From Y 2000 on, a figure of close to EUR 25 billion was pumped in the economy, in forms of direct local and foreign investments, as well as grants schemes, and bank financing. Aside from the growth created, resulting into higher than average EU rates – statistically, majority of the investments were made into non-productive, highly speculative and cyclical businesses. Some industries, which historically have proved to be economy drivers, didn't benefit enough or were not touched by the first "cash" wave at all. At a later stage, those untargeted segments, became under the scope of EU financial mechanisms, in parallel with Bank facilitation. Simply, as already part of EU, most of the developed in collaboration with European Investment Fund programs, where reintroduced to local small and medium size enterprises. By doing so, crisis recovery process was restarted, and majority of available resources were redirected towards industries with a substantial value input. In co-operation with local commercial banks, EIF intended to reach out to businesses with fresh ideas and potential for future development. The initial package of programs and products where firstly communicated with a number of domestic banks, which were chosen by the EIF. After a significant and long lasting pre-screening and evaluation process was done, the Fund selected few partners, through which allocation of potential resources would be done. Nevertheless, many questions occurred from part of the unchosen participants, how

adequate and well-grounded are the picks, during the evaluation processes. Regardless of the fact that some locally-based participants, presented indisputable facts of advantage in the initial criteria, set by the European Investment Fund, their arguments were neglected, in favour of institutions with foreign partnership.

Meanwhile, traditional bank financing remained hardly accessible for most of SMEs, which results in general inaccessibility to any funding. The dynamic and competitive business environment in the European Union in general, as Bulgaria is being part of, led to many adjustments in risk assessment policies and procedures, inside local banking system. Following the initial EU regulatory financing frame, many financial institutions adapted the know-how, and further implemented it in their internal landing policies. Local banks strived to maximize client value creation by following policies, and providing direct and in-direct financial support to beneficiaries.

3.1. Structuring of growth funds with the purpose of SME's evolution under the JEREMIE initiative.

Each fund is to aim and complete at least 3 deals from different industries and different investment types within the first year of structuring. The investment cases show a generalized summary of some of the existing projects/ deals under the specific pipeline. In the following years, performance speed should be kept at 3-4 deals per year (set as target), [104, 106, 107, 108].

It's been proven that given the development stage and nature of the SMEs in Bulgaria the most suitable instruments created by Funds management have to be as plain and simple as possible. Sophisticated financial products generally create mistrust on the local market. Thus each Fund must intend to use for its investment needs primarily direct participation in the companies via investing in common stock and in certain cases through a combination with investments in preferred stock of the company.

Structured Funds under JEREMIE most likely will aim at purchasing a significant portion of a particular company in order to be able to have a larger influence in its governing and to speed up its growth via the experience and know-how of its investment team. Typically Funds will seek to participate via a capital increase

aiming at further strengthening the shareholder's equity, and support the continued growth through acquisitions as well as organic growth.

In order to protect its investment each Fund might seek also participation trough preferred stock as it has many advantages including a greater claim of the assets than common stock thus limiting the downside of the investment. Buying preferred stock could include the option of converting them into common stock at any point of time, in which case the owners will lose the right of a dividend, but will gain the ability to participate in the decision making process. Preferred stocks could be flexible in terms of the dividend rates that they hold, which could be adjusted along the way so that it does not interfere with the company's sustainable growth.

In limited number of cases each Fund have to aim at lending different types of hybrid loan products, suited to best fit the business needs of each company. A common type of debt product that Funds will be looking at will be the convertible debt, where the loan is secured via the right to convert it to common stocks at certain predetermined conditions. This will reduce both the risk to each Fund and the requirement to the company to provide collateral, which as have mentioned before proves to be a major obstacle for the SMEs on their way to receiving a proper financing.

Each structured Fund must target an investment with a clear potential to generate above 30% internal rate of return (IRR). As some of them could be expected to not realize their full potential and reach all financial targets at the predefined time horizon, managers should expect that the overall performance that one Fund will be able to achieve will be equivalent to IRR of 18%, [1*].

3.2. Generalized Net model of the methodology for analysis of the creditworthiness and evaluation of credit risk in SMEs financing.

Considering the harder economic conditions, to which SME's are exposed, the attitude to external financing changes. The research of the sector show that 10 years ago about 7% of enterprises utilized investment loans, 17% had access to working capital funds, and 67% didn't have any access to financing. The aggressive development of banking system along with EU structured funds, significantly increased the accession of SME's to venture funding. From year 2010 onwards, about

55% of companies are able to reach financing of any type.

In 2010 most popular sources of financing between SME's was own resources (about 42%), illegitimate financing from friends and relatives (close to 17%), and at last EU funds and Bank financing (near 30%). A year earlier above 50% of companies are financed with own equity. Limitations and obstacles in financing occur mainly due to the reduced investment intentions of SME's within the last few years. Main reasons for it are lack of economic stability within the country and EU, along with gradual increase of intercompany leverage. The figures show that, intercompany debt over the past 3 years has gone up over 100%.At present time about 83% of all SME's have uncollected receivables (Bulgarian Industrial Association), [105].

One third of all investments made by SME's are into new equipment and machinery (about 35%), re qualification, training and advertisement is the second investment direction (29%), development of present and design of additional newer products (22%), introduction of systems for intercompany management processes (9%). Alternative ways of raising funds by SME's are via leasing schemes, where at present about 32% of SME's are able to reach their investment goals, whereas couple of years earlier the figure is close to 45%.

Due to worsen economic environment and interbanking debt, weaker turnover and profit results, most SME's are unable to rely on own resources. This is valid to such an extent that the financing with own funds has decreased 10 times and in spite of the difficulties, concerning the receipt of a bank loan, it has turned into the most preferred source of funds.

The most popular source of financing among commercial banks and leasing companies is public procurement. Statistics show that about 15% of SME's take advantage of public procurement. Raising funds via government programs was used by 2.9% of the companies, and access to financing via programs of non-government organizations has a share of 2%. Financing via EU structured funds had an insignificant portion (1.6%) up until few years ago. Nowadays the percentage has increased considerably and 45% of SME's is making efforts to receive the embedded financing and grant schemes, (Bulgarian Small and Medium Enterprise Promotion Agency).

Regardless of the above mentioned statistics there hasn't been any considerable changes in regards to the specific difficulties, with which SME are confronted upon the receipt of a bank loan. Most of which they encounter are:

- Considerable interest rates and requirements for sufficient loan collateral. Often companies do not dispose with the necessary real estates, and the interest rates are close to the profitability of their assets.
- Lacking or insufficient credit history (valid to an even greater extent for the new companies). The reason for this often is the concealing of tax, despite the decrease in the tax and social security burden in the last years.
- The relatively low economic and legal general knowledge of the owners of SMEs.
- Incapacity for the preparation of a long-term plan for the development of business. This is the result of the unstable economic environment, as well as of the incapacity of SMEs to prepare reliable long-term financial forecasts.
- High fees, "hidden" interest and the heavy research, associated with loan granting/project financing.
- Requirements for minimum equity and minimum turnover.

A Generalized Net (GN) model is described in [2*] used GN shown on Figure 3.1. Five types of tokens move in this GN.

The tokens from the first type are α_1 and α_2, and they represent bank-administrators. The tokens have the initial and current characteristics: *"Credit specialist at branch level"* in place l_8 and *"Experts at Headquarters level"* in place l_{15}.

The tokens from the second type are the φ-tokens that permanently enter place l_1 with initial characteristic *"Potential SME Borrower"*.

The tokens from the third type are χ_1, χ_2 and χ_3, representing Bank management. They have the initial and current characteristics: *"Credit Council"* in place l_{18}, *"Management Board"* in place l_{21} and *"Supervisory Board"* in place l_{24}.

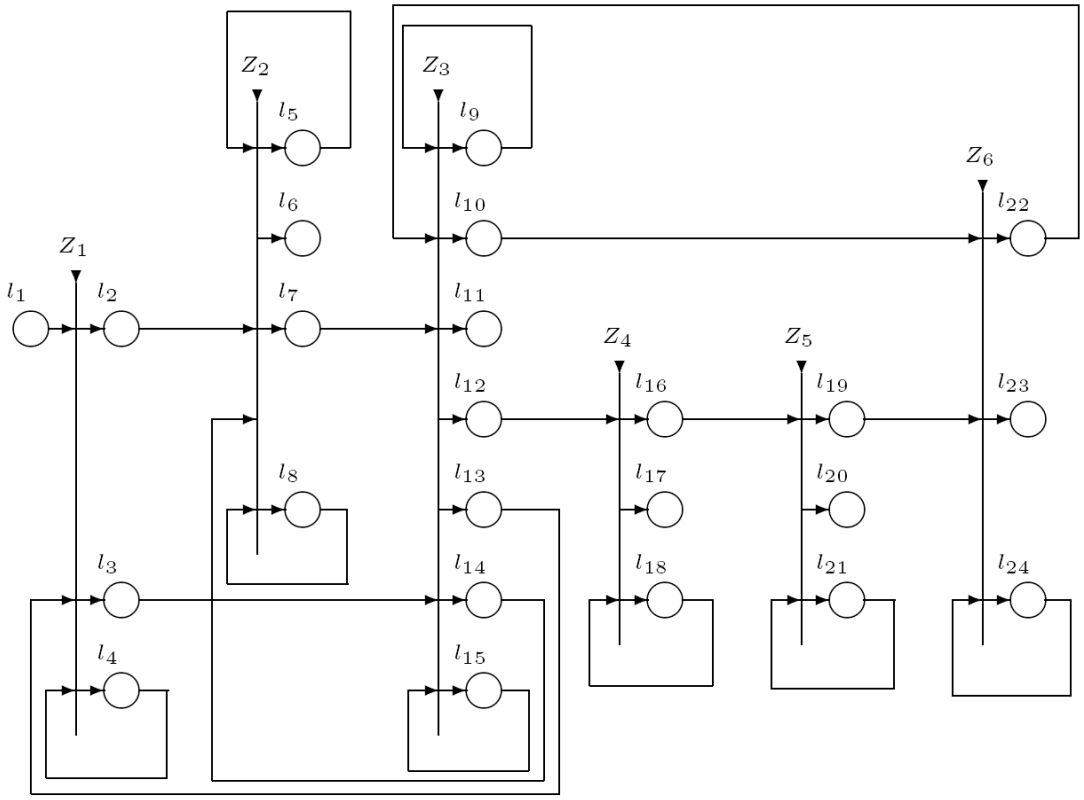

Figure 3.1. Generalized Net model of the methodology for analysis of the creditworthiness and evaluation of credit risk in SMEs financing

In some time-moments, some token φ will split to the original token φ and a token π, while some α-token and the χ_3-token will split to the original α- or χ_3-token and a β-token. These new types of tokens will be discussed below.

$$Z_1 = \langle \{l_1, l_4, l_{13}\}, \{l_2, l_3, l_4\}, r_1 \rangle \tag{3}$$

$$r_1 = \begin{array}{c|ccc} & l_2 & l_3 & l_4 \\ \hline l_1 & false & false & true \\ l_4 & W_{4,2} & W_{4,3} & true \\ l_{13} & false & false & true \end{array},$$

where:

$W_{4,2}$ = *"There is a SME client that has prepared a project"*,

$W_{4,3}$ = *"There is an answer from the SME client to a question from the credit specialist at branch level".*

Token φ enters place l_4 without a new characteristic.

Token β_4 enters place l_4 and unites with token φ, staying there.

If $W_{4,2}$ = *true*, then token φ splits to the original token φ and token π. The second one enters place l_2 and there it obtains the characteristic *"Loan application, based upon a prepared project"*. If $W_{4,3}$ = *true*, then token φ splits to the original token φ and token β_1. The second one enters place l_3 and there it obtains the characteristic *"Requested additional information in regards to submitted project"*. This token is generated in a result of token β_4 that enters place l_4.

$$Z_2 = \langle \{l_2, l_5, l_8, l_{14}\}, \{l_5, l_6, l_7, l_8\}, r_2 \rangle \tag{4}$$

$$r_2 = \begin{array}{c|cccc} & l_5 & l_6 & l_7 & l_8 \\ \hline l_2 & true & false & false & false \\ l_5 & W_{5,5} & W_{5,6} & W_{5,7} & false \\ l_8 & false & false & W_{8,7} & true \\ l_{14} & false & false & false & true \end{array},$$

where:

$W_{5,5}$ = „*By the moment, there is not a solution for the project*",

$W_{5,6}$ = *"Project rejected at first level (at branch level)",*

$W_{5,7}$ = *"Project accepted at branch level, sent to Headquarters for further detailed research",*

$W_{8,7}$ = *"There is an answer of a question initiated by Headquarters experts in regards to the submitted project".*

Token π enters place l_5 without any new characteristic. Token β_5 enters place l_8 and unites with token α_1.

When $W_{5,5}$ = *true*, token π continues to stay in place l_5 without a new characteristic. When $W_{5,6}$ = *true*, token π enters place l_6 with a characteristic *"Project*

rejected (due to specific motives)". When $W_{5,7}$ = *true*, token π enters place l_7 with a characteristic *"Project accepted (due to specific motives)".* If $W_{8,7}$ = *true*, then token α_1 splits to the original token α_1 and token β_2. The second one enters place l_7 and there, it obtains the characteristic *"Answer from branch level".*

$$Z_3 = \langle \{l_3, l_7, l_9, l_{l5} l_{22}\}, \{l_9, l_{10}, l_{11}, l_{12}, l_{13}, l_{14}, l_{15}\}, r_3 \rangle \tag{5}$$

$r_3 =$

	l_9	l_{10}	l_{11}	l_{12}	l_{13}	l_{14}	l_{15}
l_3	*false*	*false*	*false*	*false*	*false*	*false*	*true*
l_7	$W_{7,9}$	*false*	*false*	*false*	*false*	*false*	$W_{7,15}$
l_9	$W_{9,9}$	*false*	$W_{9,11}$	$W_{9,12}$	*false*	*false*	*false*
l_{15}	*false*	$W_{15,10}$	*false*	*false*	$W_{15,13}$	$W_{15,14}$	*true*
l_{22}	*false*	*false*	*false*	*false*	*false*	*false*	*true*

where:

$W_{7,9}$ = *"The current token is from* π*-type"*,

$W_{7,15}$ = *"The current token is from* β_5*-type"*,

$W_{9,9}$ = „*By the moment, there is not a solution for the project*",

$W_{9,11}$ = *"Rejected at Headquarters level",*

$W_{9,12}$ = *"Accepted and prepared for loan granting",*

$W_{15,10}$ = *"An inquiry is initiated and addressed to the Supervisory Board",*

$W_{15,13}$ = *"An inquiry is initiated and addressed to the SME Client-borrower",*

$W_{15,14}$ = *"An inquiry is initiated and addressed to branch level".*

Token β_1 enters place l_{15} and unites with token α_2.

When $W_{7,9}$ = *true*, token π enters place l_9 without a new characteristic.

When $W_{9,15}$ = *true*, token β_2 enters place l_{15} and unites with token α_2, that obtains the above mentioned current characteristic.

When $W_{9,9}$ = *true*, token π contains to stay in place l_9 without a new characteristic.

When $W_{9,11}$ = *true*, token π enters place l_{11} with a characteristic *"Project rejected at Headquarters level (due to specific motives)".*

When $W_{9,12}$ = *true*, token π enters place l_{12} with a characteristic *"Project accepted at Headquarters level (due to specific motives)".*

When $W_{15,10}$ = *true*, token α_2 splits to the original token α_2 and token β_3. The second one enters place l_{10} and there, it obtains the characteristic *"An inquiry is addressed to the Supervisory Board for specific project" or "An answer of Head quarters level to the Supervisory Board"*

When $W_{15,13}$ = *true*, token α_2 splits to the original token α_2 and token β_4. The second one enters place l_{13} and there, it obtains the characteristic *"An inquiry is addressed to the SME Client-borrower in regards to a specific detail of the project".*

When $W_{15,14}$ = *true*, token α_2 splits to the original token α_2 and token β_5. The second one enters place l_{14} and there, it obtains the characteristic *"An inquiry is addressed to Branch level in regards to specific details of the project".*

$$Z_4 = \langle \{l_{12}, l_{18}\}, \{l_{16}, l_{17}, l_{18}\}, r_4 \rangle \tag{6}$$

$$r_4 = \begin{array}{c|ccc} & l_{16} & l_{17} & l_{18} \\ \hline l_{12} & W_{12,16} & W_{12,17} & true \\ l_{18} & false & false & W_{18,18} \end{array},$$

where:

$W_{12,16}$ = *"There is a positive decision by Credit council in regards to specific project",*

$W_{12,17}$ = *"There is a negative decision by Credit council in regards to specific project"*,

$W_{18,18}$ = *"There is a token in place* l_{12}*".*

When $W_{12,16}$ = *true*, token π enters place l_{16} with a characteristic "*The project is voted and accepted for financing by the Credit council under the original or new updated parameters*".

