Econometric Analysis of the Impact of Expert Assessments on the Business Activity in the Context of Investment and Innovation Development

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Abstract. The purpose of this paper is to build a logistic regression model where the outcome is the logit of probability of business success in quantitative and qualitative terms and predictor variables are identified factors that contribute to business success. The logit model is based on a sample of of 40 successful and unsuccessful businesses in Ukraine. The applied methodology with obtained results can serve to identify factors that contribute to improving business success, as well as a base for future research on the impact of selected factors on business success with a bigger sample of participants, and to improve decision making in conditions of uncertainty and instability of the external environment in developing countries.

Keywords: logit model, enterprise activity estimation, quantitative and qualitative terms, decision making

Introduction

Uncertainty and instability of the business environment in Ukraine are increasing despite the investment and innovation development of the country and a supportive international environment. In a competitive environment, enterprises are constantly forced to search for optimal solutions in order to gain or maintain an advantage over their rivals. In principle, in this situation, evaluation of the success of the enterprise without application of mathematical approach in decision making processes is particularly difficult.

Business-investors are interested in measures of business performance as base for their investment-decisions in the firm. Business success is defined in different ways, very often, a combination of financial performance and organizational performance is used [3].

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Ramadan, Ajami, Mohamed, Lazarova-Molnar [19] highlight the role of modeling and simulation in enhancing decision-making processes in enterprises. Decision-making in enterprises holds different possibilities for profits and risks. Due to the complexity of decision making processes, modeling and simulation tools are being used to facilitate them and minimize the risk of making wrong decisions in the various business process phases.

Despite the increasing pace of different types of enterprise activity modelling, little is known about correct evaluation of the success of the enterprise. Understanding the features of evaluation of the success of the enterprise is important for several reasons. First, many management scholars have inferred that a relationship exists between the correct assessment of the success of the enterprise and its internal capabilities, the stochastic processes in the organization, an advanced management practices, the external environment. In the absence of these basic elements, decision making practices will be more risky and costly. Second, managers of many enterprises are faced with making a strategic decision about whether or not to use the modellingFinally, the using of quantitative and qualitative data in modelling can help managers, who are trying to improve decision making in conditions of the investment and innovation development of the economy in developing countries. This needs putting in place a model for evaluation of the business success.

The role of the logit regression model and its economic interpretation is to provide a synthetic presentation of the calculated data that will aid in the formulation of policy of the enterprise, integration into social and economic environment and the evaluation of the success or failure of economic activity.

This paper analyzes the effects of individual factors on the business success. The empirical analysis was conducted over the sample of food industry enterprises in Ukraine.

The goal of the research was to establish how the value of some variable changes in response to change the values of a defined list of factors. Since the analyzed variable “Business success” is a binomial variable, the model of logistic regression is used. The McFadden maximum likelihood method (logarithmic likelihood function) are used to find logistic regression coefficients. Finding an estimate of an unknown parameter is simplified by maximizing the natural logarithm. A binary independent variable in logistic regression is obtained. The Newton-Raphson method are utilized to maximize the function L. The initial values of a parameters (W) are defined as the vector of linear regression parameters. The conjugate gradient method for the calculation of logistic regression coefficients are used. The obtained parameter estimates are interpreted. The rest of the study is structured as follows. Section 2 presents the literature review, in section 3 we define the methodology, section 4 presents the main practical results and finally section 5 concludes.

Literature review

Managers need business success measurement systems to improve and better orchestrate capabilities and their impact on the business, which is also called business

performance. A quite elaborate body of research has suggested that the application of business success measurement systems has a positive effect on the improvement of capabilities and consequentially the improvement of business performance [14].

There is no universally accepted definition of business success has been interpreted in many ways [6].

There are two important dimensions of business success: 1) financial vs. other success; and 2) short- vs. long-term success. Business success can have different forms In business studies, the concept of success is often used to refer to a firm's financial performance (high productivity, efficiency and effectiveness, business performance).

Based on uncertainty, it is not easy for companies to choose measures to assess the performance of their business [12].

Luta [16] considers that managing the assessed performance is a very important process in enterprise. This process starts after the performance evaluation of the personnel in the enterprise and depends on the performance score previously assessed.

Mitsel, Alimkhanova [18] view the means of evaluating the operating efficiency of enterprises based on the DEA (Data Envelopment Analysis) and financial indicators are taken as the input and output parameters. The profitability of capital invested in different business activities and the improvement of employee engagement are used for performance demonstrations [17].

