A Model for Business Success Prediction using Machine Learning Algorithms

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Abstract. A major problem facing a Nation is the inability of business to last for a long period of time with good returns on investment and profit. This inefficient nature of businesses is rapidly affecting the growth of its economy. In an attempt to solve this problem this research provides a business success diagnosis system. The aim of the paper is to presents a design and implementation of a system for the diagnosis, prediction, and provision of recommendation for the success of a Business. The methodology used to develop the prediction model is based on correlation analysis for the data pre-processing and the combination of Naïve Bayes and J48 classification algorithm. Necessary heuristics for the diagnosis were collated from the review of existing business consulting systems, expert systems and human experts in the field of business consulting in Nigeria. In conclusion, the developed system will improve the rate of business success in Nigeria and provide a platform for entrepreneurial improvement in the Nigerian Economy. Finally the result of the evaluation revealed a great acceptance and necessity of the developed business diagnosis system.

1. INTRODUCTION
Presently there are a lot of small and medium businesses that do not succeed. Unfortunately, over half of the overall percentage of small businesses fail in the opening year and quite a number of about 95% fail within the opening year. Businesses with a hand full of employees have about 37% chance of surviving for some time and only about 9% have a chance of survival for 10 years. Numerous studies have made known that a lot of people with ideas start up their business every year but a good number of them flop before the year run out or in the start of their operations while a larger part close before their second year [1]. Businesses are the pillar of almost all the economies of the world because of the role they play in employment creation and provision of personalized services [2]. Business(SMEs) assumes the imperative part in the modern advancement of a country [3]. Little scale industry has a superior prospect for creating domestic economy through the age of products and services that impels the economy of Nigeria [4]. Businesses(SMEs) have been perceived as an imperative means in the financial development of a country by contributing towards net house product(GDP), creating occupations, decrease in destitution (poverty), create salary and encourage country riches thus bringing about national advancement. A country without conducive atmosphere with no good policies to support businesses will hinder the growth of a business and economy growth. It is therefore important for most businesses in the developing countries succeed within a short period of time. Most business fail due to the following reasons; personality of the owner, insufficient capital, poor knowledge management, lack of business and managerial skills, poor business planning, uncontrolled growth etc.
There is therefore a need for a free consulting online system that is able to predict the success of a business even before the business starts. In this research, we developed a system designed to predict if the business will succeed or if it will fail using the data gathered from researches, questionnaire etc. the system recommends the necessary actions to take if the business owner still wants to continue with his/her idea(startups) or businesses (already running). The idea of this system is to solve the problem of businesses not surviving for a long period of time leading to; waste of time, resources and capital, enable the owners know what kind of business to do and the kind not to do. The system helps is supporting business decision making which is very important, for example; if a startup business is used as input to the system, the system can provide answers which will be able to give a diagnose as to why the business is struggling and proffer some listed solution to the problem allowing the owner to make decision from it. The implementation of the system will be to the following benefits; Easy identification of business problems from the individual inputted data, the system will be able to give prompt solution or related solution to the business based on the inputted data, the system will be able to help the individual or business owner make profound decision on how to increase business capital, people going in business can use the system to predict where they stand in that line of business, the system will be able to reduce time wastage on the long run: users of this system can know their faith before going in to business that will eventually fail. Etc.

2. LITERATURE REVIEW
Prediction models gotten from data mining technique is broadly used in business due to the fact that most business relies on successful forecasting. Classification and Regression are two main forms of forecast predictive analysis. Classification is in predicting a class label for data while Regression predicts unavailable data values or trends. Classification predicts model for categorical i.e. discrete or unordered data while predicting missing or unavailable numerical data is done by regression. The most popular aspect involved in predictive analysis is classification. It involves deriving a model that distinguishes and describes data sets.

Presently, business success has been viewed from the following perspective; [5] observed that it was important to able to identify the current future successful ventures and to determine the drivers of successful ventures. In addition, to know the business performance, it is relevant for start-ups or pre-revenue firms to understand that non-economic performance influences the likelihood of survival as well. When comparing firms with the same economic performance, different mortality rates for firms exists, indicating that firms have different minimum viable levels of economic performance or that the non-economic performance is influencing the mortality rate. According to [6], Business survival is leveraged by both the determinants of economic and non-economic performance and minimum viable levels of performance. The above statement made by Gimero states that it is important to examine the determinants of non-economic performance and economic performance, because these determinants affects the probability of business success.