When $W_{12,17}$ = *true*, token π enters place l_{17} without any characteristic.

$$Z_5 = \langle \{l_{16}, l_{21}\}, \{l_{19}, l_{20}, l_{21}\}, r_5 \rangle \tag{7}$$

$$r_5 = \begin{array}{c|ccc} & l_{19} & l_{20} & l_{21} \\ \hline l_{16} & W_{16,19} & W_{16,20} & true \\ l_{21} & false & false & W_{21,21} \end{array},$$

where:

$W_{16,19}$ = *"The Project receives affirmative decision when voted by Management Board",*

$W_{16,20}$ = *"The Project receives negative decision when voted by Management Board",*

$W_{21,21}$ = *"There is a token in place* l_{16}*"*.

When $W_{16,19}$ = *true,* token π enters place l_{19} with a characteristic *"The project is voted and accepted for financing by the Management Board under the original or new updated parameters"*.

When $W_{16,20}$ = *true,* token π enters place l_{20} without any characteristic.

$$Z_6 = \langle \{l_{10}, l_{19}, l_{24}\}, \{l_{22}, l_{23}, l_{24}\}, r_6 \rangle \tag{8}$$

$$r_6 = \begin{array}{c|ccc} & l_{22} & l_{23} & l_{24} \\ \hline l_{10} & false & false & true \\ l_{19} & false & W_{19,23} & false \\ l_{24} & W_{24,22} & false & W_{24,24} \end{array},$$

where:

$W_{19,23}$ = *"Final decision by Supervisory Board",* $W_{24,22}$ = *"There is an answer of the Supervisory Board to the Management Board level or there is an answer of the Supervisory Board to a question from the Credit council "*,

$W_{24,24}$ = *"There is a token in place* l_{19}*"*.

Token β_3 enters place l_{24} and unites with token χ_3.

When $W_{19,23}$ = *true,* token π enters place l_{23} with a characteristic "*Final decision (positive or negative) of the Supervisory Board about the project".*

When $W_{24,22}$ = *true,* token χ_3 splits to two tokens – the original token χ_3 and token β_6 that obtains the characteristic *"Answer of the Supervisory Board".*

The so constructed Generalized Net (GN) model describes the most important steps of the process of evaluation of a business project proposal intended for financing**.** In a next research, the authors plan to elaborate the model in the aspect related to the process of decision making within the frames of the bank administration.

First, the model can be used for real-time control of the processes, flowing in a particular bank. If this is the case, the databases of the model will correspond to the real databases of that bank, and the process of adding new characteristics of the respective GN-tokens will correspond to the process of inputting new information in the bank's databases.

The tokens, representing the bank's clients, will have as initial characteristics their specific parameters and with their real project proposals intended for financing**.** The movement of these real projects will be observed and information for the current status of each of them can be obtained from the model. Practically, the GN-model will synchronize the real processes, related to the above described procedure.

Second, it can be a tool for prognostics of different situations, related to the modeled processes, for example in a given moment of time, a large number of projects may be submitted, and these have to be evaluated in parallel or compete for a limited amount of funding.

Third, on the basis of the model, some changes of the process of evaluation can be simulated and the results can be used for searching the optimal scheduling of the separate steps of this process.

3.3. Generalized Net model of internal financial structural unit's functionality with intuitionistic fuzzy estimations.

The description of the finance process is presented with the implementation of the efficiency assessment application procedure, which will find its dimension during real time SME financing steps. Detailed analysis of the above described process is published in [3*].

The GN model, discussed here, is shown on Figure 3.2 and contains five transitions, that represent sub-transitions of the transitions Z_2, …, Z_6 respectively. The sub-transitions' input/output places here are subsets of the input/output places, and for the sake of simplicity the indexes are kept as given in [2*]. For each of these transitions, construct intuitionistic fuzzy estimations representing the number of all projects, qualified to reach the respective *i*-th stage of the process of evaluation of loan applications (let us mark it by *i*, where $i = 2, \ldots, 6$, to correspond to the ordering of the generalized net transitions).

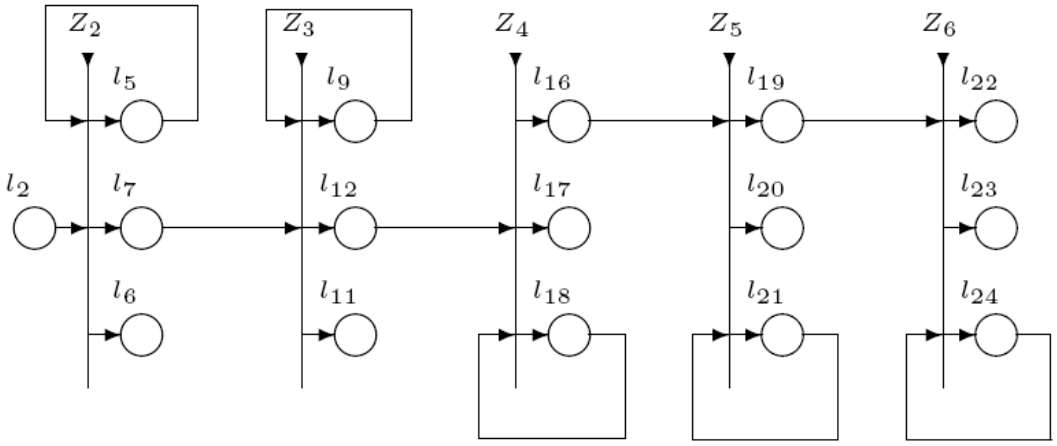

Figure 3.2. Generalized Net model of internal financial structural unit's functionality

Intuitionistic fuzziness is introduced in these estimations, using the following scheme:

$$\mu_i = \frac{\text{number of accepted by the moment projects}}{\text{number of all received by the moment projects}},$$

$$\nu_i = \frac{\text{number of rejected by the moment projects}}{\text{number of all received by the moment projects}},$$

$$\pi_i = 1 - \mu_i - \nu_i,$$

where π_i is the index of uncertainty and it corresponds to the number of projects that are under discussion in the respective bank administration, as described by the transition Z_i.

The GN-tokens represent the application projects that have been obtained in the bank. These tokens are denoted in [2*] by π, but for the needs of the present research, reserve the denotation of π for the index of uncertainty, described above, while the tokens containing information about the modelled application projects only refer to as 'the tokens'.

Below, describe the forms of the transition condition predicates in the form "$var \in [a, a + b]$", where $0 \leq a \leq a + b \leq 1$ and *var* is a random variable.

The tokens enter the GN through place l_2 with the characteristics *"Loan application, based upon a prepared project proposal".*

$$Z_2 = \langle \{l_2, l_5\}, \{l_5, l_6, l_7\}, r_2 \rangle,$$

$r_2 =$

	l_5	l_6	l_7
l_2	*true*	*false*	*false*
l_5	$W_{5,5}$	$W_{5,6}$	$W_{5,7}$

where:

- $W_{5,5}$ = "$var \in (\mu_2, \mu_2 + \pi_2]$"
- $W_{5,6}$ = "$var \in (\mu_2 + \pi_2, 1]$",
- $W_{5,7}$ = "$var \in [0, \mu_2]$" ,

The token enters place l_5 without any new characteristic. When $W_{5,5}$ = *true*, the token continues to stay in place l_5 without a new characteristic. When $W_{5,6}$ = *true*, the token enters place l_6 with a characteristic *"Project rejected (due to specific motives)".* When $W_{5,7}$ = *true*, the token enters place l_7 with a characteristic *"Project accepted (due to specific motives)".*

$$Z_3 = \langle \{l_7, l_9\}, \{l_9, l_{11}, l_{12}\}, r_3 \rangle,$$

$$r_3 = \begin{array}{c|ccc} & l_9 & l_{11} & l_{12} \\ \hline l_7 & true & false & false \\ l_9 & W_{9,9} & W_{9,11} & W_{9,12} \end{array}$$

where:

- $W_{9,9}$ = "$var \in (\mu_3, \mu_3 + \pi_3]$"
- $W_{9,11}$ = "$var \in (\mu_3 + \pi_3, 1]$",
- $W_{9,12}$ = "$var \in [0, \mu_3]$",

The token enters place l_9 without a new characteristic.

When $W_{9,9}$ = *true*, the token remains to stay in place l_9 without a new characteristic. When $W_{9,11}$ = *true*, the token enters place l_{11} with a characteristic *"Project rejected at Headquarters level (due to specific motives)".* When $W_{9,12}$ = *true*, the token enters place l_{12} with a characteristic *"Project accepted at Headquarters level (due to specific motives)".*

$$Z_4 = \langle \{l_{12}, l_{18}\}, \{l_{16}, l_{17}, l_{18}\}, r_4 \rangle,$$

$$r_4 = \begin{array}{c|ccc} & l_{16} & l_{17} & l_{18} \\ \hline l_{12} & false & false & true \\ l_{18} & W_{18,16} & W_{18,17} & W_{18,18} \end{array}$$

where:

- $W_{18,16}$ = "$var \in [0, \mu_4]$",
- $W_{18,17}$ = "$var \in (\mu_4 + \pi_4, 1]$",
- $W_{18,18}$ = "$var \in (\mu_4, \mu_4 + \pi_4]$".

When $W_{18,16}$ = *true*, the token enters place l_{16} with a characteristic "*The project is voted and accepted for financing by the Credit council under the original or new updated parameters*". When $W_{18,17}$ = *true*, the token enters place l_{17} without any characteristic. When $W_{18,18}$ = *true*, the token remains to stay in place l_{18} without a new characteristic.

$$Z_5 = \langle \{l_{16}, l_{21}\}, \{l_{19}, l_{20}, l_{21}\}, r_5 \rangle,$$

$$r_5 = \begin{array}{c|ccc} & l_{19} & l_{20} & l_{21} \\ \hline l_{16} & false & false & true \\ l_{21} & W_{21,19} & W_{21,20} & W_{21,21} \end{array}$$

where:

- $W_{21,19}$ = "$var \in [0, \mu_5]$",
- $W_{21,20}$ = "$var \in (\mu_5 + \pi_5, 1]$",
- $W_{21,21}$ = "$var \in (\mu_5, \mu_5 + \pi_5]$".

When $W_{21,19}$ = *true*, the token enters place l_{19} with a characteristic *"The project is voted and accepted for financing by the Management Board under the original or new updated parameters"*. When $W_{21,20}$ = *true*, the token enters place l_{20} without any characteristic. When $W_{21,21}$ = *true*, the token remains to stay in place l_{21} without a new characteristic.

$$Z_6 = \langle \{l_{19}, l_{24}\}, \{l_{22}, l_{23}, l_{24}\}, r_6 \rangle,$$

$$r_6 = \begin{array}{c|ccc} & l_{22} & l_{23} & l_{24} \\ \hline l_{19} & false & false & true \\ l_{24} & W_{24,22} & W_{24,23} & W_{24,24} \end{array}$$

where:

- $W_{24,22}$ = "$var \in [0, \mu_6]$",
- $W_{24,23}$ = "$var \in (\mu_6 + \pi_6, 1]$",
- $W_{24,24}$ = "$var \in (\mu_6, \mu_6 + \pi_6]$".

When $W_{19,22}$ = *true*, the token enters place l_{22} with a characteristic "*Final positive decision of the Supervisory Board about the project".* When $W_{19,23}$ = *true*, the token enters place l_{23} with a characteristic "*Final negative decision of the Supervisory Board about the project".* When $W_{24,24}$ = *true*, the token remains to stay in place l_{24} without a new characteristic.

The so constructed GN model describes the most important steps of the process of evaluation of a business project proposal intended for financing. In a next research, the authors plan to elaborate the model in the aspect related to the process of decision making within the frames of the bank administration.

First, the model can be used for real-time control of the processes, flowing in a particular bank. If this is the case, the databases of the model will correspond to the real databases of that bank, and the process of adding new characteristics of the respective GN-tokens will correspond to the process of inputting new information in the bank's databases. The tokens, representing the bank's clients, will have as initial characteristics their specific parameters and with their real project proposals intended for financing**.** The movement of these real projects will be observed and information for the current status of each of them can be obtained from the model. Practically, the GN-model will synchronize the real processes, related to the above described procedure.

Second, it can be a tool for prognostics of different situations, related to the modeled processes, for example in a given moment of time, a large number of projects may be submitted, and these have to be evaluated in parallel or compete for a limited amount of funding.

Third, on the basis of the model, some changes of the process of evaluation can be simulated and the results can be used for searching the optimal scheduling of the separate steps of this process.

The model can be implemented in the internal banking scoring system, as it would aim to reach the optimal period of evaluation process.

3.4. Uncertainty modeling in the process of SMEs financial mechanism using intuitionistic fuzzy estimations.

Supporting emerging and present legal entities as making a form of investment, such as financing SME sector involves substantial risk in general and particularly in emerging markets like Bulgaria. A significant portion of this risks results from the lack of business ethics in the market and a legislation, which doesn’t support in particular this kind of investments.

Local agriculture sector is experiencing a boost in the last few years, and falls under the program of rehabilitation and modernization of value creating industries, as the main focus is to overturn present trade situation where the country imports more goods than it exports. The overall aim is to utilize the EU accession and its supportive

instruments, local Government programs assistance, and financial institution involvement into accelerating growth processes and SMEs further development.

The above mentioned facts allow us to look for new techniques for intelligent analysis of the process of SMEs financial mechanism. The evaluation follows a predefined hierarchy of the levels of the bank's decision makers, and sophisticated policies and procedures.

For the needs in paper [4*], is make a relatively simple model, which takes into account which levels of the bank hierarchy receive and process the business applications for bank loans, which levels make funding decisions, and in case of uncertainty, which upper levels of the hierarchy are these applications directed to, for taking a decision at the higher level, illustrated on Figure 3.3.

In this highly regulated process, for each level of the bank's decision making hierarchy, it is interested to estimate and interpret in terms of intuitionistic fuzzy sets the share of successfully approved applications, the share of rejected applications and the share of those applications, which for various reasons, may exhibit certain uncertainty (e.g. high risk / high return of investment) and thus get forwarded from lower to upper level of bank hierarchy, being a higher authority in the decision making process.

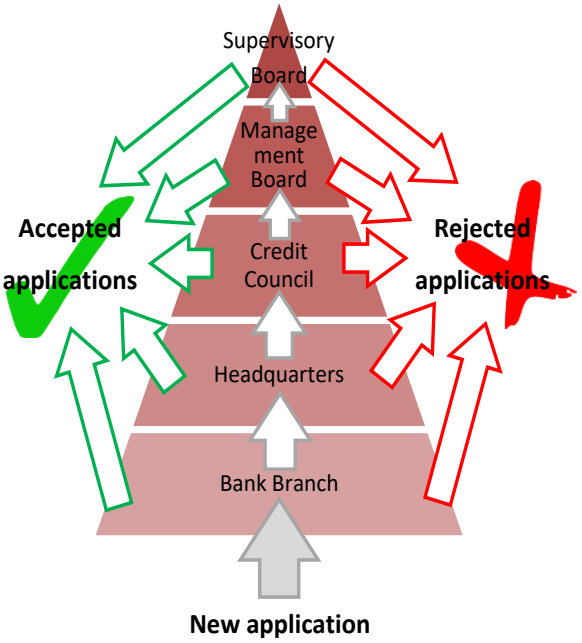

Figure 3.3. Diagram of the process of bank loan applictions review along the bank's decision making hierarchy

The process of evaluation of every bank loan application passes through one or more (rarely more than three) levels of the bank's decision making hierarchy. Usually the decision about the approval or rejection of the applications is taken on the Branch level or the Headquarters level, however in certain cases when lower levels cannot take a categorical decision, the application is sent to the upper level.

It is introduced intuitionistic fuzziness in these estimations, using two possible schemes, which are mathematically identical and can be used interchangeably, although visually they produce rather different results. In both cases, denote the levels of the bank's decision making hierarchy with the following denotations:

- Level 0 represents bank loan applicants,
- Level 1 is 'Branch' level,
- Level 2 is 'Headquarters' level,
- Level 3 is 'Credit Council' level,
- Level 4 is 'Management Board' level,
- Level 5 is 'Supervisory Board' level.