Buttenberg [3] investigate the challenges in measuring business success in young firms and focuses on financial as well as product-market-performance indicators (sales growth, revenue growth rate of sales to current customers, Market share, market share growth) that are specific to start-up firms in order to support their strategic decision-making. The decisions of founder(s) on the acquisition, development and shedding of resources and capabilities as well as the factors and indicators taken into consideration when measuring business performance are pathbreaking for the development of the firm. Venkatraman and Ramanujam [21, 803-804] include operational performance alongside financial performance (such as sales performance or market share) in the definition and thereby enlarge the previously dominant models of management research.

The results of the study [7] validate that the non-financial dimensions (namely, image and customer loyalty, and product service innovation) are not valid dimensions for measuring business success, while the other two dimensions (namely, business growth and profitability) show a high degree of correlation. This indicates that business growth is aligned with profitability, that growth for profitability is a major concern, and that profitability still remains the key measure of business success.

To measuring business success with the use of financial indicators, Horváthová and Mokrišová [10] were focused on success measurement applying aset of non-financial indicators.

- Return on investment (ROI), return on assets (ROA), profit and growth rates of financial indicators are widely common measures used and reliable indicators for business success and organizational effectiveness.
- To evaluate business success, the following mathematical methods are used: a matrix model, a linear programming model for addressing the problems of input and output transformations [10] data envelopment analysis (DEA) non-parametric approachordinary least squares (OLS); stochastic frontier approach (SFA); maximum likelihood estimation (MLE); corrected ordinary least squares (COLS); thick frontier approach (TFA); modified ordinary least squares (MOLS); distribution-free approach (DFA) with the application of characteristics such as the EVA indicator, MVA, INEVA, WACC RONA, or indicators based on CVA, FCF and others [1; 20].
- A modeling techniques with the aim of the measurement of the business success should be developed from a combining statistical data and expert judgment, including various types of factors.

Methodology

The relationship between the factors and rates of success or failure of organizations should be established to undertake assessment of the business success. The rates of success and failure of organizations can be took on exactly two values. A binary variable is a variable with only two values (0 and 1). So, we need to build a model for predicting a binary variable.

Constructing a regular multiple regression will not produce the desired result. But the reason why is that the calculated values of the dependent variable may not belong to the interval [0, 1]. In this case, the task of constructing a regression dependence may not be as a prediction of the values of a binary variable, but as a simulation of some continuous variable that may yield values inside the [0,1] range. Such problems can be described by linear probability models or logit and probit models. The predicted values can not only correspond to the values 0 and 1, but can also be interpreted as the probability of success of the enterprises.

The modeling of the assessments of the business success in order to predict its future state was considered. This means the evaluation of a qualitative variable (business success - 1 or 0) by several quantitative factors. Discriminant analysis tools can be used to select the most informative quantitative variables. Logit regression allows to determine the success group of an enterprise. And furthermore, logit regression provides an opportunity to consider the likelihood that an enterprise would be categorized as a particular success group.

The logit model looks likes this:

$$p(x) = P(Y = 1 | X = x) = (1 + \exp(x^T w))^{-1}, \quad (1)$$

where w are unknown parameters which will need to be assessed.

The logistic curve (the solid line) shown in Fig. 1.