Corporate failure models can be broadly divided into two groups: quantitative models and qualitative model. Quantitative model is based on financial data while qualitative model is based on internal assessment of the company concerned. The both models try to identify features whether financial or non-financial used to differentiate between surviving and non-surviving firms. Quantitative model identifies financial ratios that differentiate between surviving, non-surviving and previously failing companies. The accepted financial indicator that is commonly used to identify failure include the following: Low profitability related to asset and commitments, Low equity returns, both dividend and capital, Poor liquidity, High gearing, High variability of income. Qualitative model uses financial measures which includes non-accounting or qualitative variables as an indicator of the company’s performance.

Several attempts have been made to employ prediction for the purpose of business success diagnosis. Borlea used correlation, induction-deduction, analysis-synthesis, scoring assessment graphs and so forth[7]. The model tends to predict when a firm is about to enter into bankruptcy. When
choosing the pointers representing a recognized field and when allocating essential scores, a critical part is held by the experience and professionalism of the budgetary examiner. These will enable him to make objective and sufficient qualitative and quantitative assessment. In the utilization of SWOT technique (to verify a quantitative method), many banks, rating offices or government organization are consuming the deterministic models with a specific end goal to catch the last appraising of business on which further will be based on decision making process. The major advantage of this model is it help the firm to detect when a its facing some financial problems and if early detected can save the firm from bankruptcy but the challenge of this model is if the defect is not early detect then the company will not stand a chance to survive. As model that diagnosis global business to evaluate the business performance and the risk to which it is exposed including also the risk of insolvency and bankruptcy was developed by [8]. [9], in their study, demonstrated how proactivity is related with business prosperity, it demonstrate that a variation of individual difference factors are related with entrepreneurial expectations, individual distinction include sex (female or male), schooling (MBA or Undergraduate) and business person guardian. [10] utilized expectation from markets to join prediction from various forecasters, under three conditions: markets of human forecasters, market of artificial-neural-net specialist, and markets where both human and agents are used together. A few distinct measures and criteria were utilized to survey and analyzed the nature of forecasting, including exactness (measured utilizing 3 common scoring rules), Sharpe ratios (it is usually used in finance to measure reward and hazard performance, helps us to consider precision against fluctuations of forecasting blunders, making the contrast more enlightening [10], [11] provided an online platform for entrepreneurs and start-ups that want to evaluate the business and develop business cases. Their work provided a framework of 32 criteria to evaluate venture proposals and support the assessment of a business case. These criteria and relative importance are based on research about venture capitalist’s product and market related investment criteria. The evaluation is done by either entrepreneur team, performing a self-assessment, or by external checker (eg an industry expert, a scientist). [9] developed a proactive Personality Scales as a Predictor of Entrepreneurial Intentions. Making Business Prediction by Combining Human and Machine Intelligence in Prediction Markets was carried out by [12]. The advantage is that the predictions made by hybrid human-and-agent markets provide the best tradeoff of accuracy and variability of prediction errors measured by sharpe ration. Hybrid market provide a better tradeoff between good and bad decision using the ROC methodology [12]. [13] developed a data Mining Approach to Predict Prospective Business Sectors for Lending in Retail Banking Using Decision Tree. The system uses customers transactional related data, data mining techniques in search of consistent patterns and/or systematic relationships between variables, and then to validate the findings. [14] developed an Assessment Methodology for Improving Performance in SMEs. The assessment methodology is used for monitoring and assessing SMEs performance. It can also be used by manufacturing SMEs as an assessment and benchmark tool which enables them to find opportunities for improving and determining the breach in current performance; the methodology assist manufacturing SMEs to select a suitable tool to improve their performance in order to achieve company aims and improve performance. It uses the opportunities, benefits and series of questions to conclude its assessments. [14]. The existing methods of understanding, diagnosing and predicting business behavior can therefore be summarized as including Multiple Discriminant Analysis (MDA), the Golden Egg Check [15] and several data mining techniques.