Is also agree to denote with μ_i, ν_i and π_i respectively, the number of applications, which on the i-th level are accepted, rejected or forwarded for decision to the level $(i + 1)$, and with t – the total number of applications submitted for evaluation.

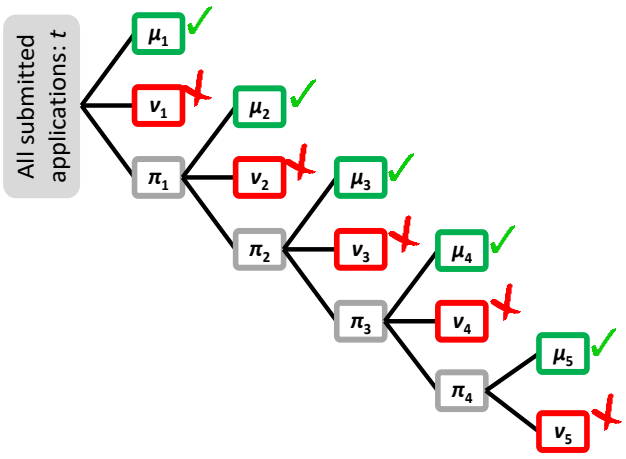

Figure 3.4. IF estimations of the performance of the different levels of decision making hierarchy during the bank loan applications review process

Obviously, in the top level of the Supervisory Board, $\pi_5 = 0$, as all applications that have reached this level must there get final resolution. The whole process, interpreted in terms of IF estimations can be graphically illustrated in the Figure 3.4.

First scheme of i-fuzzification

In the first scheme of i-fuzzification, on every level of the bank's decision making hierarchy, at a given moment of time, estimate what percentage of the total number of submitted applications for evaluation have been approved, and, respectively, hitherto rejected. Let us denote these by $M_i^1, N_i^1,\ i = 1, \ldots, 5$, hence:

$$M_i = \frac{\sum_{k=1}^{i} \mu_k}{t}, \quad N_i = \frac{\sum_{k=1}^{i} \nu_k}{t}.$$

Second scheme of i-fuzzification

In the second scheme of i-fuzzification, on every level of the bank's decision making hierarchy, at a given moment of time, estimate what percentage of the applications for evaluation, received from the lower level are approved, and, respectively, rejected, on that level. Let us denote these by $M_i^2, N_i^2,\ i = 1, \ldots, 5$, hence:

$$M_i^2 = \frac{\mu_i}{\pi_{i-1}}, \quad N_i^2 = \frac{\nu_i}{\pi_{i-1}}.$$

Graphical interpretation of the two proposed i-fuzzification schemes

Let us give the following numerical example, which will make the differences between both proposed schemes easy to follow.

In given moment of time, let the following exemplary distribution of project applications along the levels in the bank's decision making hierarchy be observed, as shown on Figure 3.5. Applying the first scheme of i-fuzzification over these data, will give the results in the following Table 3.1, as illustrated in Figure 3.6.

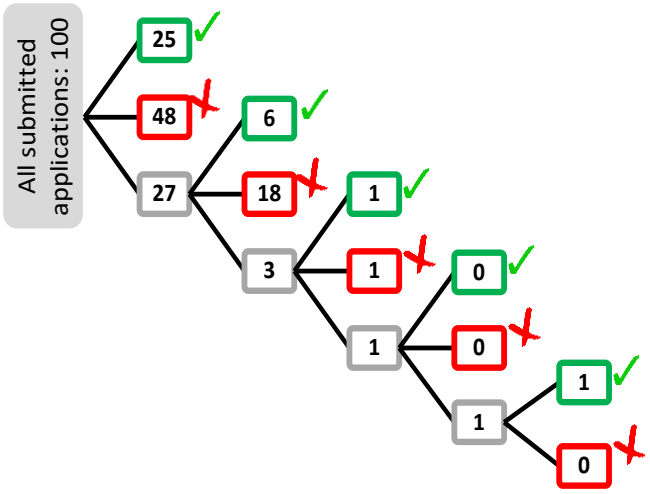

Figure 3.5, IF estimations for the numerical example

Table 3.1. Application of the first i-fuzzification scheme

	μ_i	ν_i	π_i
Level 1	25/100 = 0.25	48/100 = 0.48	27/100 = 0.27
Level 2	(25 + 6)/100 = 0.31	(48 + 18)/100 = 0.66	3/100 = 0.3
Level 3	(31 + 1)/100 = 0.32	(66 + 1)/100 = 0.67	1/100 = 0.01
Level 4	(32 + 0)/100 = 0.32	(67 + 0)/100 = 0.67	1/100 = 0.01
Level 5	(32 + 1)/100 = 0.33	(67 + 0)/100 = 0.67	0/100 = 0.00

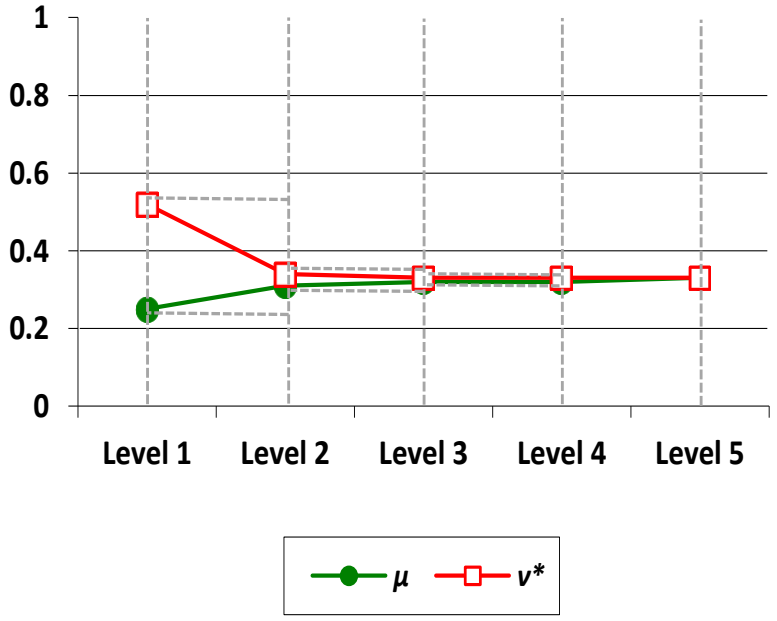

Figure 3.6. Interpretation of the first i-fuzzification scheme

Applying the second scheme of i-fuzzification over these data, will give the results in the following Table 3.2, as illustrated in Figure 3.7.

Table 3.2. Application of the second i-fuzzification scheme

	μ_i	ν_i	π_i
Level 1	25/100 = 0.25	48/100 = 0.48	27/100 = 0.27
Level 2	6/27 = 0.22	18/27 = 0.67	3/27 = 0.11
Level 3	1/3 = 0.33	1/3 = 0.33	1/3 = 0.33
Level 4	0/1 = 0.00	0/1 = 0.00	0/1 = 0.00
Level 5	1/1 = 1.00	0/1 = 0.00	0/1 = 0.00

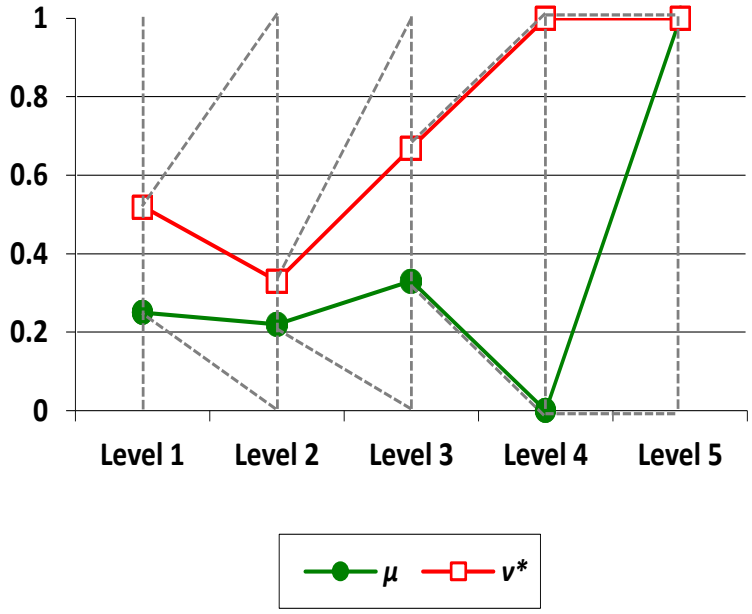

Figure 3.7. Interpretation of the second i-fuzzification scheme

The comparison between both i-fuzzification schemes shows well that in the first scheme, at every level *i*, the [0, 1] - interval corresponds to the initial number of *t* submitted bank loan applications, and M_i^1, N_i^1, i=1,…,5, are cumulative. In comparison, in the second scheme, on every upper level *i* only operate with the IF evaluations for that level, and every time the degree of uncertainty from the lower (i – 1)$^{\text{-th}}$ level is again re-normed to match the [0, 1] - interval (see the grey dotted lines).

Both approaches can be used interchangeably, and may prove useful in different situations, when it is necessary to evaluate the effectiveness of the different bank's internal financial structural unit as levels of the bank's decision making hierarchy.

3.5. Generalized Net model of internal structural unit functionality focused on SME financing.

In [5*] is proposed an original GN model of internal structural bank unit functionality. The advantage of this approach is in modelling the inherent aspects of parallelism and concurrency between agents in a situation of competition.

The majority of SME companies in Bulgaria experience difficulties in maintaining a normal life cycle and tend to suffer from early maturity and decline without being able to materialize its full potential. There are many reasons for this, with the most common being - poor management and lack of financing. The Fund will aim in this cases at eliminating these factors with different optimization strategies, so the company converges to its natural development path and then seek expansion opportunities. More than 80% of the companies in the manufacturing business are managed with outdated structures, based on personal skills and single person's authority. It is believe that implementation of modern business processes and process management would increase significantly profitability. Optimization of the marketing strategy and establishment of adequate financial management will be in most of the investment cases the other substantial driver for successful expansion. Raising funds via government programs was used by 2.9% of the companies, and access to financing via programs of non-government organizations has a share of 2%. Financing via EU structured funds had an insignificant portion (1.6%) up until few years ago. Nowadays the percentage has increased considerably and 45% of SMEs is making efforts to receive the embedded financing and grant schemes, [1*]. One third of all investments made by SMEs are into new equipment and machinery (about 35%), re qualification, training and advertisement is the second investment direction (29%), development of present and design of additional newer products (22%), introduction of systems for intercompany management processes (9%). Paper [5*] analyze the process of evaluation of N number of projects, entering one bank facility (branch – first level of competence). The total estimate of project volume shall equal the amount of attracted

funds in the form of deposit instruments, accrued at banks branch. The N number of projects is submitted in the branch facility within the spread of L business days. Each project application amount is within granting limits of the Branch manager, voted to him by Management Board. In the first visit of the branch by each potential SME borrower, the loan specialist (banks representative) has to perform a preliminary research as he is required to conduct a detailed and exhaustive dialogue with each SME borrowers representative in regards to the aim and purpose of each individual project, the legal status of each entity, the characteristics and perspectives of future development of the business, each main contractors and competitors. Information concerning financial statements of each legal entity will be required, along with personal economic justification, relationship with financial institutions, credit history statements, and most important the type of collateral available. The above mentioned details are gathered by the branch specialist, in order for him to acquire a general glance of the costumers. The accumulated information will later be used in the preparation process of the loan application, respectively the loan itself. During first meeting the loan officer is required to inform the potential SME borrower of all conditions, sequence of loan review procedures and timing estimate. Once initial meeting is complete, each potential borrower is given an application form, along with a list of supporting docs and declarations, which needs to be presented at application time. The evaluation process is held in accordance with internal Banks regulation, voted by Management Board. Each application form is evaluated on separate case by case scenario, as a unified scoring system is applied. As each applicant completes their project application form, they proceed onto in branch submission. All of N number project requests are deposited and registered internally by branch representative as each one receives entry number in the informational system of the Bank. The N numbers of projects applications have entered the administrative IT system of the financial institution within a spread of L business days. Each applicant submits all required by the Bank information, concerning the applicant itself along with third party liable persons or entities in regards to:

• Legal status of the entity/ies, financial statements, audit reports, detailed transcript of all receivables and payables, specified terms of origination and extinction,

economic justification of the loan request, along with contractual agreements, declarations, references, ratings, etc. Additional data may be requested by bank officers, in regards to information about market environment, major suppliers, clients and competitors, experience in the sector, professional training of management team, all backed by the necessary documents and materials.

• As completed and fully organized (N number project requests), are distributed between loan officers to begin analyzing and processing the loan application. Once personnel from branch level (including Branch Manager) have determined that the documents and the data information provided by the borrower are sufficient the official assessment of creditworthiness and credit risk of the borrower begins. The unit (Banks branch officers) has to follow the internal rules of evaluation and come up with a well-grounded proposal/decline of the application within L business days.

The N numbers of project applications are distributed between loan officers for evaluation on the basis of “first come first serve”. Following internal evaluation rules the loan officer is able to contact potential borrowers for further clarifications on submitted data. Communication respectively clarification of all details is done according to bank rules (via e-mail, and via written registered and dated documents), and within time frame set by the financial institution at first. As the evaluation process moves forward each project request receives an individual scoring result, which is based primarily on the purpose of the request, backed by well explained and detailed business plan, characteristics of the existing business (unless an SME startup), perspectives for further development of the business in the future again presented in realistic figures and not so optimistically generated cash flow for the time of the loan, written engagements with contractors and data about major competitors and respective market share. Major portion in the scoring approach has the financial result of the SME for a period of at least 3 years prior to application (unless an SME startup) and last quarter of present year. Another components bearing value are credit history and financial institutions relationship of each applicant. Once each loan officer completes the evaluation of the project request according to Banks rules and regulations and within the time frame of L business days, the transactions are moved to Branch management for final decision. In the spread of few business days the Branch manager

receives from his staff (loan officers) an N number of evaluated project applications for decision. Each one of the loan requests falls in the scope or in the limits given as an authorization limits (as value) to the Branch Manager by Executive Directors and Management Board of the Bank. As evaluated each project application has an individual score presented in generated points.

Here is an example for the bank unit functionality:

• 60–70 pts. The project request is declined.

• 70–80 pts. The project request is returned for further evaluation and additional data such as need of additional collateral, references from clients, etc.

• 80–90 pts. The project request is returned for minor adjustments in the performed evaluation and few little additional data requested.

• 90–95 pts. The project request has received all adjustments and necessary evaluation, and is sent to the Headquarters of the Bank for final comments and requirement before granting.

• 95–100 pts. The project request receives an automatic approval by the Branch Management and is prepared in internal system for granting.

In the current case, the Branch Manager has N number of evaluated project applications with following scores: P1 receives 97 pts.; P2 receives 96 pts.; P3 receives 94 pts.; P4 receives 95 pts.; Px receives 94 pts.; Py receives 98 pts. As the evaluation procedures are complete, Branch Manager encounters a complicated situation where out of N number of evaluated project applications, x of them have to receive an automatic approval and be prepared in the informational accounting system for granting on one side, and y number of evaluated project applications have to be sent to the Headquarters for concordance and other requirements. Having in mind the fact that such accumulation of number of project requests in one particular branch will bring the attention of Executives and Management Board of the Bank, the Branch manager has to proceed with caution and according to internal rules and regulations. Such accumulation could be interpreted as an attempt for fraud activities on the side of the Branch, because similar event is considered add within the financial institution system, where regularity in project requests respectively granting or declining is

generally accepted. As each project is again thoroughly screened by Branch management and loan officers, the following outcome occurred:

• Project requests P1, Py and others should receive an automatic OK, due to the fact that total individual score generated is over 96–97 pts. An important fact to mark is that requests Py through N are submitted by SMEs who are potential customers of the particular bank.

• Projects P3 and Px both received around 94 pts., which (following internal rules) would put them in line for additional comments and requirement by the Headquarters of the Bank, prior project financing. At the same time those application requests are received from existing costumers of the bank with outstanding credit history, as both have utilized financial instruments in the past and have managed service with no delays and problems.

• The rest of the projects received scores which varied between 93 and 96 pts. As they came from internal costumers of the bank with prior failure of conduct in terms of instrument service, they would receive same treatment as ordinary project applications.