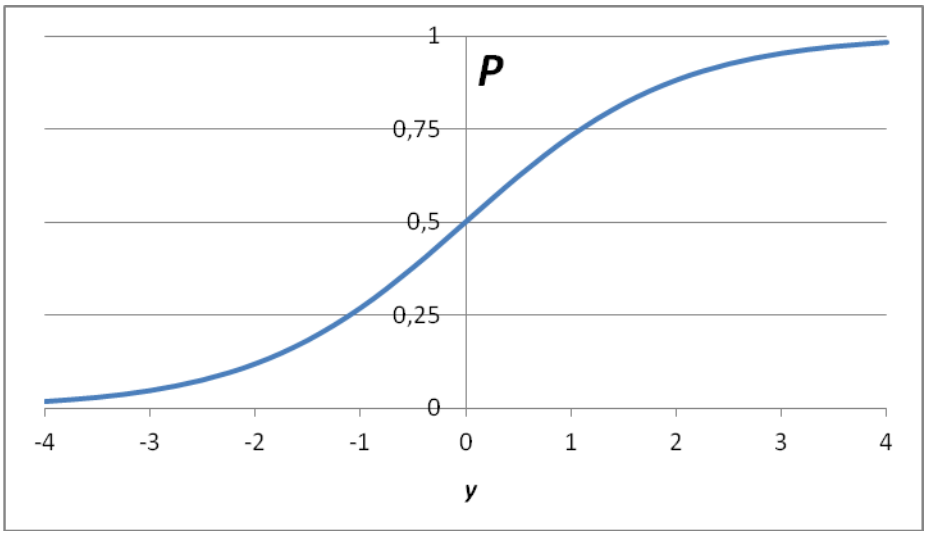

Fig. 1. Logistic curve

Positive points of logit analysis: logit analysis takes into account the model of nonlinear dependence, logit analysis has the ability to interpret the resulting success rate of the company. The resulting indicator determines the nominal value of the business success.

The following **Error! Reference source not found.** were used to build a model for assessing the success rate for enterprises.

The prepared data (Table 1) will be used to estimate the unknown parameters of the econometric model:

$$P(y_i = 1|x_i) = F(w_0 + w_1x_{i1} + w_2x_{i2} + \cdots + w_5x_{i5}) + \varepsilon_i,\ i = 1,2,\ldots,n \qquad (2)$$

where $P(y_i = 1 \mid x_i)$ is s the probability that the i-th value of the binary variable is 1 with the xi condition;

$F(z) = \frac{1}{1+e^{-z}}$ – logistics function;

ε_i – random component;

x_1 – expert evaluation of the quality of management in enterprise;

x_2 – expert evaluation of the qualifications of the staff;

x_3 – expert evaluation of the quality of products;

x_4 – net revenue from product sales / cost of purchasing;

x_5 – net revenue from product sales / number of employees.

There are several ways to find logistic regression coefficients. In the study, the maximum likelihood method was used. This method is used to get the parameter estimates of the general population from the sample data.

Table 1. Data table (factor matrix) for evaluating business success

№	Business success	Quality of management in enterprise	Qualifications of the staff	Quality of products	Number of employees	Cost of purchasing	Net revenue from product sales
9	1	9	9	8	278	3392,8	160496
10	0	5	8	9	208	4500	9845
11	1	10	6	9	1694	7214369	3463868
12	0	7	6	7	304	6374	11362
13	1	10	7	8	2320	6244672	3317232
14	0	7	8	8	153	14637	12843
15	1	9	7	8	4044	145	2616316
16	0	5	7	9	189	11738	10012
17	0	7	7	8	158	7384	9838
18	1	10	9	7	513	45620	119851
19	0	8	6	8	211	13726	12472
20	1	10	7	8	3339	83550,7	629267
21	1	9	8	8	624	46554	829712
22	0	8	9	8	325	5475	10984
23	0	7	8	9	187	4736	328

The likelihood function is the basis of the method and expresses the probability density (probability) of the simultaneous appearance of the sample results Y1, Y2,…, Yn:

$$L(Y_1,Y_2,\ldots,Y_k;\Theta)=p(Y_1;\Theta)\cdot\ldots\cdot p(Y_n;\Theta) \quad (3)$$

According to the maximum likelihood method, the value of $\Theta=\Theta(Y_1,\ldots,Y_n)$ that maximizes the function L is accepted to be in estimation of an unknown parameter.

The calculation process is being simplified by maximizing not the function L, but the natural logarithm $\ln(L)$. It has to do with the fact that the maximum of both functions is achieved with identical values of Θ:

$$L^*(Y;\Theta)=\ln(L(Y;\Theta))\rightarrow\max \quad (4)$$

We do have a binary independent variable through logistic regression. Therefore, we denote the probability of occurrence of 1 (P_i =Prob(Y_i=1)) by P_i. This probability will depend on $\boldsymbol{X_i}$,, where $\boldsymbol{X_i}$, is the row of the regressors matrix, $\boldsymbol{W}$ is the vector of regression coefficients:

$$P_i = F(X_i),\ F(z) = \frac{1}{1+e^{-z}} \tag{5}$$

The log-likelihood function is:

$$L(\boldsymbol{Y}, \mathbf{W}) = \prod_{y_i=1}^{n} F(\boldsymbol{X_i W})^{Y_i} [\mathbf{1} - F(\boldsymbol{X_i W})]^{1-Y_i} \tag{6}$$

We use ln$L$ instead of function L. It does not change the essence of the task, but allows us to get rid of the multiplication:

$$L^* = \ln L = \sum_{\boldsymbol{i=1}}^{n} \boldsymbol{Y_i} \ln F(\boldsymbol{X_i W}) + (\mathbf{1} - \boldsymbol{Y_i}) \ln(\mathbf{1} - F(\boldsymbol{X_i W})) \tag{7}$$

Here the following designations are introduced:

$$\begin{gathered} \boldsymbol{W} = (W_0,\ W_1,\ldots,W_m)^T, \\ \boldsymbol{X}_i = (1,\ X_{i1},\ldots,X_{im}), \\ \boldsymbol{X}_i \boldsymbol{W} = W_0 + W_1 X_{i1} + W_2 X_{i1} + \ldots + W_m X_{im} \end{gathered} \tag{8}$$

The Newton-Raphson method was used to maximize the function L.