3. BUSINESS SUCCESS PREDICTION MODEL

The methodology used in this research contains six major processes, which include the data gathering, correlation analysis module, prediction or diagnosis module, user interface module, explanation module and the recommendation module. The business success prediction model is aimed at providing an approach which will efficiently diagnose business problems and help provide solution and guidance to the challenges discovered. The model for business success prediction is captured in Figure 3.1. The following section is a detailed description of these modules.
3.1. Data Gathering

The survey instrument employed to gather the data include both the online questionnaire (google doc) and the manually distributed questionnaire. A total of 232 questionnaires were administered while 162 was harvested back from the respondents. These questions, which will form the set of heuristics which we used to develop the business success diagnosis system was compiled by consulting experts in the field of Business Management and Psychology. These experts have a doctorate degree in business admiration and most of them are professional business consultants. They also currently lecture in the field of Business Management and psychology. A professional psychologist was also part of the experts used in order to understand the psychological perspective of how entrepreneur’s or business owners react to issues and what characteristics they must sustain to be successful in their businesses. These questions were further validated using [16][17]. The questionnaire consists basically of three different sections; the first section retrieves the background information of the respondents; the section is focused on entrepreneurship success and the last section is focused on business success prediction attributes. The questionnaires were distributed in different states of Nigeria, such as Rivers, Lagos and Ogun state, via the internet and was administered to anybody who has floated any kind of business before, small or big, whether the business has succeeded or not. We ignored incomplete questionnaires and considered 168 questionnaires that contained all the information, which represents 70% of the total respondents.

3.2. Correlation Analysis
Correlation analysis was used to select the attributes for prediction. Correlation is the relationship between variables and how strong their relationship is. Pearson’s correlation coefficient or Linear product-moment. Correlation coefficient is used to calculate the strength of their relationship and the direction of the variables, \( r \) is used to denote the Pearson’s correlation coefficient. \( R \) is the end result gotten in which the value must range from \(-1\) to \(+1\) or \(-1 \leq R \leq 1\) [18].

\[
r = \frac{n\sum{xy} - \sum{x}\sum{y}}{\sqrt{[n\sum{x}^2 -(\sum{x}^2)](n\sum{y}^2 -(\sum{y}^2)^2)}}
\]

Many data mining activities experience some difficulty from having too many attribute and they tend to run slow. Correlation helps to identify and eliminate the attributes that depend on one another under the assumption that they are redundant and do not add any information to the data. The correlation analysis was implemented using rapid miner studio (www.rapidminer.com).

3.3. Model Development using Naïve Bayes Algorithm

Both the Naïve Bayes algorithm and the J48 algorithm were used for the prediction. The algorithm selected for a particular type of prediction was selected based on the percentage accuracy generate by it on the data using the WEKA workbench. Also due to the quantity of the data, in order to increase the accuracy of prediction, stratified cross validation was used to train and test generated prediction model.

Bayesian classifier is based on Bayes’ theorem. Naïve Bayesian classifiers assume that the effect of an attribute value on a given class is independent of the values of the other attributes. This assumption is known as conditional independence [19]. Naïve Bayes Algorithm is a machine learning algorithm used to solve classification problems.