Once the additional screening is complete, the Branch Manager makes his final decision. Considering all facts in connection with each project application, along with and according to internal rules and regulations of the Financial Institution, Branch Management decides on the following. projects P3 and Px, which came from internal costumers of the bank with no prior bad history within, regardless of the fact that do not meet the criteria for automatic approval (based on points generated) received the approval and were eligible for granting. The rest of the project applications where kept divided as initially, but where sent to the Headquarters' Credit Operations and Credit Risk Division for additional opinion and comments. Again, the following was done, due to the high number of requests which were received at one particular banks location. As mentioned such aggregation of loan requests, could result into irregular sudden inspections from the Headquarters' divisions, as a motive for fraud prevention. Such checkups would not only distress the working rhythm in the Branch, but will put pressure on Management and Staff as predefined (by Management Board) results have to be reached on monthly and quarterly basis.

The current token αcu (below, mark is as α, only) enters place l1 with the initial characteristic “S number of projects submitted in the branch, in a spread of L business days”.

$$Z_1 = \langle \{l_1\}, \{l_2, l_3, l_4\}, \begin{array}{c|ccc} & l_2 & l_3 & l_4 \\ \hline l_1 & W_{1,2} & W_{1,3} & W_{1,4} \end{array} \rangle,$$

where:

• W1,2 = “Project is submitted by present clients of the financial institution and in line with grant limit of branch manager”,

• W1,3 = “Project is submitted by external legal entity in line with grant limit of branch manager”, • W1,4 = “Project is submitted by internal or external legal entity and is over the grant limit of branch manager”.

When W1,2 = true, token α enters place l2 with characteristic “Present client with project, which is within the grant limit”.

When W1,3 = true, token α enters place l3 with characteristic “Potential client with project, which is within the grant limit”.

When W1,4 = true, token α enters place l4 with characteristic “Present or Potential client with project, which is out of the grant limit of Structural Unit Manager”.

$$Z_2 = \langle \{l_2, l_6, l_{10}\}, \{l_5, l_6\}, \begin{array}{c|cc} & l_5 & l_6 \\ \hline l_2 & true & false \\ l_6 & true & false \\ l_{10} & false & true \end{array} \rangle.$$

Token α enters place l5 with characteristic “Project being discussed”, and enters place l6 with characteristic “Project pending discussions”.

$$Z_3 = \langle \{l_3, l_9, l_{13}\}, \{l_7, l_8, l_9\}, \begin{array}{c|ccc} & l_7 & l_8 & l_9 \\ \hline l_3 & true & false & false \\ l_9 & W_{9,7} & W_{9,8} & false \\ l_{13} & false & true & false \end{array} \rangle,$$

where:

• W9,7 = “Potential client’s project is being sent for discussions”,

• W9,8 = “Potential client’s project is discussed and sent to the Headquarters of the Bank for further analysis”.

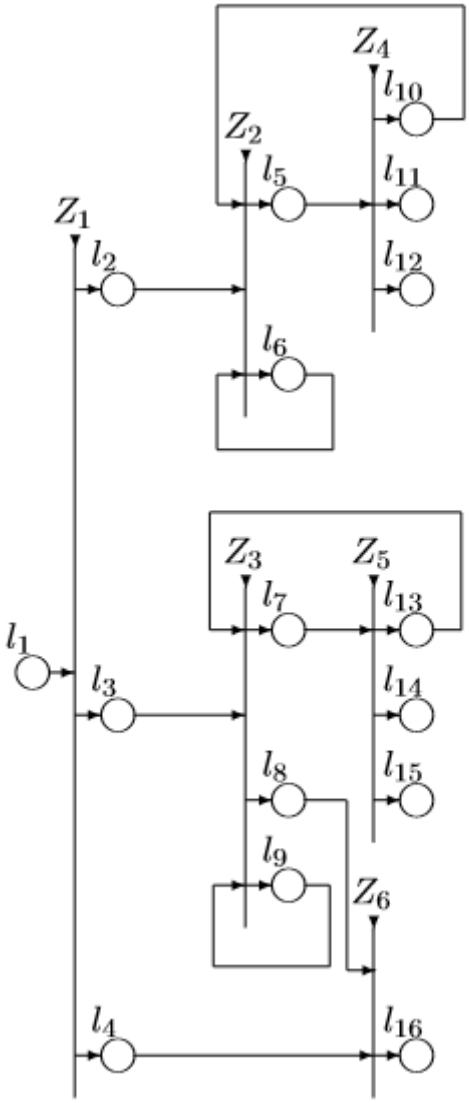

Figure 3.8. The constructed Generalized Net model

Token α enters place l7 with characteristic “Potential client’s project receives an ID number and is waiting for assessment” and it enters place l9 with the characteristic “Potential client’s project receives an ID number and stays i database”.

When W9,7 = true, token α enters place l7 with characteristic “Evaluation of the project”.

When W9,8 = true, token α enters place l3 with characteristic “Rejection after evaluation of the project”.

$$Z_4 = \langle \{l_5\}, \{l_{10}, l_{11}, l_{12}\}, \begin{array}{c|ccc} & l_{10} & l_{11} & l_{12} \\ \hline l_5 & W_{5,10} & W_{5,11} & W_{5,12} \end{array} \rangle,$$

where:

• W5,10 = “Project is sent back with further questions”,

• W5,11 = “Project is evaluated and approved for financing”,

• W5,12 = “Project is evaluated and rejected at Branch level”.

When W5,10 = true, token α enters place l10 with characteristic “Project evaluation, additional information for further review”.

When W5,11 = true, token α enters place l11 with characteristic “Project is evaluated, Contract, Grant”.

When W5,12 = true, token α enters place l12 with characteristic “Evaluation of the project and rejection at branch level”.

$$Z_5 = \langle \{l_7\}, \{l_{13}, l_{14}, l_{15}\}, \begin{array}{c|ccc} & l_{13} & l_{14} & l_{15} \\ \hline l_7 & W_{7,13} & W_{7,14} & W_{7,15} \end{array} \rangle,$$

where:

• W7,13 = “Potential client’s project is evaluated and generates questions”,

• W7,14 = “Potential client’s project is evaluated and approved for granting”,

• W7,15 = “Potential client’s project is evaluated and proposed for rejection”.

When W7,13 = true, token α enters place l10 with characteristic “Project evaluation, request for additional information”.

When W7,14 = true, token α enters place l11 with characteristic “Project evaluation, contract and grant”.

When W7,15 = true, token α enters place l12 with characteristic “Evaluation of project and rejection under branch level”.

$$Z_6 = \langle \{l_4, l_8\}, \{l_{16}\}, \begin{array}{c|c} & l_{16} \\ \hline l_2 & true \\ l_6 & true \end{array} \rangle.$$

Token α enters place l16 with characteristic “Evaluation of project sent to the Headquarters for further analysis”.

In this research is considered an original Generalized Net model of internal structural unit functionality focused on SME financing mechanism. The research presents in details the mechanism according to which the first–level of a bank institution operates. The advantages are outlined of the application of the apparatus of generalized nets to the description of this process, featuring both parallel behavior and competitiveness. This approach can be beneficially used in different situations, when it is necessary to evaluate the effectiveness of the different banks internal financial structural unit as levels of the bank’s decision making hierarchy. The results, obtained in this research, can be successfully applied to analyze the work of any structural unit of a financial institution.

3.6. Assessment finance approach from the glance of a Generalized Net model implemented in a structural unit of a financial institution.

The most popular source of financing among commercial banks and leasing companies is public procurement. Statistics show that about 15% of SMEs take advantage of public procurement, [105]. The paper [6*] traces the most important steps of the process of evaluation of a business project proposal, applying for bank financing. The research model is offered how the concept of the generalized nets (GN) can be applied to the process of evaluating creditworthiness of the SMEs.

As in previous research provided, part of initially generated project applications where approved and financed at Branch level. The rest of the projects where then provided to the Headquarters of the Bank for further review and higher hierarchy final decision on the applications. As all unapproved Branch level projects reach the Headquarter office of the Bank, they are registered internally in the internal Records Department, and receive authentic application entry number. Then they are distributed between the following Departments for further analysis: Credit Operations and Credit

Risk Department, Legal Department, and Security Department. All of them should provide additional opinions and comment on each project. Each department is in position to request additional information for each project, as the requests goes through the Branch personnel, instead of directly from client. Financial institutions internal rules and regulation for project assessment disallow direct communication between potential borrower and experts from Headquarter office. This is done with the special purpose of evaluating projects solely on provided written application forms and supportive documents and declarations. As communications between borrowers and banks representative (including Branch manager) from first level of competence are part of the procedure, projects received at Headquarters level are assessed strictly against provided written data. The possibility of verbal or any kind of influence over experts from Headquarters is restricted due to likelihood of incorrect opinion or proposal at decision making time. In this research, the process of Headquarters Department evaluation will be addressed, along with further assessment by Credit council of the Bank, intermediate decision by Management Board and reception of final decision by Supervisory Board. Once projects are distributed between Departments, experts begin the review of the completeness of each application, as first step of the decision making process. Any lack of information or supportive documents is then requested from Branch representatives. Once received, verified and determined that the documents and the supportive data provided by Branch level are sufficient the additional assessment of creditworthiness, credit risk and potential other risks of the project and potential borrower is done. Each department receives a certain amount of time to analyze each project, as application and supportive data is shared between Departments. As preliminary assessment at Headquarters level is done by Experts, projects are then prepared for next step of evaluation Credit Council. The Credit Council is an internally structured committee, which is obliged to perform a comprehensive discussion on each assessed project, and to either request additional data, or prepare the application for the next step of competence. The Council constitutes from Bank staff, usually Heads the above mentioned departments, who are authorized by Management Board to perform such project reviews, and precede an official statement to both Management and Supervisory Board. Considering the fact

that Credit Council opinion on financial instruments granting, is taken as most significant one (in terms of detailed analysis of each project application), both next step decisions is going to be based mostly on motives addressed by Credit Council with few exceptions. When a project discussion is complete and the committee has decided to continue the application forward, a supportive form is prepared and presented to Management Board for sign off. In cases where the Council do not fully agree on certain elements of project application, then its sent back to Headquarters Departments for further processing, or when the committee disagree with the presented project it is rejected and the potential borrower is informed officially for the final decision. As the Management Board receive the project and supportive official forms from the Headquarters Department and Credit Council, a protocol of each meeting is prepared and Board Members provide their opinion, which is recorded and finalized. If the Board members opinion is positive, then the minutes from the Board meeting is prepared for the final step Supervisory Board. The Supervisory Board very seldom will react different and make any adjustments on previous levels of competence, but in some cases (again rare) might take a different approach of certain project financing. As top level in the hierarchy of the financial institution, such decision is permissible and usually well-grounded. In such events, top Board members dispose with information on either the borrower, the project itself, or the economic environment, which is not available for all other levels of competence, and the usual outcome is rejection of project.

Initially, in the GN, shown on Figure 3.9, four tokens $\alpha,\beta,\gamma,\delta$ stay in places l6,l10,l15,l20, with initial characteristics, respectively:

“Headquarters of the Bank – Departments of competence”,

“Credit Council”,

“Management Board”,

“Supervisory Board”.

During the GN functioning, tokens $\varepsilon1,\varepsilon2,...$ enter place l1 with initial characteristic “Projects receive additional analysis in Headquarters level, for final approval”.

For brevity, below mention these tokens without their indices.

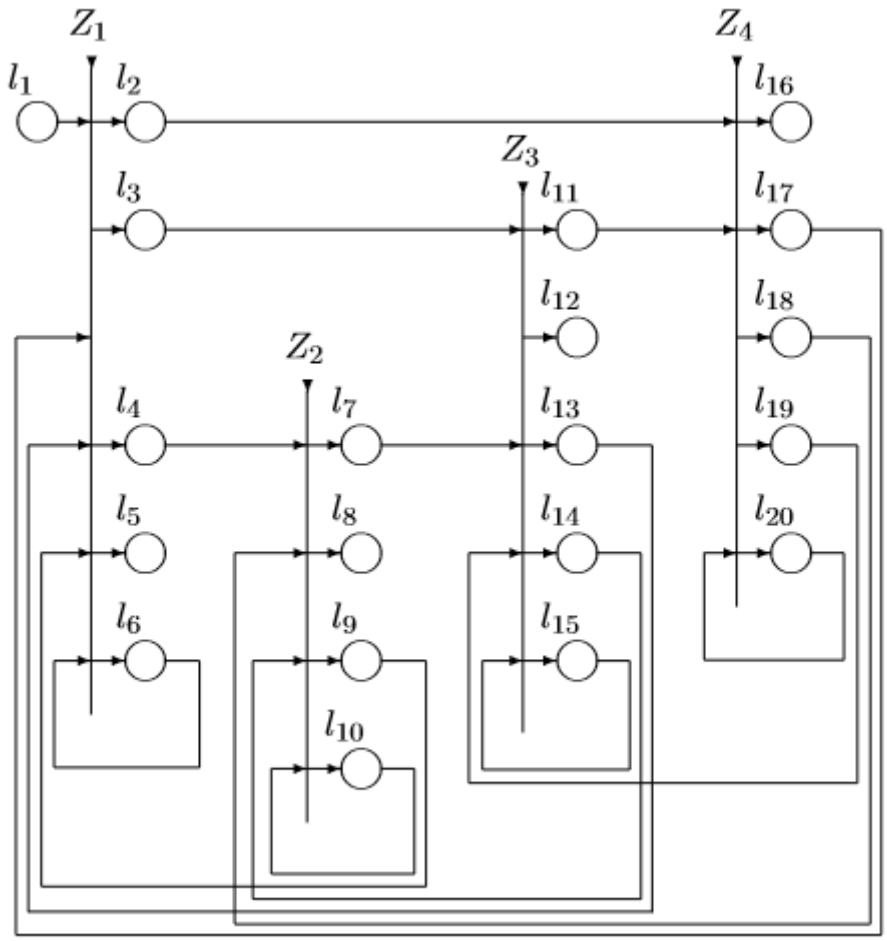

Figure 3.9. The constructed Generalized Net model

$$Z_1 = \langle \{l_1, l_6, l_9, l_{13}, l_{17}\}, \{l_2, l_3, l_4, l_5, l_6\},$$

	l_2	l_3	l_4	l_5	l_6
l_1	$false$	$false$	$false$	$false$	$true$
l_6	$W_{6,2}$	$W_{6,3}$	$W_{6,4}$	$W_{6,5}$	$true$
l_9	$false$	$false$	$false$	$false$	$true$
l_{13}	$false$	$false$	$false$	$false$	$true$
l_{17}	$false$	$false$	$false$	$false$	$true$

$\rangle$

where:

• W6,2 =“Project request is further submitted to Supervisory Board”,

• W6,3 =“Project request is further submitted to Management Board”,

• W6,4 =“Project request is further submitted to Credit Council”,

• W6,5 =“Project request is rejected at Headquarters level due to specific motives”.

During the GN functioning, tokens ε1,ε2,... enter place l1 with initial characteristic “Projects receive additional analysis in Headquarters level, for final approval”.

Tokens ε from each one of the input places of the transition Z1 enter place l6 where they unite with token α, that obtains the characteristic “Projects entered in Headquarters data base”.

When W6,2 = true, token α splits to the tokens α and token ε that enters place l2 with characteristic “Project sent to Supervisory Board from Headquarters for initial comments”.

When W6,3 = true, token α splits to the tokens α and token ε that enters place l3 with characteristic “Project sent to Management Board from Headquarters for initial comments”.

When W6,4 = true, token α splits to the tokens α and token ε that enters place l4 with characteristic “Project sent to Credit council for further review”.

When W6,5 = true, token α splits to the tokens α and token ε that enters place l5 with characteristic “Project rejected at Headquarters level”.

$$Z_2 = \langle \{l_4, l_{10}, l_{14}, l_{18}\}, \{l_7, l_8, l_9, l_{10}\},$$

	l_7	l_8	l_9	l_{10}
l_4	$false$	$false$	$false$	$true$
l_{10}	$W_{10,7}$	$W_{10,8}$	$W_{10,9}$	$true$
l_{14}	$false$	$false$	$false$	$true$
l_{18}	$false$	$false$	$false$	$true$

$\rangle,$

where:

• W10,7 = “Project application is assessed by Credit Council and submitted to Management Board”,

• W10,8 = “Project application is rejected by Credit Council”,

• W10,9 = “Credit Council requests additional information from Headquarters in regards to project”.

Tokens ε from each one of the input places of the transition Z2 enter place l10 where they unite with token β, that obtains the characteristic “Project enters Credit Council data base.