A Newton- Raphson method is used to perform the minimization which typically requires several iterations:

$$\boldsymbol{W}_{t+1} = \boldsymbol{W}_t - \frac{\partial \ln L(\boldsymbol{W}_t)}{\partial \boldsymbol{W}} \left[\frac{\partial^2 \ln L(\boldsymbol{W}_t)}{\partial \boldsymbol{W}\, \partial \mathbf{W}'}\right]^{-1} \tag{9}$$

where

$$\begin{gathered} \frac{\partial \ln L(\boldsymbol{W})}{\partial \boldsymbol{W}} = \left(f_0(\boldsymbol{W}),\ f_1(\boldsymbol{W}), \ldots,\ f_m(\boldsymbol{W})\right) \\ f_0(\boldsymbol{W}) = \sum_{i=1}^{n} F(\boldsymbol{X_i W}) - \sum_{\{i:Y_i=1\}} 1 \\ f_j(\boldsymbol{W}) = \sum_{\boldsymbol{i=1}}^{n} F(\boldsymbol{X_i W}) X_{ij} - \sum_{\{i:Y_i=1\}}^{n} X_{ij},\ j = 1,2,\ldots,m \end{gathered} \tag{10}$$

$$\frac{\partial^2 \ln L(\boldsymbol{W}_t)}{\partial \boldsymbol{W}\, \partial \mathbf{W}'} =$$

$$\begin{pmatrix} \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} F(\boldsymbol{X_i W})(\mathbf{1} - F(\boldsymbol{X_i W})), & \ldots & \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} F(\boldsymbol{X_i W})\left(\mathbf{1} - F(\boldsymbol{X_i W})\right) X_{im}, \\ \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} F(\boldsymbol{X_i W})\left(\mathbf{1} - F(\boldsymbol{X_i W})\right) X_{i1}, & \ldots & \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} F(\boldsymbol{X_i W})\left(\mathbf{1} - F(\boldsymbol{X_i W})\right) X_{im} X_{i1}, \\ \ldots\ \ldots\ \ldots & & \ldots \\ \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} F(\boldsymbol{X_i W})\left(\mathbf{1} - F(\boldsymbol{X_i W})\right) X_{im}, & \ldots & \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} F(\boldsymbol{X_i W})\left(\mathbf{1} - F(\boldsymbol{X_i W})\right) X_{im} X_{im} \end{pmatrix}$$

This is usually the initial values which has been determined to be the the vector of linear regression parameters:

$$\boldsymbol{W}^{(\text{поч})} = (\boldsymbol{X}^T \boldsymbol{X})^{-1} \boldsymbol{X}^T \boldsymbol{Y} \tag{11}$$

For our research we are going to use the conjugate gradient method.

Empirical results

The parameters of the resulting logistic regression model in analytics software package STATISTICA are as follows:

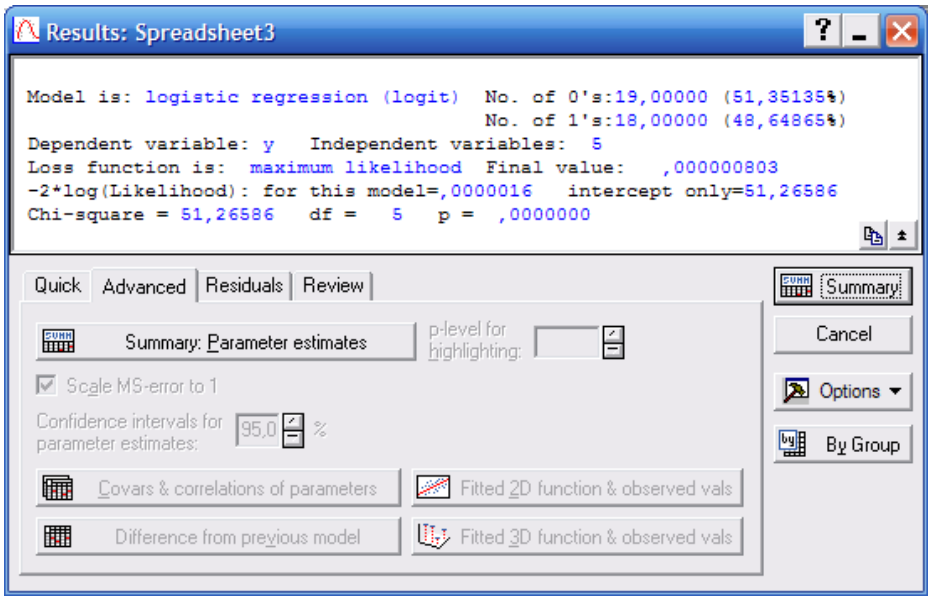

Fig. 2. The parameters of the resulting logistic regression model in analytics software package STATISTICA

It is to be noted (Fig. 2) that the five-factor logit model ensures a high degree of reliability. Its reliability was confirmed by x_i^2 = 55,99. And it may even be concluded that the null hypothesis can be not rejected with near zero probability.

Based on the foregoing, the logistic model are obtained:

$$P(y_i = 1|x_i) = (1 + e^{65,1-6,02x_1-0,54x_2+1,27x_3-0,02x_4-0,16x_5})^{-1}$$

The adequacy of the constructed logistic model can be calculated by likelihood ratio index (LRI, McFadden's-R2 statistic):

$$LRI = 1 - \frac{\ln L(\boldsymbol{w})}{\ln L(\boldsymbol{w})} = 0,97 \quad (12)$$

where

$$L(\boldsymbol{y}, \boldsymbol{w}) = \prod_{y_i=1}^{n} F(\boldsymbol{x_i w})^{y_i} [\boldsymbol{1} - F(\boldsymbol{x_i w})]^{1-y_i} \quad (13)$$

$\ln L(\boldsymbol{w})$ – is the maximum value of the log-likelihood function. This is reached at a point whose coordinates are equal the estimates of the model parameters, $w = (w_0, w_1, w_2, \dots, w_m)$

$\ln L(\boldsymbol{w_0})$ – the value of the logarithmic likelihood function which is calculated on the basis of the assumption that $w_1 = w_2 = ... = w_m = 0$.

The calculated value of likelihood ratio index points to the adequacy of the constructed model.

An assessment of the business success rate at different values of factors has been carried out.

The Figure 3 show how business success would change when x1 factors (expert evaluation of the quality of management in enterprise) for certain values of factor x3 (expert evaluation of the quality of products) and fixed values of other factors: x2 = 7 (expert evaluation of the qualifications of the staff), x4 = 18 (net revenue from product sales / cost of purchasing), x5 = 163 (net revenue from product sales / number of employees) are changed. That is, increased the quality of the management (x1) for different values of product quality and fixed values of other indicators (x2, x4, x5) leads to better the business success indicator.

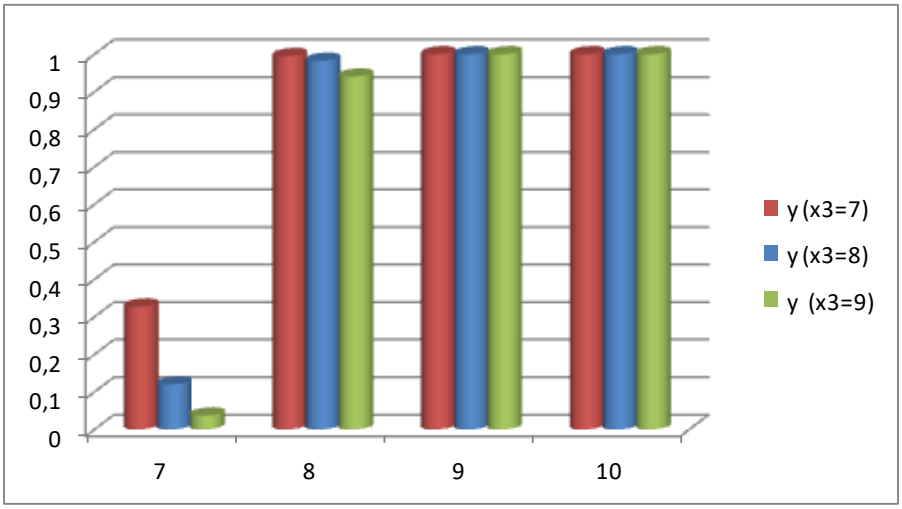

Fig. 3. Dependence of business success on the expert evaluation of the quality of management (for certain values of expert evaluation of the quality of products)

The strategic concept of management on the quality of tangible and intangible elements of product is a good way of gaining competitive advantage. Considering modern business activities of companies, there are numerous reasons for emphasizing the importance of quality management [2]. One of the most important elements that must be taken into consideration is the relation between the price and quality of products. The innovation is actually the key to improving the quality of products. Management of an enterprises must be able to recognize opportunities, i.e. the sources of innovation that such changes bring about, which will certainly improve the quality of products [13].