The naive Bayesian classifier works as follows:
1. Let T be a training set of samples, each with their class labels. There are \( k \) classes, \( C_1, C_2, \ldots, C_k \). Each sample is represented by an \( n \)-dimensional vector, \( X = \{x_1, x_2, \ldots, x_n\} \), depicting \( n \) measured values of the \( n \) attributes, \( A_1, A_2, \ldots, A_n \), respectively.
2. Given a sample \( X \), the classifier will predict that \( X \) belongs to the class having the highest a posteriori probability, conditioned on \( X \). That is \( X \) is predicted to belong to the class \( C_i \) if and only if \( P(C_i|X) > P(C_j|X) \) for \( 1 \leq j \geq m, j \neq i \).
   Thus we find the class that maximizes \( P(C_i|X) \). The class \( C_i \) for which \( P(C_i|X) \) is maximized is called the maximum posteriori hypothesis. By Bayes’ theorem
   \[
P(C_i|X) = \frac{P(X|C_i) P(C_i)}{P(X)}.
\]
3. The value of \( P(X) \) not different for all classes, but there is need to maximize \( P(X|C_i) P(C_i) \). For the apriori class probabilities, if the value of \( P(C_i) \), is not revealed, then the classes are likely equal, that is, \( P(C_1) = P(C_2) = \ldots = P(C_k) \). This will maximize the value of \( P(X|C_i) \).
4. If we have a data that has a lot of attributes, there will be a high computational cost to compute \( P(X|C_i) \). To solve this problem there is need to reduce the computation by evaluating \( P(X|C_i) P(C_i) \). This is expressed mathematically as
   \[
P(X|C_i) \approx \prod_{k=1}^{n} P(x_k|C_i).
\]
In order to predict the class label of \( X \), \( P(X|C_i) P(C_i) \) is evaluated for each class \( C_i \). The classifier predicts that the class label of \( X \) is \( C_i \) if and only if it is the class that maximizes \( P(X|C_i) P(C_i) \) [19].

J48 is a classification algorithm which is used to build model of classes from a set of records that contain class labels. According to [20], the J48 classification algorithm is able to find out the
attributes-vector behaviours for a number of instances. The J48 is an extension of ID3, which includes additional features that helps to account for missing values, decision trees pruning, continuous attribute value ranges, derivation of rules, and so on. In WEKA toolkit (https://www.cs.waikato.ac.nz/ml/weka/), J48 is an open source Java implementation of the C4.5 algorithm. The following is the three steps involved in the algorithm:

- The tree represents a leaf such that the instances belong to the same class, the leaf is returned by labelling with the same class.
- The potential gain is calculated for all the attributes.
- Finally, the best attribute is found on the basis of the present selection criterion and that attribute selected for branching [21].

3.4. User Interface, Explanation and Recommendation Module

The system analysis for the business success diagnosis system was done using the following UML tools as the design platform, particularly the use case diagram and the sequence diagram. The Java net beans platform was used as the application development platform.

A Bayesian network (Naive Bayes), contains nodes that represent chance variables, and the arcs that expresses the qualitative relations among the variables. The dependence relations that exist among the variables are valued with conditional probability distribution. Explanation tasks in Bayesian networks can be categorized into three categories; explanation of reasoning, explanation of model, and explanation of evidence [22]. In the area of diagnosis systems, according to [23] explanation can be provided by paraphrasing the rules or methods that was used for the prediction, which is well expressed in English language. To achieve this, in the business diagnosis system, the rules generated for explanation is gotten from the decision trees that generated the prediction model. The diagnosis system contains link to more explicit information of the result gotten from the user, which forms the recommendation. This is to help the user understand the result gotten and how to improve on it.

3.5. Business Success System Evaluation

The system was evaluated by using both the usability based [24] method of evaluating expert systems or prediction system and the prediction accuracy result using the test data and the precision and recall embedded in the WEKA toolkit. At least 17 users who were interested in predicting the future of their business was made to interact with the system. These set of users included those who have run one business or the other in the past, those who are currently running a business and experts who are into business success consulting. The evaluation questions is based on the combination of Jakob Nielsen heuristics [25] and evaluation of expert system application based on usability aspect by [24].

4. RESULT AND DISCUSSION

4.1. Correlation Analysis Result

About 30 diagnostic questions were asked from the respondents and the ones with positive correlation with respect to the predicted goals were selected. The ones selected for prediction based on the result of the correlation is displayed in Table 3.1

| Questions Asked | Label to predict the success of your | Label to predict the probability of the success of | Label to predict how long your business will last |
|----------------|------------------------------------|-----------------------------------------------|-----------------------------------------------|