When W10,7 = true, token β splits to the tokens β and token ε that enters place l7 with characteristic “Project approved by Credit Council, sent to Management Board”.

When W10,8 = true, token β splits to the tokens β and token ε that enters place l8 with characteristic “Project rejected by Credit Council”.

When W10,9 = true, token β splits to the tokens β and token ε that enters place l9 with characteristic “Additional information requested by Credit Council”.

$$Z_3 = \langle \{l_3, l_7, l_{15}, l_{19}\}, \{l_{11}, l_{12}, l_{13}, l_{14}, l_{15}\},$$

	l_{11}	l_{12}	l_{13}	l_{14}	l_{15}
l_3	$false$	$false$	$false$	$false$	$true$
l_7	$false$	$false$	$false$	$false$	$true$
l_{15}	$W_{15,11}$	$W_{15,12}$	$W_{15,13}$	$W_{15,14}$	$true$
l_{19}	$false$	$false$	$false$	$false$	$true$

$\rangle,$

where:

• W15,11 = “Project is assessed by Management Board and submitted to Supervisory Board ”,

• W15,12 = “Project is assessed and rejected by Management Board”,

• W15,13 = “Management Board requests additional information from Headquarters in regards to project”,

• W15,14 = “Management Board returns project to Credit Council for additional information and further review”.

Tokens ε from each one of the input places of the transition Z3 enter place l15 where they unite with token γ, that obtains the characteristic “Project enters Management Board data base”.

When W15,11 = true, token γ splits to the tokens γ and token ε that enters place l11 with characteristic “Project approval by Management Board, submission to Supervisory Board”.

When W15,12 = true, token γ splits to the tokens γ and token ε that enters place l12 with characteristic “Project rejection by Management Board”.

When W15,13 = true, token γ splits to the tokens γ and token ε that enters place l13 with characteristic “Request to Headquarters of additional information by Management Board”.

When W15,15 = true, token γ splits to the tokens γ and token ε that enters place l15 with characteristic “Project awaits evaluation”.

$$Z_4 = \langle \{l_2, l_{11}, l_{20}\}, \{l_{16}, l_{17}, l_{18}, l_{19}, l_{20}\},$$

	l_{16}	l_{17}	l_{18}	l_{19}	l_{20}
l_2	$false$	$false$	$false$	$false$	$true$
l_{11}	$false$	$false$	$false$	$false$	$true$
l_{20}	$W_{20,16}$	$W_{20,17}$	$W_{20,18}$	$W_{20,19}$	$true$

$\rangle,$

where:

• W20,16 = “Project is assessed by Supervisory Board and granted”,

• W20,17 = “Supervisory Board requests additional information from Headquarters in regards to project”,

• W20,18 = “Supervisory Board returns project to Credit Council for additional information and further review”,

• W20,19 = “Supervisory Board returns project to Management Board for further review”.

Tokens ε from each one of the input places of the transition Z4 enter place l20 where they unite with token δ, that obtains the characteristic “Project to Supervisory Board data base”.

When W20,16 = true, token δ splits to the tokens δ and token ε that enters place l16 with characteristic “Project grant by Supervisory Board”.

When W20,17 = true, token δ splits to the tokens δ and token ε that enters place l17 with characteristic “Request to Headquarters of additional information by Supervisory Board”.

When W20,18 = true, token δ splits to the tokens δ and token ε that enters place l18 with characteristic “Request to Credit Council of additional information, review by Supervisory Board”.

When W20,18 = true, token δ splits to the tokens δ and token ε that enters place l19 with characteristic “Further review request to Management Board”.

The approach with an application of the apparatus of generalized nets is justified due to the high volume of projects received at one particular banks Headquarters office. As usual such aggregation of project requests, results into measure taking action on behalf of Management body of the financial institution. The level approach may by proven to be useful in different situations, when it is necessary to evaluate the effectiveness of the different banks internal financial structural unit as levels of the bank’s decision making hierarchy. The obtained in this research results can be successfully applied for analysis of the work of one structural unit of a financial institution. In a next step of research, estimations of the effectiveness of the described process will be made, taking consideration of the aspects of uncertainty. Uncertainty is an inherent part of the processes of evaluation of applications for bank support and evaluation of the process itself. For this sake the apparatus of intuitionistic fuzzy sets will be used.

3.7. Optimisation procedures in SMEs financial mechanism.

In the paper [7*] is discussed the mechanism of bank support of small and medium-sized enterprises (SMEs). Analysis is made of the effectiveness of the bank’s internal financial structural unit and hierarchy, and it is shown how the concept of Multi-Criteria Decision Analysis (MCDA) can be applied to the process of evaluating creditworthiness of the SMEs applications for bank loans, from the bank’s perspective. The presented approach aims to yield estimations of the effectiveness of the process, taking consideration of the aspects of uncertainty, which is an inherent part of the processes of evaluation of applications for bank support and evaluation of the process itself.

Multi-Criteria Decision Analysis (MCDA) [109] is a valuable tool that can apply to many complex decisions. It is most applicable to solving problems that are characterized as a choice among alternatives. It has all the characteristics of a useful decision support tool. It helps us focus on what is important, is logical and consistent, and is easy to use. The MCDA is useful for:

- Dividing the decision into smaller, more understandable parts;

- Analyzing each part;
- Integrating the parts to produce a meaningful solution.

When used for group decision making, MCDA helps groups talk about their decision opportunity (the problem to be solved) in a way that allows them to consider the values that each views as important.

It also provides a unique ability for people to consider and talk about complex trade-offs among alternatives. In effect, it helps people think, re-think, query, adjust, decide, rethink some more, test, adjust, and finally decide.

MCDA problems are comprised of five components:

1. Goal;
2. Decision maker or group of decision makers with opinions (preferences);
3. Decision alternatives;
4. Evaluation criteria (interests);
5. Outcomes or consequences associated with alternative or interest combination.

In general, there exist two distinctive types of MCDM problems due to the different problems settings: one type having a finite number of alternative solutions and the other an infinite number of solutions. Normally in problems associated with selection and assessment, the number of alternative solutions is limited. In problems related to design, an attribute may take any value in a range. Therefore the potential alternative solutions could be infinite. If this is the case, the problem is referred to as multiple objective optimisation problems instead of multiple attribute decision problems.

A MCDM problem may be described using a decision matrix. Suppose there are m alternatives to be assessed based on n attributes, a decision matrix is a $m \times n$ matrix with each element Y_{ij} being the j-th attribute value of the i-th alternative.

All criteria in a MCDM problem can be classified into two categories. Criteria that are to be maximised are in the profit criteria category, although they may not necessarily be profit criteria. Similarly criteria that are to be minimised are in the cost criteria category. An '*ideal solution'* to a MCDM problem would maximise all profit criteria and minimise all cost criteria. Normally this solution is not obtainable. The

question is what would be a best solution for the decision maker and how to obtain such a solution?

In paper [99] is shown that many small and medium enterprises (SMEs) in the UK use the beta (Business Excellence Through Action) approach to the EFQM Excellence Model to conduct business excellence self-assessment, which is in essence a multiple criteria decision analysis (MCDA) problem. This research introduces a decision support software package called Intelligent Decision System (IDS) to implement the beta approach. It is demonstrated in the paper that the IDS-beta package can provide not only average scores but also the following numerical results and graphical displays on:

- Distributed assessment results to demonstrate the diversity of company performances.
- The performance range to cater for incomplete assessment information.
- Comparisons:
  - between current performances and past performances,
  - among different companies,
  - among different action plans.
- Strengths and weaknesses.

The IDS-beta package also provides a structured knowledge base to help assessors to make judgments more objectively. The knowledge base contains guidelines provided by the developers of the beta approach, best practices gathered from research on award winning organizations, evidence collected from companies being assessed and comments provided by assessors to record the reasons why a specific criterion is assessed to a certain grade for a company. Four small UK companies, the industry partners of the research project, have carried out the preliminary self-assessment using the package. The results and experience of the application are discussed at the end of the paper [99].

Competition for investments from other PE equity funds is expected to be low due to small number of locally active funds, the fact that most are fully invested, their investment focus, and as well negative track record of some international players.

Based on geography mandated and on-the-ground presence competing funds could be broadly classified in two categories.

- Funds with entirely local focus and presence like Advance Equity Holding (generalist, fully invested and preparing for exit), NEVEQ (IT focus, venture capital, fully invested)
- Regional or global with mandates for transactions in the country like Global Finance (PE firm with funds targeting SE Europe), GED Eastern Europe Fund (generalist; targeting Bulgaria and Romania), Bancroft (generalist, targeting Eastern Europe), 3TS Capital Partners (generalist, targeting CE Europe), NBG Private Equity (generalist, SE Europe), Alpha Ventures which usually have limited local presence through a representative office with 1-2 professionals.

The second group of funds usually target investments above EUR 5 million with preferred size of transactions in range of EUR 10-15 million. Their approach to investments is usually more opportunistic and targets the higher end of the mid-size company sector and companies in later stages of development.

90% of the SMEs remain unevaluated from the existing local PE sector. Traditional bank financing remains currently as well hardly accessible for SMEs. The result is a general inaccessibility to growth funding for the most of SMEs in Bulgaria.

The investment appetite of foreign PE is additionally reduced by the fact that several PE funds experienced a complete loss of single investments due to fraud and weak legal execution.

The fund management maintains excellent professional relationship with representatives of local and regional private equity funds and institutional investors. It is highly esteemed in the professional community and possesses a good network of contacts due to multitude and variety of roles in the industry and this is expected to be of vital importance in co-operating with outside investors. The fund will seek in single cases cooperation with external capital providers where sizeable follow-up rounds of financing is needed (e.g. acquisitions, elevated CAPEX needs) or in cases where the initial investment is too high or risky. Expectation at this kind of cooperation is to maintain possibility to invest in high return opportunities by sharing risk. The

cooperation with other PE funds will be important for the execution of the exit strategy e.g. seeking of pre-IPO financing, secondary sale etc.

The individual investments in each fund's portfolio should be selected based on the combination between the mandatory and at least one of the optional criteria:

Mandatory Criteria:

- Management team and human resources' potential;
- Profound market and industry knowledge;
- Business model scalability;
- Distinctive competitive advantages;
- Double digit growth potential of the companies revenues;
- Clear Exit Route.

Optional Criteria:

- Value-adding opportunities through process optimization, strategy fine-tuning;
- Market scalability of the products (export);
- Potential for horizontal or vertical integration.

The majority of SME companies in Bulgaria experience difficulties in maintaining a normal life cycle and tend to suffer from early maturity and decline without being able to materialize its full potential. There are many reasons for this, with the most common being – poor management and lack of financing. The Fund will aim in this cases at eliminating these factors with different optimization strategies, so the company converges to its natural development path and then seek expansion opportunities. Companies that have already accomplished this stage of their life cycle will be prepared for the next level.

By providing equity financing, business expansion and optimization can be achieved primarily through the implementation of various strategies: production capacity expansion; new product or a new line of products launch; commercial network development, process improvement and efficiency

More than 80% of the companies are managed with outdated structures, based on personal skills and single person's authority. This implementation of modern business processes and process management would increase significantly profitability.

Optimization of the marketing strategy and establishment of adequate financial management will be in most of the investment cases the other substantial driver for successful expansion.

The step to the next lifecycle stage of the company will be achieved by providing equity capital and financial structuring of the implementation of one or several of the following strategies:

- Organic growth for companies with interesting and multipliable business models;
- Non-organic growth, horizontal integration;
- Non-organic growth, vertical integration across the value chain;
- Creating regional leaders and consolidation plays.

Investment Case 1* – *initial expansion

A diary company developing was established 2006. Original funding came from mortgaging owner's land and real estate property. These sources were sufficient to enable the company to become operational and to establish an organic production cycle. The sales experienced a steady double digit growth, but production is distributed under different conventional brands by the different contracted resellers. The owner wants to create an own brand, to be certified as an organic/bio producer and establish own/ new sales channels. The EBITDA increase after implementation is projected at 50%.

Investment Case 2* – *expansion and optimization

Food producer established in 2001 produces a high class product, higher price segment. Clear quality leader in the segment, but brand is not well established on the market. Company needs to develop and execute winning marketing strategy. Need for expansion of the production cycle to achieve economy of scale. Need for optimization of process and overall management. Due to liquidity problems and poor financial management the company is currently valuated from the owners at 2.5 x EBITDA. After expansion and optimization EBITDA is expected to triple in 4 years and exit at 5 to 6 x EBITDA would be achievable.

Investment Case 3* – *take to the next level, organic growth with a scalable business model in a highly fragmented segment

Auto Repair Shop, all in one concept with 13 different activities brought to one place, incl. car sales, leasing and insurance consulting, guarantee repairs, general repairs, sale of parts & tires, paint, carwash, accessories, restaurant and coffee and education center for car mechanics.

Company has 12 years' experience in the different activities as single shops. The company has developed and optimized over the years an own business process management system for combining all 13 activities including the education of the employees, fully automated and centralized. This management system results in a 3 times higher productivity of the single employee compared to the averages in the industry. The resulting excess work free time is invested in education and bonus holiday as incentive.

The company plans to multiply the concept in several large Bulgarian cities.

Investment Case 4* – *creating regional player through vertical and horizontal integration

A mid-size raw material processing company with good marketing strategy and well established product basket wants parallel to widen the production cycle and to increase the output and sales. Vertical integration through acquisition is targeted to complete the production cycle, the synergy effects of the integration would increase the joint EBITDA with 25%. At a second step an acquisition of a competing company would provide additional production capacity, a further increase of the synergy effects of the integration and additional market share. The company plans to fund their growth strategy with a 50% capital increase and debt. The investor will have an exit option after 5 years with a projected IRR of 18%.

Investing in growth capital in the SME sector involves substantial risk in general and particularly in emerging markets like Bulgaria. A significant portion of this risks results from the lack of business ethics in the market and a legislation, which doesn't support in particular this kind of investments. Several cases from the experience of international PE players in Bulgaria have shown that even a complete loss of the investments is possible due to fraud and weak legal execution. It is believe that the unique combination of experience in team combining more than 120 successful financial deals in the local business environment and understanding of the

peculiarities of the execution of financial deals in Bulgaria will be crucial for mitigating the legislative and fraud risk.

In order to mitigate the business and industry risks, it is necessary to achieve a relative diversification in stages/ types of investment, industries, size and number of portfolio companies. It is believe that fund needs to be able to invest in no less than eight companies in its total lifetime and not more than twelve at any moment of it.

The main purpose of the fund per definition is to support SME growth and not to takeover companies. Therefore general intention is to hold not more than 50% of the company's equity. Although, as the mentioned negative experience of other PE investors in the country shows, even as minority shareholder it is appropriate to implement irrevocable control mechanisms over the decisions process of the company's management as guarantee that the invested capital is used for its original goals. Attendance in the management board of the company will be just one of these mechanisms.

Generally the management processes of the companies will be reviewed and if needed adjusted. The client would prefer to invest in companies that have already existing or are willing to implement modern business and management processes, which are detached and independent from individual talent skills and single persons authority. The latter is unfortunately still the business standard for the majority of SMEs in Bulgaria, and bares a high potential business risk in the cases of disloyalty of this key people.

As the fund will be investing in growth, the equity investments as a general rule will be done as a capital increase and not as a partial or full shareholders exit. Exceptions to this rule can be evaluated if one or some of the shareholders hinder the development of the company.

Given experience and the targeted industries the ideal investment sizes are between EUR 1.5 million (smallest investment, as described in the example cases) and EUR 8 million (large). This numbers show the initial investment size. For follow-up capital increases the fund will keep special reserves of 10% to 15% of the total fund capital. Ideally, capital injections will be scheduled in tranches tied to performance and/or investment cornerstones.

The general holding period of an investment will be around 5 years, depending on the industry, life cycle of the company and the general economic cycle. Overall fund target will be an IRR of 18%. Some of the companies will need to be prepared for acquisition by international buyers due to the natural limitation of the local market. Such companies need to have grown to a size and stage that will make such acquisitions possible.

Following additional investment rules will apply to cover the principles described above:

- A single investment should not exceed EUR 10 million, and if it does, then a decision of the supervisory board will be needed. Single investments below EUR 1.5 million will be not evaluated.
- To assure diversification of companies, Top 4 investments should not exceed EUR 30 million
- To assure diversification in the targeted industries, the limit per single industry will be 30% of the funds capital.
- A balance (50/50) between the two types of investment will be targeted

In the initial year the aim is to complete 3 deals from different industries and different investment types. The investment cases show a generalized summary of some of the existing projects/ deals in pipeline. In the following years 3-4 deals per year will be the target.

