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Generalized net model of internal financial structural unit's functionality with intuitionistic fuzzy estimations

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Abstract: In the present paper, an application of the apparatus of generalized nets is proposed for modeling of the mechanism of financial support of small and medium-sized enterprises. In the model, the aspects of internal financial structural unit's functionalities are reflected, and it is offered how the concept of intuitionistic fuzziness can be applied to the process of evaluating creditworthiness of the SMEs' applications for bank loans, from the bank's perspective.
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1 Introduction

During the period of 2000 through 2008 Bulgaria faced its first real economic blow for the last 25 years. The EU accession plan, the currency board and western oriented governments combined with booming banking industry and cheap credit resources created an investor friendly business environment that attracted in total more than EUR 25 billion of FDI and assured steady growth of the economy with rates double than the EU average. Unfortunately more than 70% of these investments went into non-productive, highly speculative and cyclical businesses or were triggered by arbitrage opportunities in privatization deals. Looking back in a period of 25 years Bulgaria 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. As the economic crisis became a reality for the Bulgarian economy in the period after 2008, some sectors felt the worst of it. Prime example for the bubble burst is the construction sector, where the actual slowdown surpassed the prognosis of the most pessimistic analyzers. Majority of SME' involved in the particular business, either bankrupted or experienced M&A procedures. The manufacturing and service sectors where also influenced by the crisis, as the decline and the economic slowdown reached the zero level back in 2011.

The financial system took adequate measures against the crisis, with the price of re-negotiations, drastic decline in financing and carefully screening potential borrowers.

Considering the harder economic conditions, to which SME's are exposed, the attitude to external financing changed. The research of the sector shows 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 (per data of Bulgarian Industrial Association).

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%).

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.

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 embedded financing and grant schemes, [4].

Regardless of the above mentioned statistics there has not 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 paperwork, associated with loan granting/ project financing.
- Requirements for minimum equity and minimum turnover.

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.

Generalized Nets (GN) [1, 2] are extensions of Petri nets and other modifications of them. They are tools intended for the detailed modelling of parallel processes. A GN is a collection of *transitions* and *places* ordered according to some rules. The places are marked by circles. The set of places to the left of the vertical line (the transition) are called *input places*, and those to the right are called *output places*. For each transition, there is an index matrix with elements called *predicates*. Some GN-places contain *tokens* – dynamic elements entering the net with initial characteristics and getting new ones while moving within the net. Tokens proceed from an input to an output place of the transition if the predicate corresponding to this pair of places in the index matrix is evaluated as *"true"*. Every token has its own identifier and collects its own history that could influence the development of the whole process modelled by the GNs.

Detailed analysis of the above described process is published in [7], and based on [6]. Fig. 1 below is taken from [7], and elaborated further.

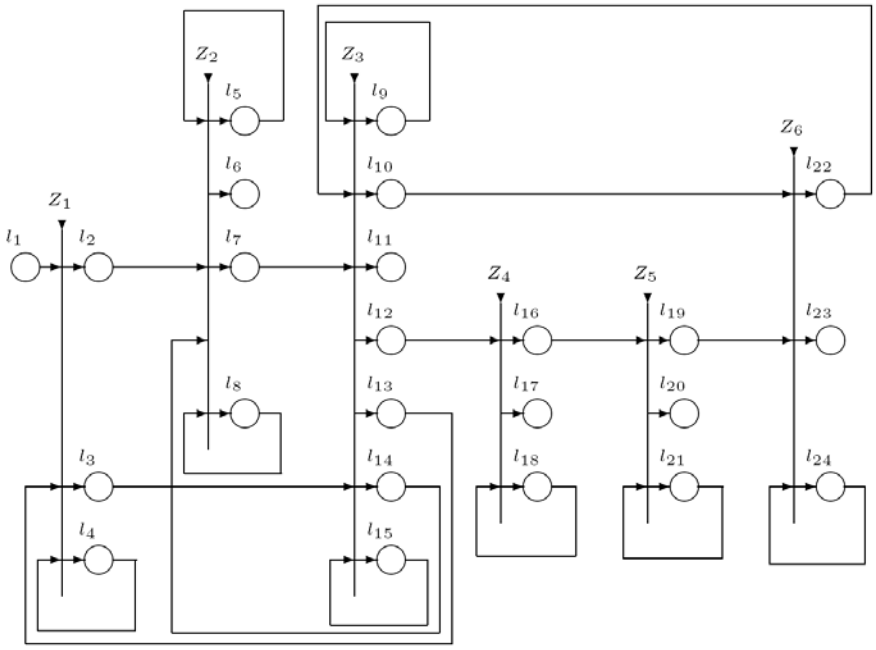

Figure 1. Generalized net model, [7]

2 Generalized net model

The GN model, discussed here, is shown in Fig. 2 and contains five transitions, that represent sub-transitions of the transitions Z_2, …, Z_6 from Fig. 1, 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 [7]. For each of these transitions, we construct intuitionistic fuzzy estimations (for intuitionistic fuzziness, see [3]), 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).

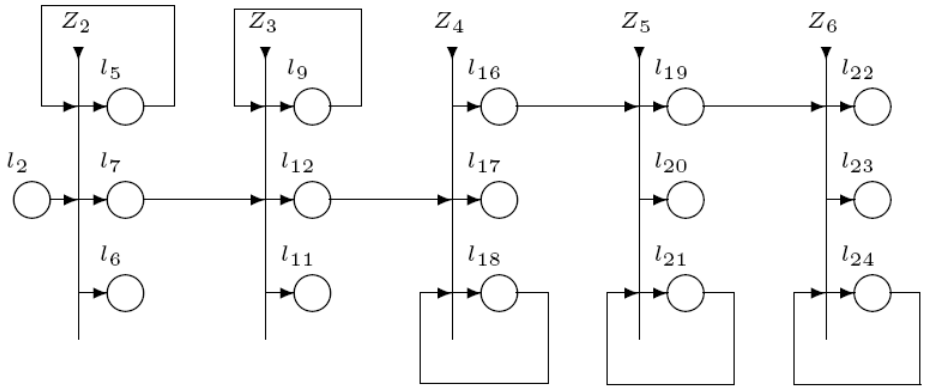

Figure 2.

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 [7] by π, but for the needs of the present research, we will reserve the denotation of π for the index of uncertainty, described above, while the tokens containing information about the modelled application projects we will only refer to as 'the tokens'.

Below, we 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"*.

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

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

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)"*.

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

$r_3 =$

	l_9	l_{11}	l_{12}
l_7	*true*	*false*	*false*
l_9	$W_{9,9}$	$W_{9,11}$	$W_{9,12}$

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)"*.

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

$r_4 =$

	l_{16}	l_{17}	l_{18}
l_{12}	*false*	*false*	*true*
l_{18}	$W_{18,16}$	$W_{18,17}$	$W_{18,18}$

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.

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

$r_5 =$

	l_{19}	l_{20}	l_{21}
l_{16}	*false*	*false*	*true*
l_{21}	$W_{21,19}$	$W_{21,20}$	$W_{21,21}$

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.

3 Conclusions

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.

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