The Figure 4 show how business success would change when x1 factors (expert evaluation of the quality of management in enterprise) for certain values of factor x2 (expert evaluation of the qualifications of the staff) and fixed values of other factors: x3 = 7 (expert evaluation of the quality of product), x4 = 17 (net revenue from product sales / cost of purchasing), x5 = 144 (net revenue from product sales / number of employees) are changed. That is, increased the quality of the management (x1) for different values of the qualifications of the staff and fixed values of other indicators (x3, x4, x5) leads to better the business success indicator.

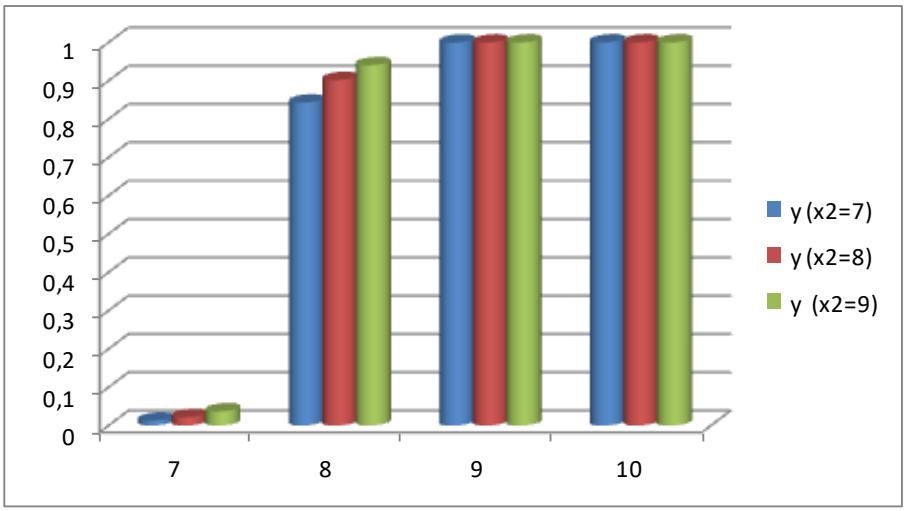

Fig. 4. Dependence of business success on the expert evaluation of the quality of management (for certain values of expert evaluation of the qualifications of the staff)

Hasebrook [9] was calculated how the quality of management can determine business (financial) success based on data about 1,900 banks and 2,700 respondents. It was thus found that there was a positive correlation between management quality and qualifications of the staff. The result shows a correlation between 35% (2009) and 95% (2013). To provide the success of the management manageres need the professional qualifications approach to enhancing staff professional qualifications in the process of creation of competitive relations.

The Figure 5 show how business success would change when x2 factors (expert evaluation of the qualifications of the staff) for certain values of factor x1 (expert evaluation of the quality of management) and fixed values of other factors: x3 = 8 (expert evaluation of the quality of product), x4 = 19 (net revenue from product sales / cost of purchasing), x5 = 122 (net revenue from product sales / number of employees) are changed. That is, increased the x2 factor for different values of the quality of management and fixed values of other indicators (x3, x4, x5) leads to better the business success indicator.