The fund will utilize a two-pronged approach for deal flow generation. The origination will benefit from the commitment of the Bank, a commercial bank specialized in SME financing, and the partners' extensive network and experience in Bulgaria's financial market. The partners' combined network covers more than 50% of the Bulgarian SMEs in the targeted size and industries.

The fund will strive to maximize value creation by following policies providing in-direct and direct support to capital beneficiaries. Taking into consideration the business environment in the country and the usual practices of SMEs, the fund management is convinced that the potential for value-creation is immense and should be addressed adequately. As already several times described in this document even well-run Bulgarian companies often suffer from inefficient management, un-timely

access to performance metrics, no monitoring procedures, and lack of access (or unwillingness to rely) to third-party advisory/consulting services. Post-investment strategies for value creation will also be designed as to address the mentioned risks of fraudulent behavior, and to handle resistance for cooperation.

In this research it's been proven that given the development stage and nature of the SMEs in Bulgaria the most suitable instruments created by Funds management have to be as plain and simple as possible. Sophisticated financial products generally create mistrust on the local market. Thus each Fund must intend to use for its investment needs primarily direct participation in the companies via investing in common stock and in certain cases through a combination with investments in preferred stock of the company.

Structured Funds under JEREMIE most likely will aim at purchasing a significant portion of a particular company in order to be able to have a larger influence in its governing and to speed up its growth via the experience and know-how of its investment team. Typically Funds will seek to participate via a capital increase aiming at further strengthening the shareholder's equity, and support the continued growth through acquisitions as well as organic growth.

In order to protect its investment each Fund might seek also participation trough preferred stock as it has many advantages including a greater claim of the assets than common stock thus limiting the downside of the investment. Buying preferred stock could include the option of converting them into common stock at any point of time, in which case the owners will lose the right of a dividend, but will gain the ability to participate in the decision making process. Preferred stocks could be flexible in terms of the dividend rates that they hold, which could be adjusted along the way so that it does not interfere with the company's sustainable growth.

In limited number of cases each Fund have to aim at lending different types of hybrid loan products, suited to best fit the business needs of each company. A common type of debt product that Funds will be looking at will be the convertible debt, where the loan is secured via the right to convert it to common stocks at certain predetermined conditions. This will reduce both the risk to each Fund and the requirement to the company to provide collateral, which as have mentioned before

proves to be a major obstacle for the SMEs on their way to receiving a proper financing.

3.8. InterCriteria analysis applied to various EU enterprises.

The present research, published in [8*], aims to detect certain correlations between four economic indicators, against which have been evaluated the economic entities of the European Union with 27 Member States, as split into four categories: micro, small, medium and large enterprises. The mathematical formalism employed for revealing these dependencies, particularly termed here 'positive' and 'negative consonances', is a novel decision support approach, called InterCriteria Analysis, which is based on the theoretical foundations of the intuitionistic fuzzy sets and the augmented matrix calculus of index matrices. The proposed approach can be useful in processes of decision making and policy making, and it can be seamlessly integrated and further extended to other related application areas and problems, where it is reasonable to seek correlations between a variety of economic and other indicators.

In [8*] is make the consequent step in a series of research, aimed at proposing the application of the novel approach of InterCriteria Analysis (ICA) to economic data, aimed at the discovery of correlations between important economic indicators, based on available economic data. At this new step, it is take as input information about the economic enterprises in the EU27, the European Union with 27 Member States, as grouped in the four types of enterprises with respect to the scale: micro, small, medium and large enterprises, [110].

The indicators against which these four types of EU27 enterprises have been evaluated are four, namely: 'Number of enterprises', 'Number of persons employed', 'Turnover' and 'Value added at factor cost'. Potential discovery of correlations (in this approach termed as *positive consonances*) between economic indicators can bring new knowledge and improve decision making and policy making processes.

The ICA approach is specifically designed for datasets comprising evaluations, or measurements of multiple objects against multiple criteria. In the initial formulation of the method, the aim was to detect correlations between the criteria, in order to eliminate future evaluations/measurements against some of the criteria, which exhibit high enough correlations with others. This might be the desire, when some of the criteria are for some

reason deemed unfavourable, for instance come at a higher cost than other criteria, are harder, more expensive and/or more time consuming to measure or evaluate. Elimination or reduction of these unfavourable criteria from the future evaluations or measurements may be desirable from business point of view in order to reduce cost, time or complexity of the process.

Here dispose of and analyze the following input datasets from [110]:

- The number of enterprises in EU27, by country, divided to the four categories: Micro, Small, Medium and Large (Table 3.6)
- The number of persons employed in EU27, by country, divided to the four categories: Micro, Small, Medium and Large (Table 3.8)
- The Turnover (millions of €) in the EU27, by country, divided to the four categories: Micro, Small, Medium and Large (Table 3.10)
- Value added at factor cost (millions of €), by country, divided to the four categories: Micro, Small, Medium and Large (Table 3.11).

These four source datasets rearrange in a way to discover for each of the four indicators: 'Number of enterprises (NE)', 'Number of persons employed (PE)', 'Turnover (TO)' and 'Value added at factor cost (VA)' what are the correlations between them in the different scale, given by the type of enterprises: 'Micro', 'Small', 'Medium' and 'Large'.

During this processing, remove both the rows and the columns titled 'Total' and 'Pct', and remain to work only with the data countries by indicators, that are homogeneous in nature.

In these new 4 processed datasets (Tables 3.3 – 3.6), for each type of enterprise, have one index matrix with 27 rows being the countries in the EU27, and 4 columns for the four indicators.

The data from Tables 3.3 – 3.6 concerning the micro, small, medium and large enterprises, have been analysed using a software application for Inter-Criteria Analysis, developed by one of the authors, [77]. The application follows the algorithm for ICA and produces from the matrix of 27 rows of countries (objects per rows) and 4 indicators (criteria per columns), two new matrices, containing respectively the membership and the non-membership parts of the IF pairs that form the IF positive,

negative consonance and dissonance relations between each pair of criteria, In this case, the 4 criteria form 6 InterCriteria pairs.

Table 3.3. Data for the microenterprises in the EU27 countries, as evaluated against 4 criteria (in %)

EU Member	NE	PE	TA	VO
Austria	88	25	18	19
Belgium	92	30	21	19
Bulgaria	88	22	20	14
Cyprus	92	39	30	31
Czech Rep.	95	29	18	19
Denmark	87	19	23	28
Estonia	83	20	25	21
Finland	93	24	16	19
France	92	38	19	21
Germany	83	23	12	16
Greece	96	25	35	35
Hungary	94	58	21	18
Ireland	82	35	12	12
Italy	95	20	28	33
Latvia	83	47	23	19
Lithuania	88	23	13	12
Luxembourg	87	19	18	24
Malta	96	22	22	21
Netherlands	90	34	15	20
Poland	96	29	23	18
Portugal	95	39	26	24
Romania	88	42	16	14
Slovakia	76	21	13	13
Slovenia	93	25	20	20
Spain	92	28	23	27
Sweden	94	15	18	20
United Kingdom	87	22	14	18

Table 3.4. Data for the small enterprises in the EU27 countries, as evaluated against 4 criteria (in %)

EU Member	NE	PE	TA	VO
Austria	11	23	23	20
Belgium	7	22	20	20
Bulgaria	9	24	21	18
Cyprus	7	25	29	26
Czech Rep.	4	19	18	16
Denmark	11	22	22	21
Estonia	14	25	29	25
Finland	6	28	14	16
France	6	26	19	19
Germany	14	19	16	18
Greece	3	21	23	20
Hungary	5	17	18	16
Ireland	15	19	20	17
Italy	5	26	23	23
Latvia	14	22	28	27
Lithuania	9	25	24	23
Luxembourg	11	24	24	20
Malta	4	28	22	20
Netherlands	8	20	21	21
Poland	3	21	13	12
Portugal	5	12	23	22
Romania	9	23	21	16
Slovakia	19	20	16	15
Slovenia	6	21	19	19
Spain	7	18	24	24
Sweden	5	18	18	18
United Kingdom	10	18	16	16

Table 3.5. Data for the medium enterprises in the EU27 countries, as evaluated against 4 criteria (in %)

EU Member	NE	PE	TA	VO
Austria	2	19	22	21
Belgium	1	16	19	19
Bulgaria	2	24	22	21
Cyprus	1	20	24	21

Czech Rep.	1	20	24	20
Denmark	2	19	22	19
Estonia	3	21	28	30
Finland	1	26	18	18
France	1	15	17	16
Germany	2	18	20	19
Greece	0	16	19	17
Hungary	1	12	19	18
Ireland	3	16	25	23
Italy	1	23	20	16
Latvia	3	12	28	28
Lithuania	2	26	27	29
Luxembourg	2	23	17	19
Malta	1	26	26	23
Netherlands	1	20	26	21
Poland	1	17	23	22
Portugal	1	19	22	21
Romania	2	16	21	20
Slovakia	4	23	21	18
Slovenia	1	18	24	21
Spain	1	21	20	17
Sweden	1	23	19	18
United Kingdom	2	15	18	17

Table 3.6. Data for the large enterprises in the EU27 countries, as evaluated against 4 criteria (in %)

EU Member	NE	PE	TA	VO
Austria	0.3	33	37	40
Belgium	0.2	33	39	42
Bulgaria	0.3	30	37	46
Cyprus	0.2	17	17	21
Czech Rep.	0.2	32	41	45
Denmark	0.3	40	33	32
Estonia	0.4	34	18	24
Finland	0.3	22	52	46
France	0.2	22	44	45
Germany	0.5	41	52	47
Greece	0.1	38	23	28
Hungary	0.2	13	41	48

Ireland	0.5	29	43	48
Italy	0.1	32	29	28
Latvia	0.3	19	20	26
Lithuania	0.3	25	35	36
Luxembourg	0.4	33	42	37
Malta	0.1	24	30	36
Netherlands	0.3	26	38	38
Poland	0.2	33	41	48
Portugal	0.1	31	30	32
Romania	0.4	18	41	50
Slovakia	1.0	36	50	54
Slovenia	0.3	36	37	40
Spain	0.1	33	33	32
Sweden	0.2	44	44	44
United Kingdom	0.4	45	51	49

Because of the diverse nature of the types of enterprises (micro, small, medium or large enterprises), it is expected that these six InterCriteria pairs will be different depending on which kind of enterprises are taken into consideration. Thus, for the micro enterprises, for which are the data in Table 3.3, the two index matrices with InterCriteria pairs are respectively given in Table 3.7, for the small enterprises the two index matrices are given in Table 3.4 – in Table 3.8, for the medium enterprises, for which are the data in Table 3.5, the two index matrices are given in Table 3.9, and for the large enterprises for which are the data are in Table 3.6, the two index matrices are given in Table 3.10. Respectively, the InterCriteria correlation pairs for small, medium and large enterprises are given in Tables 3.7 – 3.10. It can immediately note the similar patterns in the conditional formatting of the eight tables in Tables 3.7 – 3.10, which are highlighted in a way to outline the highest possible positive consonances.

Table 3.7. InterCriteria pairs in micro enterprises

μ	NE	PE	TO	VA
NE	1.000	0.504	0.621	0.584
PE	0.504	1.000	0.496	0.413
TO	0.621	0.496	1.000	0.735
VA	0.584	0.413	0.735	1.000

ν	NE	PE	TO	VA
NE	0.000	0.396	0.256	0.285
PE	0.396	0.000	0.425	0.493
TO	0.256	0.425	0.000	0.160
VA	0.285	0.493	0.160	0.000

Table 3.8. InterCriteria pairs in small enterprises

μ	NE	PE	TO	VA
NE	1.000	0.436	0.533	0.484
PE	0.436	1.000	0.567	0.527
TO	0.533	0.567	1.000	0.803
VA	0.484	0.527	0.803	1.000

ν	NE	PE	TO	VA
NE	0.000	0.447	0.362	0.387
PE	0.447	0.000	0.319	0.342
TO	0.362	0.319	0.000	0.077
VA	0.387	0.342	0.077	0.000

Table 3.9. InterCriteria pairs in medium enterprises

□	NE	PE	TO	VA
NE	1.000	0.316	0.433	0.456
PE	0.316	1.000	0.516	0.467
TO	0.433	0.516	1.000	0.781
VA	0.456	0.467	0.781	1.000

□	NE	PE	TO	VA
NE	0.000	0.299	0.222	0.182
PE	0.299	0.000	0.376	0.385
TO	0.222	0.376	0.000	0.088
VA	0.182	0.385	0.088	0.000

Table 3.10. InterCriteria pairs in large enterprises

μ	NE	PE	TO	VA
NE	1.000	0.453	0.578	0.567
PE	0.453	1.000	0.527	0.481
TO	0.578	0.527	1.000	0.829
VA	0.567	0.481	0.829	1.000

ν	NE	PE	TO	VA
NE	0.000	0.328	0.242	0.248
PE	0.328	0.000	0.399	0.450
TO	0.242	0.399	0.000	0.120
VA	0.248	0.450	0.120	0.000

Here can note for the interested reader, that the intuitionistic fuzzy interpretation triangle, shown on Figure 3.10, is the IFS-specific graphical interpretation of IFSs, which is not available for graphical interpretation of the ordinary fuzzy sets, defined by Zadeh. The triangle is part of the Euclidean plane, with vertices the points (0, 0), (1, 0) and (0, 1), staying respectively for the complete uncertainty, complete truth and complete falsity as the boundary values with which elements of an IFS can be evaluated. The hypotenuse corresponds to the graphical interpretation of the [0, 1] interval, and points belonging to it are elements of a classical fuzzy set.

In this interpretation, can plot the 24 resultant points onto a single IF triangle: 6 InterCriteria correlation points for the 4 types of enterprises. Since are interested in the highest InterCriteria correlations, in these terms, it means finding the points, which are closest to the complete truth in point (1, 0), which is equivalent to having their

membership parts greater than a given threshold value α, and, simultaneously, their non-membership parts less than a second threshold value β. For each of the points, i.e. for each of the correlations between two different criteria C_i and C_j, $i \neq j$, and can calculate its distance from the (1, 0) point, according to the simple formula:

$$d_{C_i,C_j} = \sqrt{(1-\mu_{C_iC_j})^2 + \nu_{C_iC_j}{}^2}$$

The results are given in Table 3.11, and presented sorted in ascending order according to the distance.

Table 3.11. Ranking the InterCriteria pairs by distance to Truth (1, 0)

Enterprise type	C_i	C_j	μ_{CiCj}	ν_{CiCj}	d_{CiCj}
Large	TO	VA	0.829	0.120	0.209
Small	TO	VA	0.803	0.077	0.212
Medium	TO	VA	0.781	0.088	0.236
Micro	TO	VA	0.735	0.160	0.310
Micro	NE	TO	0.621	0.256	0.457
Large	NE	TO	0.578	0.242	0.486
Large	NE	VA	0.567	0.248	0.499
Micro	NE	VA	0.584	0.285	0.504
Small	PE	TO	0.567	0.319	0.538
Medium	NE	VA	0.456	0.182	0.574
Small	PE	VA	0.527	0.342	0.584
Small	NE	TO	0.533	0.362	0.591
Medium	NE	TO	0.433	0.222	0.609
Medium	PE	TO	0.516	0.376	0.613
Large	PE	TO	0.527	0.399	0.619
Micro	NE	PE	0.504	0.396	0.635
Large	NE	PE	0.453	0.328	0.638
Small	NE	VA	0.484	0.387	0.645
Medium	PE	VA	0.467	0.385	0.658
Micro	PE	TO	0.496	0.425	0.659
Large	PE	VA	0.481	0.450	0.687
Small	NE	PE	0.436	0.447	0.720
Medium	NE	PE	0.316	0.299	0.746
Micro	PE	VA	0.413	0.493	0.767

Then, make two rounds of discussions. On one hand, on Figure 3.10, can seek and formulate some assumptions about the InterCriteria correlations with respect to the type of enterprise.

Here can notice from here that micro and small enterprises exhibit very similar patterns of InterCriteria consonance, with all the InterCriteria pairs exhibiting relatively low levels of uncertainty, and only the pair TO/VA exhibiting relatively high positive consonances. The same pair ranges highest among the InterCriteria correlations with the other two types of enterprises, medium and large. The large type of enterprises also exhibits relatively low uncertainty in the InterCriteria correlations, being lowest with TO/VA, PE/TO and PE/VA, and highest uncertainty featured in the rest three of the pairs. Expectedly, the most scattered is the pattern with the medium type of enterprises, where also the largest uncertainty is observed, all in the pairs containing the number of enterprises: NE/PE, NE/TO and NE/VA.