Table 4.1: Correlation analysis Result
entrepreneur skills (Correlation analysis value) | your business (Correlation analysis value) | (Correlation analysis value)
--- | --- | ---
Gender | 0.101 | 0.101 | 0.048
What is your age range? | - | - | 0.140
What is your highest level of education? | 0.118 | 0.118 | -0.018
Do you have a succession plan? | 0.021 | - | 0.021
Select the category of hours you invest in your business in a day? | 0.057 | 0.242 | 0.057
Do you keep records of customer details? | 0.009 | - | 0.009
Do you have a documented business plan? | - | 0.108 | 0.033
Do you make any kind consultation before you make any major decision? | 0.025 | 0.011 | 0.025
Are your customer satisfied with your product and services? | - | - | 0.070
On a scale of 100, rate the return on your investment? | - | 0.024 | 0.029
Do you embark on any marketing activities for your business? | - | 0.024 | 0.138
Do you manage the finances of your business? | - | - | -0.007
Is your business experiencing any difficulty? | 0.025 | - | 0.025
Do you know your target customer? | - | 0.050 | -
Do you know your competitors | - | 0.040 | -
Does government policies affect your policies | - | - | -0.001
I know how to communicate with my customers? | 0.202 | 0.202 | 0.196
I can lead and manage the environment? | 0.096 | 0.095 | 0.044
I am willing to take risk? | 0.093 | - | -0.236
I am competitive? | 0.173 | 0.173 | 0.154
I have emotional intelligence? | 0.027 | 0.027 | -0.059

4.2. System Description and User Interface

The system makes three different types of prediction which includes; To know the success of your entrepreneur skills; To predict the probability of the success of your business and To predict how long your business will last.

Figure 3.2 is an example of the interface for the system to receive the attributes for which the uses to makes prediction. When submitted, the user is given an option to select which type of prediction and proceed.
Figure 4.1: Business Diagnosis Form

Figure 4.2: Output of the Prediction

Figure 41 is an example of the prediction output generated by the diagnosis system, for predicting the success of your entrepreneurial skills. The user is also allowed to further query the prediction system for more explanation on the predicted result. The system provides explanation by making available the rules that generated the predicted result so that the user can have a better understanding of the prediction result and use this to improve the chances for the business success.

4.3. Evaluation Result

Table 4.2: Result of Evaluating the Prediction Models

| Prediction Goal                  | Precision | Recall | F-Measure | Percentage Accuracy |
|----------------------------------|-----------|--------|-----------|--------------------|
| To know the success of your      | 52.4%     | 55.0%  | 53.7%     | 56%                |
entrepreneur skills

|                                | 58.6% | 77.4% | 66.7% | 64.1% |
|--------------------------------|-------|-------|-------|-------|
| To predict the probability of the success of your business |       |       |       |       |
| To predict how long your business will last | 74.5% | 87.5% | 80.5% | 70.0% |

Table 4.2 reveals the accuracy of the models used for the three goals predicted in the business diagnosis system. The result reveals that all the models built for the prediction gave a percentage accuracy of above 50%. It is intended that more data will be gathered in future so as to improve the percentage accuracy of the system. Also the value of the precision, recall and f-measure shows that the diagnosis system can be relied upon for prediction though it can be improved upon.

Figure 4.3

Figure 4.1 Reveals the usability evaluation for the business diagnosis system. The evaluation result reveal that out of the 17 people that were used for evaluation, 12 people approved that the quality of diagnosis is above average, 9 people found the system above average as regards ease of use, 9 people found it easy to make predictions and 8 people found it excellent in appearance, navigation and so on as revealed in Figure 4.3.

5. CONCLUSION AND FUTURE WORK
In conclusion, the prediction of the performance of business success assist the business owners and entrepreneurs who are seeking to improve the structure of their business economic and non-economic model and trying to find where their strength lies when starting a business using the personality threat. This has drawn a great amount of attention over the years because of the future application of business success prediction and diagnosis analysis. Most business success prediction and diagnosis analysis do not have personality threat as one of the important factor to use when predicting the future success of a business and recommending related solution to the user, but this research has provided the use personality check as one of the factors used when predicting a business. This research has also leveraged on machine learning techniques to be able to provide a reliable business success diagnosis system. The result of the evaluation of the system reveals a high rate of acceptance and need for the developed system. This developed system will be a reference point for business owners and individuals with ideas of business startups trying to understand their weaknesses and strength. For further work, the system could be improved upon to give real-time automated explanation which is on individual basis rather than a general explanation for the category of prediction. Also the research could leverage on text analytics for inferences rather than just the structured data. Also the percentage accuracy of the system will be improved by training with more data.

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