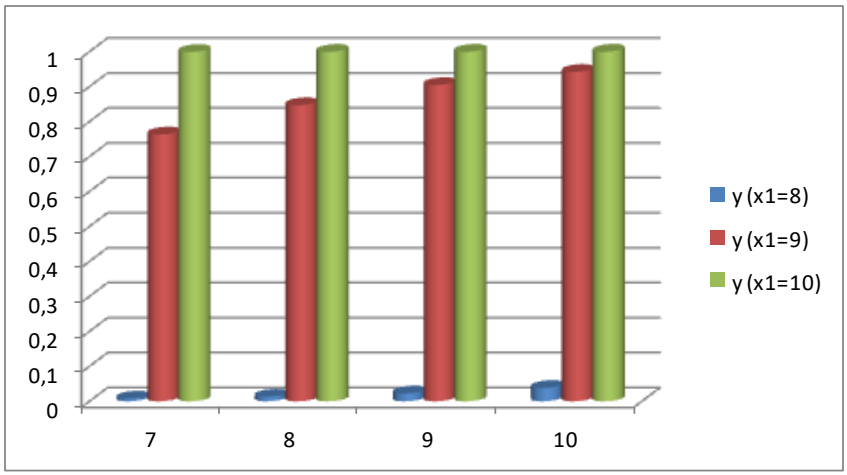

Fig. 5. Dependence of business success on the expert evaluation of the qualifications of the staff (for certain values of expert evaluation of the quality of management)

The motivational models directed at increasing the loyalty of employees must be competitive, able to retain the staff, improve its professional qualifications and focus on creating profitability of oriented at innovation enterprise. That's why the system of motivation should include not only financial incentive instruments (high wages, bonuses, bonuses and other forms of financial encouragement), but also the tools of further professional career growth, increase of loyalty and self assessment of specialists [15].

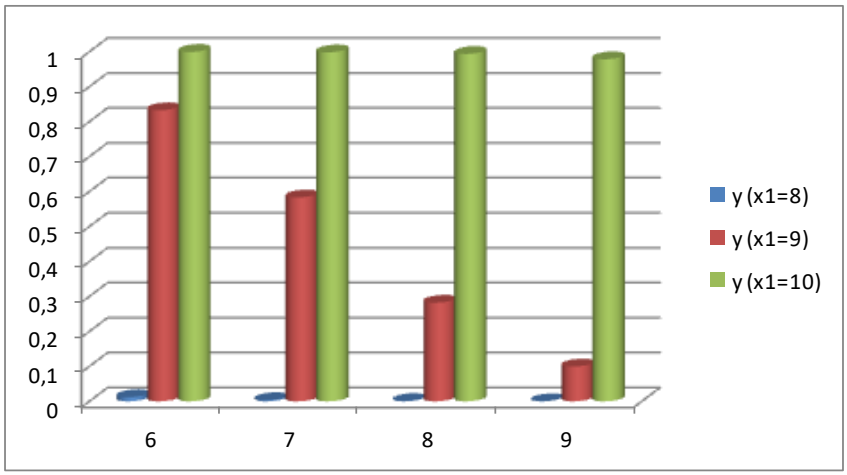

Fig. 6. Dependence of business success on the expert evaluation of the quality of products (for certain values of expert evaluation of the qualifications of the staff)

The Figure 6 show how business success would change when x3 factors (expert evaluation of the quality of products) for certain values of factor x1 (expert evaluation of the quality of management) and fixed values of other factors: x2 = 9 (expert evaluation of the qualifications of the staff), x4 = 5 (net revenue from product sales / cost of purchasing), x5 = 99 (net revenue from product sales / number of employees) are changed. That is, increased the x3 factor for different values of the qualifications of the staff and fixed values of other indicators (x2, x4, x5) leads to decrease the business success indicator.

The decline can be attributed to the slowdown in employee motivation at the enterprises, the decline in public investments in the food industry, and the rise in crisis in the country.

Generally speaking, the quality of products and employee performance depends on a large number of factors, such as motivation, appraisals, job satisfaction, training and development [11].

For Ukrainian enterprises the wages that does not meet the labor efforts and qualifications may demotivating employees and disincentive to work. This leads to employees of a company act according to the principles of irresponsibility, reduce productivity, breaking the labor legislation and operational discipline.