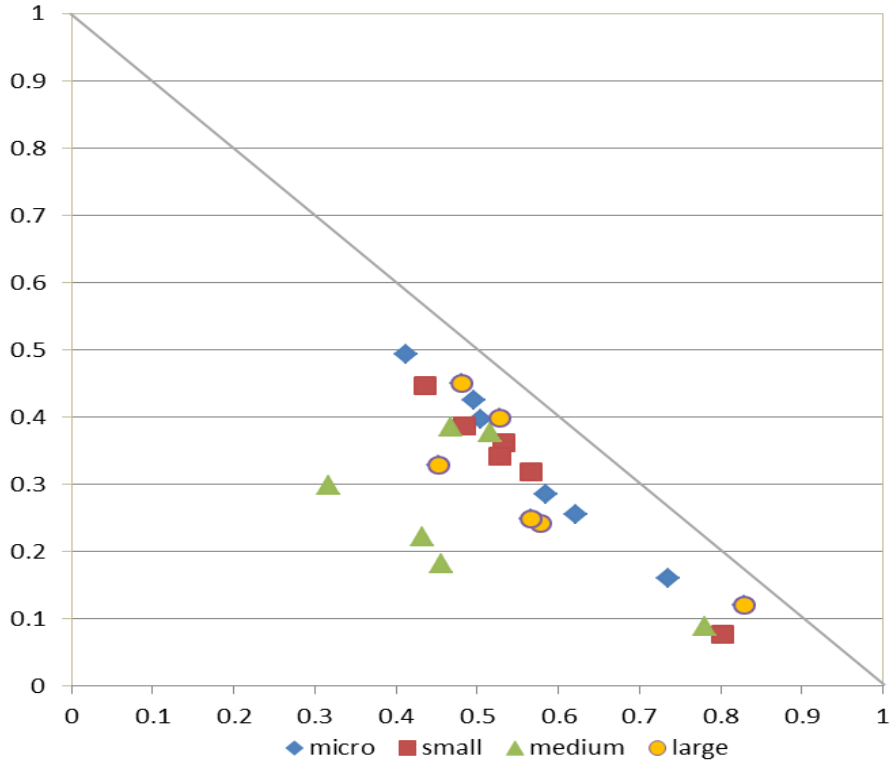

Figure 3.10. ICA results with respect to the type of enterprise

On the other hand, it is considered appropriate to analyse these 24 points as 6 groups of 4 points, grouped according to the criteria in the pair (Figure 3.11). Here can

then make some assumptions about the nature of these correlations, judging from how concentrated or how scattered the four points in each group are: the more concentrated the points for a given InterCriteria pair, the more consistent behavior of this pair across the different scales of economic entities.

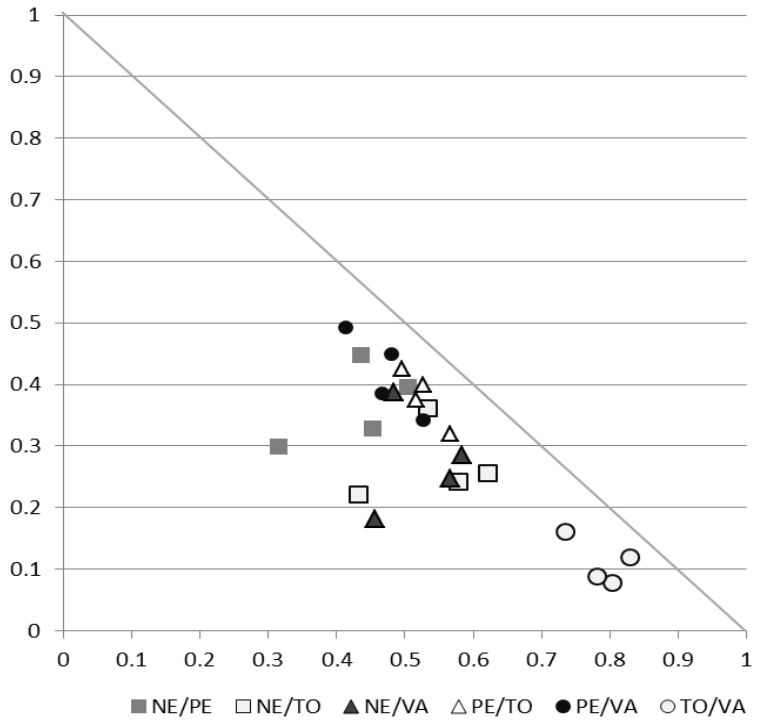

Figure 3.11. ICA results with respect to correlations between economic indicators

Here will immediately note what was visible from the Table 3.11, that that the pair of criteria TO/VA are distinctly best correlating across the different scales of economic entities, concentrated in the closest proximity to the absolute truth represented by the (1, 0) point. It is interesting however to note other, less clearly seen relations. For instance, here can note that quite similar patterns are formed for the two four-point sets corresponding to the pairs of criteria PE/VA and PE/TO: relatively parallel and closely located to the hypothenuse. In both these pairs, the distances from the (1, 0) point, according to the type of enterprise, follow in decreasing order the sequence: 'small' – 'medium' – 'large' – 'micro', with medium and large enterprises exhibiting very close results. Quite similar and closely located to each other are also the patterns for the pairs of criteria NE/TO and NE/VA.

These three observations over these particular economic data lead us to the speculation that from theoretical point of view it would be interesting to pay attention to situations when have two criteria C_i, C_j that exhibit high positive consonance with each other, and each of them exhibit similar or identical consonance patterns in the pairs C_i–C_k and C_j–C_k, or vice versa, if C_i–C_k and C_j–C_k are two pairs of criteria with high positive consonances, would there be high positive consonance in the pair C_i–C_j. This question would be worth exploring in the light of the possibility to detect, using ICA not just pairs of correlating criteria, but also triplets, etc.

The present research analysed data about the micro, small, medium and large economic entities in the EU27, as evaluated against four economic indicators (criteria). The utilized method for analysis of the datasets was the novel decision support approach, called InterCriteria Analysis. The results are two-fold: they outline correlations between economic indicators on these four levels of economic enterprise, new thus potentially brining new knowledge and understanding, and also contribute to elaboration of certain aspects of the methodology of ICA.

3.9. InterCriteria analysis of the creditworthiness of SMEs.

The latest programming period of the EU, is expected to introduce reforms in the mechanism of EU Budget funding. The subsequent consequences of those reforms will reflect to the overall European economy, as well as Bulgaria's. The general idea of economy's recovery has to go mainly through asset and know-how modernization of long-term value creating industries. Expected results of the reforms, though with some uncertainty to the direct influence on SME funding, should result into timely implementation of available financial resources to beneficiaries as first.

The creation of additional and more advanced financial instruments, along with increase of % ratio in advance payments to some programs is estimated to provide a lot more stability and reduce the risk of project realization failure. The lack of internal SME available cash positions could be compensated by those program updates. At the same time, those processes should be synchronized with the necessary updates in most financial institutions methodology of creditworthiness and credit risk assessment analysis and procedures.

The approach of the methodology is to bring up and screen the most important elements in each SME present status. The unification of the approach will provide a positive outcome to the process of analyzation and assessment of credit risk, and creditworthiness of local SME's. The main scope of the unification is to make the assessment more thorough, that way the risk undertaken by financial institution can be minimized. In the paper [9*] is provided a scoring scheme model, which will analyze majority of important objective and subjective characteristics of SME companies, all applying for financial support under a randomly picked program or instrument suited for small and medium-sized enterprises.

For this purpose, paper [9*] further employ the InterCriteria analysis, as an approach for detection and identification of dependencies between these objective and subjective characteristics of SMEs.

Most of small and medium-sized enterprises (SMEs) in Bulgaria are going through complicated times, in terms of maintaining the expected business life cycle, and in some cases are not able to reach it's maturity on time. By doing so the expected potential in the business scope is not reached at all. Plenty of reasons are known for the missed opportunities, but most common once are lack of good management and external financing barrier. By introducing a general scoring system, intended for implementation in Financial institutions „tool boxes", utilized as main source of present financial acknowledgement of SME's, the process of eliminating most of negative factors will be gapped down. Once the financing window is regulated and open for promising SME projects, the internal work of developing paths, seeking for expansion can naturally continue in its direction. At present times, researches show that most of the working SME's are managed by outdated internal structures and solely expecting results to be product of personal input (one man show type) of skills and knowledge. They believe is that the implementation of modern business processes, where the input is expected from more than one manager or high ranked officer, will change for the most part decision making structure of top management, and at the same time would significantly affect the way profitability is chased.

In addition to decision making processes, changes should follow in the strategies concerning marketing innovations, and business driving alternatives. At the

end, regardless of all in-company alterations made, in order to reach desired levels of success and earnings, most SME's are left highly dependable on external funding.

The discussed problematics has not been so far approached with the newly proposed method of InterCriteria analysis, which strength is in detecting possible dependencies between different, heterogeneous, criteria, based on analysis of a large number of objects, evaluated against these. Here are interested to see if the analysis of SME, using InterCriteria analysis, will yield new dependencies, or confirm some existing ones.

The most recent statistics of the Eurostat on SMEs (2012) report that the EU of 28 states (EU28) has more than 22.3 SMEs which are a staggering 99.8% of all companies. Taken together, SMEs generate 67.1% of all jobs and make a 57.5% contribution towards the creation of wealth. Micro and Small businesses make up typically 80 -90% of a country's SME sector. In most countries the majority of small businesses do not have to file any type of audited accounts with a government body save for tax returns. Income (Turnover) data is often understated in these filings, therefore makes it difficult to utilize the data for potential landing services. Typically, two-thirds of a small business portfolio is non-limited (e.g. sole traders/entrepreneurs) with no requirement to register business details. All of the above mentioned facts are a barrier when it comes down the external funding needs.

Most common, but as previous times mentioned underutilized options of fund raisings, are government financial programs. Less than 5% of the companies had access to that type, due to budget limitation and overwhelming requirements. Non-government organizations landing programs had an input of less than 3% on the overall SME segment. Financing via EU structured funds has significant portion (over 46%) of the whole picture, and considerable number of SMEs are striving and making efforts to the new programing period. Again, access to available programs is a subject of meeting a certain number of criteria's and requirements, which becomes a major obstacle to certain percentage of SME's.

Those type of grants are preferable way of financing projects, and gives chance of some start up and all others, to make „the first turn on their business cycle" with a lower level of risk and debt free. Unfortunately, the dependency on EU funding brings

an artificial level of comfort, considering that funds are provided as grants to the particular sector of the economy, and are not subject of return if all requirements met. Main obstacle is the programing period of the EU instruments, because once budgets are depleted or timely expired, than internal cash-flow becomes solely dependent on regularity in revenue and proper management.

Considering the unstable economic environment and intercompany debt levels, along with unsatisfactory turnover and profit results, most SME's are unable to rely on own resources. This is valid to such an extent, that financing through own cash flow revenues, has decreased considerably in comparison to some time ago. Reliable and timely financial account information is not automatically available for the majority of small businesses and is a burden to owners, when cash management is applied. In spite of all difficulties that SME's are facing with regards to proper financial documentation and other legal issues that are faced with, the most preferred source of raising external capital remains the bank loan.

In this research, a glance of the most important steps of the evaluation process is provided, along with an updated version of creditworthiness evaluation model.

The traditional approach to SME lending to a certain extend has been modified into an automated decision process, where manual underwriting has been replaced with an automated one. Main reasons for the implemented changes are the improvement of quality and decision making terms.

The key elements to consider are financials, SME capital, and collateral. Those are the so called objective characteristics that carry the most weight in the overall scoring model. Regardless of the fact traditional balance sheet, management and economic data are not always available and performed for small business, those characteristics are considered the foundation of the decision making processes. The subjective characteristics are used predominantly for the qualitative analysis of each case.

The decision making methodology or process cannot always be optimal for all credit scenarios, as some would favors a predominantly manual process, others an automated one as discussed in the present article.

The evaluation process of loan applications begins at first level - Branch facility of a financial Institution. Loan projects are initially assessed by at branch level, by manager and supporting team of loan specialist and bank's representatives. Main focus is the gathering of all necessary information, labeled as objective characteristics.

Table 3.12. Characteristics used in the model

1. FINANCIAL DATA	**2. COMPANY and OWNERS/MANAGERS DATA**	**3. MACRO-ECONOMICS DATA**	**4. COLLATERAL AND LTV DATA**
1.1. Net revenue. 1.2. EBITDA. 1.3. Capital stock. 1.4. Receivables. 1.5. Liabilities. 1.6. Assets.	2.1. Relationship with financial institutions, credit history statements. 2.2. Managerial skills and experience. 2.3. Legal status and ownership.	3.1. Characteristics and perspectives of the business, prognoses in development. 3.2. Market shares of the SME's business. 3.3. External market environment.	4.1. Analysis of the collateral, along with economic justification. 4.2. Loan type analysis. 4.3. Payment plan analysis.

Preliminary research and opinion is based on information provided, so as sent to the headquarters can be filtered and loaded into the automated scoring model. Characteristics used in the model are collaboration of the following details and data (Table 3.12):

1.1. Net revenue – provides us with information about the turnover of sales, in the form of final product or service, made by the SME for a period of time. Financial year to year comparison, can be used as main tool for analysis;

1.2. EBITDA (*Earnings, Before, Interest, Taxes, Depreciation and Amortization*) – this characteristic is the most important and valuable indicator, which provides us with information about overall SME's performance. It analyzes the profitability of the company, as it eliminates the effects of external financing and accounting decision;

1.3. Capital stock – is a characteristic which is a collaboration of, actual in company capital (cash), General reserves, Retained earnings from previous year, and losses for previous years. This indicator is a reflection of the actual financial discipline of the SME;

1.4. Receivables – gives us information on SME's rhythm of sales performed, and at same time its timely collection. This characteristic as a subject of detailed analysis and breakdown of the maturity of origination. In some cases, provision of bad receivables can be applied, and figures reduced;

1.5. Liabilities – is a characteristic which is a collaboration of, financial obligations, goods or services provided be trade partners, taxes payable, and other liabilities. As with receivables, main indicator for this characteristic is origination of obligation and ability of the SME to cover payments.

1.6. Assets – it indicates what type of long and short term assets are recorded and accounted for in the balance sheet of the Company. Fixed assets such as Land, Buildings, Technical Plant and Machinery, are so called long term assets. In short term assets, fall available goods on stock, petty cash on hand, funds available in accounts and trade receivables, which for the purpose of the article is screened as separate characteristic.

Those characteristics are considered the driving force of all objective characteristics, with main weighted input in the scoring model.

2.1. Relationship with fin. Institutions, credit history statements – this characteristic values correctness and loyalty of the customer (SME) to the Bank. Important factors are the number of utilized banking products and services, readiness to provide required information by the financial institution;

2.2. Managerial skills and experience – past experience, age, skills and organizational structure, reputation and efficiency in decision making processes are most valuable factors in this characteristic;

2.3. Legal status and ownership – it covers the period of establishment of the Company, reached results, overcoming of crisis periods, frequent changes of main scope of activity. Owners and breakdown of ownership of the SME has its input in final decision makings;

3.1. Perspectives of the business, prognoses in development – this characteristic analyses the activity of the company, and the options for realization of different projects at deck. Main business and ideas of either producing certain products, or providing services are the directions of the analysis;

3.2. Market shares of the SME's business – provides the score with information about geographical place of operation or good final destination. Competition, analysis of sales made, channels of realization of goods and services;

3.3. External market environment – it analyzes the overall macroeconomic environment in the economy, or the sector which the SME is operating.

The analyzed data from the second and third characteristics provides a less weighted input in the scoring model, due to the reason that results are collaboration of subjective factors.

4.1 Analysis of the collateral, along with economic justification – main focus is the type of collateral provided, value and liquidity. The provision of a realistic business plan, where expected results and tasks are reachable with regards to the influence of the external market and the environment of the economy are key;

4.2. Loan type analysis – the main task of the characteristic is to differentiate the risks of the type of loan, provided/requested by the SME. Main scope is to bring the actual cash flow of the Company to a rhythm, which will give ability of the company to maintain a normal business cycle.

4.3. The analysis of the payment plan as a characteristic is part of the above analyzed indicator.

The last 4 characteristics, utilized in the scoring model, are with secondary importance as part of the objective characteristics, and maintain a stronghold weight in the model.

Here will use an anonymized dataset of 10 companies, evaluated against 15 criteria (Table 3.13). The companies are all SMEs, but from different sectors and backgrounds.

Here will remind the reader that in this set of criteria, the first six are objectively measured, hence the huge differences between their values, while the next nine are subjectively evaluated within the {2, 3,…, 6} range. From the point of view of the

InterCriteria analysis method, the smaller number of possible values, which the evaluation against a given criterion yields, leads to higher degrees of uncertainty, since more objects are evaluated with the same value, thus reducing the discriminative power of the criterion. Also, the bigger number of objects helps raising the precision of the algorithm, so that another run of the algorithm over 100 objects will definitely yield improved results, compared to the dataset of 10 objects.

Table 3.13. A set of companies, evaluated against a set of criteria

	C 01	**C 02**	**C 03**	**C 04**	**C 05**	**C 06**	**C 07**	**C 08**	**C 09**	**C 10**
(1) Net Revenue	286	108	220	201	165	120	210	482	130	195
(2) EBITDA	113	74	140	10	19	20	90	241	6	46
(3) Capital stock	157	130	170	15	34	39	101	202	11	71
(4) Receivables	17	9	0	0	1	17	33	214	40	45
(5) Liabilities	16	5	20	15	16	12	21	107	33	30
(6) Assets	11	0	0	20	2	13	0	26	0	123
(7) Relationship with financial institutions, credit history statements	6	5	3	6	6	4	3	4	3	6
(8) Managerial skills and experience	4	4	4	5	6	4	4	5	4	6
(9) Legal status and ownership	3	4	4	5	5	5	4	4	3	6
(10) Characteristics and perspectives of the business, prognoses in development	5	5	4	4	4	3	3	6	2	5
(11) Market shares of the SME's business	4	5	4	4	5	2	2	5	3	5
(12) External market environment	5	5	4	4	4	2	2	5	3	4
(13) Analysis of the collateral, along with economic justification	6	6	6	6	6	4	3	4	6	6
(14) Loan type analysis	6	6	6	6	5	4	3	4	6	6
(15) Payment plan analysis	6	5	4	6	6	4	3	5	6	6

Table 3.14. The membership parts of the IFS InterCriteria pair

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1)	1.00	0.76	0.73	0.53	0.67	0.53	0.38	0.33	0.29	0.58	0.42	0.53	0.20	0.29	0.36
(2)	0.76	1.00	0.98	0.56	0.56	0.44	0.31	0.27	0.29	0.64	0.47	0.56	0.16	0.24	0.20
(3)	0.73	0.98	1.00	0.53	0.53	0.44	0.33	0.27	0.29	0.67	0.49	0.58	0.18	0.27	0.22
(4)	0.53	0.56	0.53	1.00	0.73	0.51	0.29	0.36	0.31	0.49	0.42	0.42	0.13	0.22	0.33
(5)	0.67	0.56	0.53	0.73	1.00	0.44	0.31	0.38	0.31	0.42	0.40	0.36	0.22	0.27	0.40
(6)	0.53	0.44	0.44	0.51	0.44	1.00	0.62	0.67	0.62	0.53	0.44	0.40	0.27	0.33	0.42
(7)	0.38	0.31	0.33	0.29	0.31	0.62	1.00	0.53	0.51	0.53	0.51	0.51	0.56	0.49	0.71
(8)	0.33	0.27	0.27	0.36	0.38	0.67	0.53	1.00	0.56	0.42	0.51	0.36	0.36	0.33	0.44
(9)	0.29	0.29	0.29	0.31	0.31	0.62	0.51	0.56	1.00	0.38	0.40	0.27	0.24	0.24	0.38
(10)	0.58	0.64	0.67	0.49	0.42	0.53	0.53	0.42	0.38	1.00	0.69	0.80	0.42	0.44	0.42
(11)	0.42	0.47	0.49	0.42	0.40	0.44	0.51	0.51	0.40	0.69	1.00	0.69	0.47	0.42	0.49
(12)	0.53	0.56	0.58	0.42	0.36	0.40	0.51	0.36	0.27	0.80	0.69	1.00	0.49	0.47	0.49
(13)	0.20	0.16	0.18	0.13	0.22	0.27	0.56	0.36	0.24	0.42	0.47	0.49	1.00	0.87	0.67
(14)	0.29	0.24	0.27	0.22	0.27	0.33	0.49	0.33	0.24	0.44	0.42	0.47	0.87	1.00	0.58
(15)	0.36	0.20	0.22	0.33	0.40	0.42	0.71	0.44	0.38	0.42	0.49	0.49	0.67	0.58	1.00

Table 3.15. The non-membership parts of the IFS InterCriteria pairs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1)	0.00	0.24	0.27	0.42	0.31	0.33	0.40	0.29	0.49	0.27	0.36	0.24	0.31	0.36	0.38
(2)	0.24	0.00	0.02	0.40	0.42	0.42	0.47	0.36	0.49	0.20	0.31	0.22	0.36	0.40	0.53
(3)	0.27	0.02	0.00	0.42	0.44	0.42	0.44	0.36	0.49	0.18	0.29	0.20	0.33	0.38	0.51
(4)	0.42	0.40	0.42	0.00	0.20	0.31	0.44	0.27	0.42	0.36	0.36	0.36	0.38	0.42	0.36
(5)	0.31	0.42	0.44	0.20	0.00	0.40	0.49	0.22	0.44	0.40	0.36	0.40	0.31	0.36	0.36
(6)	0.33	0.42	0.42	0.31	0.40	0.00	0.16	0.09	0.16	0.18	0.20	0.24	0.24	0.31	0.18
(7)	0.40	0.47	0.44	0.44	0.49	0.16	0.00	0.04	0.13	0.18	0.13	0.18	0.09	0.16	0.07
(8)	0.29	0.36	0.36	0.27	0.22	0.09	0.04	0.00	0.02	0.13	0.02	0.18	0.09	0.20	0.04
(9)	0.49	0.49	0.49	0.42	0.44	0.16	0.13	0.02	0.00	0.29	0.20	0.38	0.18	0.27	0.27
(10)	0.27	0.20	0.18	0.36	0.40	0.18	0.18	0.13	0.29	0.00	0.07	0.04	0.20	0.22	0.24
(11)	0.36	0.31	0.29	0.36	0.36	0.20	0.13	0.02	0.20	0.07	0.00	0.04	0.09	0.18	0.16
(12)	0.24	0.22	0.20	0.36	0.40	0.24	0.18	0.18	0.38	0.04	0.04	0.00	0.11	0.13	0.20
(13)	0.31	0.36	0.33	0.38	0.31	0.24	0.09	0.09	0.18	0.20	0.09	0.11	0.00	0.00	0.02
(14)	0.36	0.40	0.38	0.42	0.36	0.31	0.16	0.20	0.27	0.22	0.18	0.13	0.00	0.00	0.07
(15)	0.38	0.53	0.51	0.36	0.36	0.18	0.07	0.04	0.27	0.24	0.16	0.20	0.02	0.07	0.00

Here input the above dataset into the InterCriteria analysis software, developed by Mavrov, [77], and as a result obtain two tables (Tables 3.14 and 3.15) staying for the resultant table of intuitionistic fuzzy pairs, giving the positive consonance, negative consonance or dissonance, relating each pair of evaluation criteria. Here are interested in the pairs of highest positive consonance, defined as definite correlation between a pair of criteria, while negative consonance represents definite lack of correlation, and dissonance – uncertainty. Obviously, along the main diagonal all consonance values are ⟨1.00, 0.00⟩, i.e. in Table 3.14 are 1.00 and in Table 3.15 are 0.00, since each criterion correlates with itself perfectly.

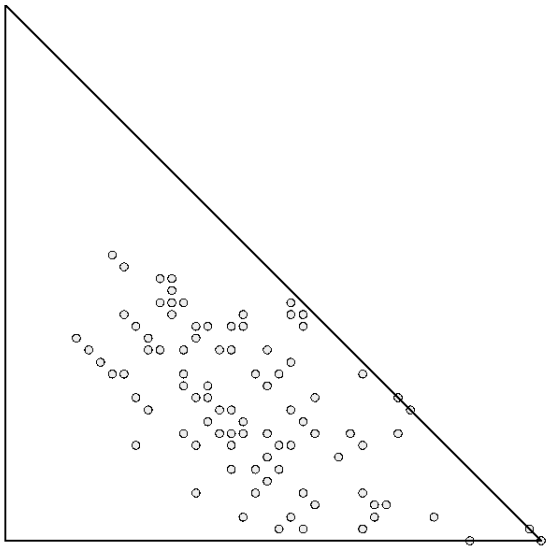

Figure 3.12. Graphics of the points, staying for the intuitionistic fuzzy pairs of InterCriteria consonances

In addition, following the recent researches in the theory of InterCriteria analysis, the obtained results can be plotted onto the intuitionistic fuzzy interpretational triangle, shown on Figure 3.12. The interpretational triangle visualizes the results of the InterCriteria analysis, as an IFS constructed of the points, representing all possible pairs between criteria, where for each point its coordinates are respectively the membership and the non-membership elements of the IF pair. Then, the points, which are closest to the (1,0) point of the triangle are those featuring the highest positive consonance (in this case, the desired ones), while those closest to the (0,1) point exhibit the highest negative consonance, and those closest to the (0,0)

points – the highest uncertainty, i.e., dissonance. In the present application, the highest positive consonance is demonstrated between the following criteria: 'EBITDA'/'Capital stock': ⟨0.98; 0.02⟩, 'External market environment'/'Characteristics and perspectives of the business, prognoses in development': ⟨0.80; 0.04⟩, and 'Analysis of the collateral, along with economic justification'/'Loan type analysis': ⟨0.87; 0.00⟩.

As seen in the graphic above, noticeable are colorations formed mainly by the characteristics, which are considered in this article as objective once. Dependencies are strongly shown among the 'Revenue', 'EBITDA', and 'Capital stock' criteria, due to the fact that in any financial statement consistency between the above is expected. Nevertheless if an SME is working with a low ore close to 0 % of margin, it is expected to automatically reflect in those three criteria, even with a negative value. One exception is observed with the relatively high membership value of 0.71 of in the InterCriteria pair between the 'Banks' and 'Payment plan analysis'. As previously mentioned in the research, the actual conclusion made on the basis of the conducted research is the following. A randomly picked SME, which has been customer of a financial institution for some time and is known be experts from inside even though has not used financial product up until, have a greater chance of identifying and suiting a payment plan, which will not burden the business cycle, when a loan is provided. Even though both indicators are considered objective, the connection between is a subject of variations, such as the example given above.

Certain levels of positive consonance in the research are observed in the InterCriteria formed between two subjective criteria: 'Perspectives of the business, prognoses in development' and 'External market environment'. The higher degree of consonance is a result of the possibility for flexible conduct of certain SME, which will adopt its business rhythm to a newer/different economy environment.

In general, the relatively high uncertainty featured in the results of the application of the InterCriteria analysis method means that no distinctively strong correlations appear between them, which can be interpreted in the sense that each of the criteria has its own specifics and has been adequately selected for the purpose of

the decision making process. On the other hand, increasing the pool of analyzed companies is anticipated to further improve the results from the analysis.

Finally, the lack of positive consonance between the subjective criteria (seen from Tables 3.14 and 3.15) is also result of the limited evaluation frame, excepted at present time. Additionally increasing the evaluation range, e.g. by refining the decimal division will provide finer discrimination among the objects, as evaluated against the criteria, and can be formulated as one of the recommendations for the future.

CONCLUSION

The dissertation is dedicated to the application of innovative, intelligent techniques for analyzing the processes of financing small and medium-sized businesses. The latest developments in the design of highly efficient data processing algorithms are applied. The intelligent techniques used require the processing of large data streams, relying on all available information about the processes being monitored.

In the dissertation, mathematical modeling tools were used for the purposes of the analysis, being selected as the most appropriate apparatus of Generalized Networks (OM). Another approach used in the dissertation work is intercriteria analysis, which is based on two mathematical formalisms: the algebraic indexed matrix (IM) apparatus, when it is necessary to apply algebraic operations on matrices of different sizes and intuitionistic fuzzy sets (IRM), as a mathematical tool for treating uncertainty.

The methodology of applied research in the dissertation, involves the use of a numerical and experimental approach. The numerical approach was used in the implementation of the algorithms by computer-based calculation of intelligent methods for analyzing the processes of financing small and medium-sized businesses.

The experimental approach is used to collect data from observations of indicators characterizing the financing processes of small and medium-sized businesses.

The list of publications used in the dissertation are included nine articles, of which two book chapters in the series:

- In: Modern Developments in Fuzzy Sets, Intuitionistic Fuzzy Sets, Generalized Nets and Related Topics, with editors K. Atanassov, M. Baczynski, J. Drewniak, J. Kacprzyk, M. Krawczak, E. Szmidt, M. Wygralak, S. Zadrozny (Eds.), two articles in magazine Notes on Intuitionistic Fuzzy Sets, and five articles in International conferences works.

SUMMARY OF OBTAINED RESULTS

As a result of the research presented in this dissertation, the following scientific, applied and applied results have been achieved:

1. The existing instrument for financing small and medium-sized businesses has been systematized through the JEREMIE initiative.

2. The results of the analysis of the processes of financing small and medium-sized businesses were obtained by applying intelligent techniques for analysis of the mechanism according to which the first level of a bank institution for financing small and medium-sized businesses operates.

3. The results of the analysis of the processes of financing small and medium-sized businesses were obtained by applying intelligent techniques for analyzing the effectiveness of the internal financial structural units of different banks, such as the levels of the hierarchy for decision-making.

4. The results of the analysis of the processes of financing small and medium-sized businesses were obtained by applying intelligent techniques for the analysis of different types of hybrid credit products.

5. The results of the analysis of SME financing processes were obtained by applying intelligent data analysis techniques for micro, small, medium and large economic entities in the EU-27, estimated by different economic indicators.

6. The results of the analysis of the SME financing processes were obtained by applying intelligent techniques for analyzing the financing mechanism of the EU budget for small and medium-sized enterprises.

GUIDELINES FOR FUTURE RESEARCH

The results obtained in the dissertation are applicable to solving a broader range of tasks related to the analysis of SME financing processes. This could be a guide for future research that will enrich the research area.

PUBLICATIONS ON THE TOPIC OF THE THESIS

1*. Shahpazov G., L. Doukovska - Structuring of Growth Funds with the Purpose of SME's Evolution under the JEREMIE Initiative, Proc. of the Second International Symposium on Business Modeling and Software Design – BMSD'12, 4-6 July 2012, Geneva, Switzerland, ISBN 978-989-8565-26-6, DOI 10.5220/0004462301590164, pp. 159-164, 2012.

2*. Shahpazov G., L. Doukovska, K. Atanassov - Generalized Net Model of the Methodology for Analysis of the Creditworthiness and Evaluation of Credit Risk in SMEs Financing, Proc. of the International Symposium on Business Modeling and Software Design – BMSD'13, Noordwijkerhout, The Netherlands, ISBN 978-989-8565-56-3, DOI 10.5220/0004776702920297, pp. 292-297, 2013.

3*. Shahpazov G., L. Doukovska - Generalized net model of internal financial structural unit's functionality with intuitionistic fuzzy estimations, Proc. of the 17th International Conference on Intuitionistic Fuzzy Sets, Notes on Intuitionistic Fuzzy Sets (NIFS), vol. 19, №3, ISSN 1310-4926, e-ISSN 2367-8283, pp. 111-117, Sofia, 2013.

4*. Shahpazov G., L. Doukovska, V. Atanassova - Uncertainty Modeling in the Process of SMEs Financial Mechanism Using Intuitionistic Fuzzy Estimations, Proc. of the International Symposium on Business Modeling and Software Design – BMSD'14, 24-26 June 2014, Luxembourg, Grand Duchy of Luxembourg, ISBN 978-989-758-032-1, DOI 10.5220/0005427002710275, pp. 271-275, 2014.

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DECLARATION OF ORIGINALITY

Hereby, I declare that I have composed the presented thesis independently on my own and without any other resources than the ones indicated.

All thoughts taken directly or indirectly from external sources are properly denoted as such.

This work has neither been previously submitted to another authority nor has it been published yet.

Sofia, 19.09.2019 Signature:

(G. Shahpazov)

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