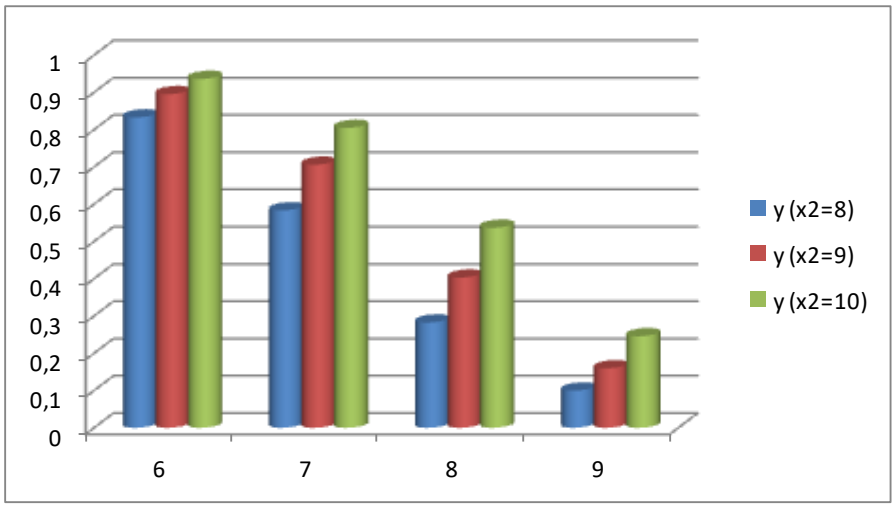

Fig. 7. Dependence of business success on the expert evaluation of the quality of products (for certain values of expert evaluation of the quality of management)

The managers should be concerned by the low level of motivating, which does not allow workers and members of their families a decent standard of living. This risk could lead to the departure, of some of skilled personnel working for the organizations.

The Figure 7 show how business success would change when x3 factors (expert evaluation of the quality of products) for certain values of factor x2 (expert evaluation of the qualifications of the staff) and fixed values of other factors: x1 = 9 (expert evaluation of the quality of management), x4 = 5 (net revenue from product sales / cost of purchasing), x5 = 99 (net revenue from product sales / number of employees) are changed.

This situation illustrates that in the food industry, the quality of products is gradually decreasing. Businesses were plagued by low level of quality product as a result of low level of product standardization, quality management, quality control.

The main factors that contributed to the decline of the product quality are: low quality of raw materials, low level of the organizations of labour and production processes, outflow of skilled workers, poor and irregular productivity in production.

Improving product quality is one of the most important things for achieving long term sales growth and profitability. Businesses seeking to improve product quality need to embed quality practices in their routine processes. So rather than just an afterthought, quality has to be intrinsic to companies' performance and daily operations management. And though increasing quality of products is not an easy task, it rewards businesses with increased revenue and reduced costs. Improving product quality based on these principles: build a solid product strategy, implement a quality management system (QMS), make quality a part of company culture, perform product and market testing, always strive for quality [5].

Let us evaluate business success with a built model. Information on activities of enterprises is presented in Table 2.

Table 2. The value of indicators to measure a new businesses success

№	Business success	Quality of management in enterprise	Qualifications of the staff	Quality of products	Number of employees	Cost of purchasing
1	8	8	8	150	15000	25000
2	6	7	8	100	5000	24000
3	10	9	8	400	10000	25000

$$P(y_1 = 1|x_i) = (1 + e^{65{,}1-6{,}02\cdot 8-0{,}54\cdot 8+1{,}27\cdot 8-0{,}02\cdot 1{,}67-0{,}16\cdot 166{,}67})^{-1} = 0{,}98$$

$$P(y_2 = 1|x_i) = (1 + e^{65{,}1-6{,}02\cdot 6-0{,}54\cdot 7+1{,}27\cdot 8-0{,}02\cdot 4{,}8-0{,}16\cdot 240})^{-1} = 0{,}958$$

$$P(y_3 = 1|x_i) = (1 + e^{65{,}1-6{,}02\cdot 10-0{,}54\cdot 9+1{,}27\cdot 8-0{,}02\cdot 2{,}5-0{,}16\cdot 62{,}5})^{-1} = 0{,}46$$

The calculations show the possible success of the first and second enterprises.

Based on this results, it can be concluded that the logistic regression is adequate for the task at hand and is well suited to analyze the business success.

Conclusions

Any evaluation of the business success can be made by modelling based on quantitative and qualitative data and analysing the results. The data collected on an activity of Ukrainian enterprises of were related to the various financial variables (net revenue from product sales, cost of purchasing, number of employees) and expert evaluation. Using the binomial logistic model the logit of probability odds of business success in dependence of quantitative and qualitative factors that contribute to business success was analyzed.

Performed logistic regression over the selected set of quantitative and qualitative variables showed that quality of the management, qualifications of the staff are most statistically significant predictors. All these factors affect the increase of probability of business success.

In addition, declining quality product significantly decrease the probability odds of business success. And, obtained results illustrate that in the food industry, the quality of products is gradually decreasing. Businesses were plagued by low level of quality product as a result of various factors.

Based on the obtained results, the management of an enterprises can focus on those areas, which are preconditioned for business success and efficiency improvement. The applied methodology with obtained results can serve as a base for the future research on the impact of quantitative and qualitative factors on success for the enterprises and organizations of different forms of ownership, working in different spheres.

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