Applying SWOT for B2B Decisions, Extension to larger data with Machine Learning Regression

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Abstract In this research Akella Systems company, AS, wants to locate its operation in another company either Sreyas an institute or C1 a company. A Business to Business, B2B association decision was required. The Strengths, Weaknesses, Opportunities and Threats, SWOT, concerning defined fields are defined and points allotted for AS, Sreyas, and C1. SWOT is used individually for decision-making on one parameter. In this analysis, a relative SWOT of the company’s capabilities is used for decision-making of location. Further, each company is evaluated relative to the other by SWOT polynomial regression. Standard regression using Cramer’s rule was used. A Business unit to Business unit, B2B decision was taken by locating the Akella Systems company, within the Sreyas Institute after relatively evaluating the SWOT. Linear equation fit of the data was also obtained from MS Excel and fits perfectly with R² =1 with the regression model. The relative evaluation of the two companies can be inferred from the coefficients of the equation. The constant-coefficient gives the average difference of all SWOT parameter differences of the company and the coefficient of the linear variable gives the progressive influence of one company over the other. Sreyas college had an average more SWOT value of 6.12 compared to AS and AS had a progressive influence in the relationship over Sreyas, as the coefficient was 0.1845. Sreyas college was selected to be the partner by AS. The polynomial fit metric developed for relative SWOT can be used as a training set, for large ML data regression.

1. Introduction

Analysis of the situation is the beginning of any thought process to plan an activity. SWOT, Strengths, Weaknesses, Opportunities, and Threats are evaluated and the plan to complete an activity and schedules are made. Yang [1], 2019 has applied to reduce the epidemic occurrence of eleven different places in the China Republic.
Probability of Default (PD) The reason for the epidemic was infected snails that had to be eradicated using chemical molluscicides. The effectiveness of this method used is shown in figure 1, as a SWOT analysis. Large areas could be disinfected to eliminate Schistosomiasis by 2025. SWOT gives an overall plan of the project undertaken.

The extent to which cross border greenhouse transmission of emissions along the borders is a challenge in evaluation and agreement among the neighboring countries. A common study was initiated by Aikatesini [2], 2020, to provide a climate control strategy for the European continent. The project developed a program, figure 2, it needed collaboration among the developed and underdeveloped neighboring countries and commitments to support. For example, Egypt and Morocco had borders to be mitigated. The use of SWOT was useful for evaluating each country's strengths or
Weaknesses evaluate Opportunities to create algorithms from the literature survey and finally predict possible Threats to the project not happening. The results helped in evolving strategies for the overall renewable energy usage in Europe.

Weilong Huang [3] 2021 This author had to decide the scope of providing Artificial Intelligence, AI, industry in Guangdong province in China. The authors did a SWOT analysis of combined Chinese and AI and concluded on the opportunities and threats. The analysis gave an overall view and was suggested by subjective analysis. The decision would be better if the authors could have rated the Guangdong province SWOT and related to the SWOT of different AI companies individually evaluated in their SWOT. The proposal in this paper proposes such an objective evaluation. In this project, it will be like doing a regression of the SWOT of Guangdong to the SWOT of AI opportunities. Such a method is used to decide the operating industry in an institute. As the objective and results were recommendations to the government policy with long term economical, technical, and social developments of the reason, the method proposed in this research can give more accurate results.

Another application of SWOT in the analysis is in the use of structural solutions for tall buildings, Jolanta [4] 2017. The authors analyzed different structural design architectural advances to modern tall building design. Modern solutions were evolved due to this analysis referring to the past designs, current practices, and future possibilities. SWOT analysis led to the identification of the important criteria that could lead to solutions applying parametric design options and methods. Again, SWOT was used to discover and evaluate to evaluate possible solutions but did not guide the decision. In the present proposed use SWOT is applied both to the company, Akella Systems which wants to establish a company to manufacture air conditioners there were options, and SWOT analysis is done for each of the options for each of the parameters Strengths, Weaknesses, Opportunities, and Threats ranking values are given. Regression analysis is done using Cramer’s rule for polynomial regression, Wojciech 2008 [5] an online referred application. This method will give a relative graph of the SWOT relation between the two business companies giving a B2B opportunity, a decision-making method compared to the available options of another company or a new premise. SWOT decision-making analysis led to the B2B decision of having the company placed in the Institute to run with the resources of the institute, research, support of the staff, and the enthusiasm of the students.

Further, Andrew Ng 2018 [6] among many others gives the difference between a few opportunities regression as done in B2B SWOT decision to an ML-AI-DL. Mieczyslaw & Zbigniew [7] have modeled a B2B digital market and a commercial conventional market for the flow of products so that the hybrid business will evolve by the flow pattern and forces that happen dynamically. Rozita et al evaluated the bus and heavy machinery business of SHAHAB KHODRO company on about 15 parameters including cost, quality, transportation, delivery, longevity, volumes, etc. Deloitte [8,9] in their internal 2019 report evaluated why some companies obtain 3 times more business than their competitors. They focus on personalization, speed, and outcome focus in their business. This study has been summarized into five key points which will keep you ahead of competitors. Priority Metrics group 2020, in their internal report evaluated different B2B and B2C business scenarios. B2B is parts manufacturers of an Original Equipment Manufacturers, OEM, in this case also the present relative mapping of the two companies, as shown in this study, in their SWOT will help. Their work can be enhanced by this relative SWOT method presented in this paper. LOSASSO a company that evaluates companies has evaluated the fast tracks which are laid in the market for new opportunities that evolve in the digitally-driven market. KPMG [10,11,12] 2020 has surveyed about 75000 customers over 6 months of the Covid pandemic time, they have seen a change in the consumer trends, the digital opportunity has enhanced the supply chain speed and the market is dynamically changing. Hootsuite [13] has evaluated 11189 markets including many of the fortune 500 companies they are all looking at the digital platforms. About 60% are on Instagram and Facebook Tic-tac, Linked In, etc. BoF [14] 2021 has deeply analyzed the market trend. Out of the many companies which are down since the pandemic of 2019 it would take up to 2022 and into the 2023 3rd quarter [15,16]. Heli HalliKainen et al, 2021 have seen the emergence of B2B fostering in the consumer market. Large data if big data analytics are applied then consumer may increase manyfold. Eckert et al [17] predicted business trends up to 2040. Kumar et, el proposed various digital image watermarking techniques for privacy preserving [18-23]. Basic changes will be in the area of design, the customer needs to be met continuously from this viewpoint also the present relative SWOT of the Customer to the manufacturer
can be used to evaluate the Big Data of his business. Many business fields have large opportunities which need to be relatively evaluated to decide on selecting the best choices. This available large data is evaluated using the same method. First by dividing data into training, development, test, and future sets and adjusting for repeatable regression fits. The numerical calculations were done with MS Excel.

Figure 3. SMAC a portable air conditioner

2. Background of the Companies that are evaluated in this work.

The project is to give a location to establish a private seeding company Akella Systems, started by Suresh Akella a professor who had about 23 years of research and quality experience in hermetic compressor manufacturing and its application. Subsequently, he joined the Sreyas Institute of Engineering & Technology, at Nagole, Hyderabad, India. Akella Systems started with student projects in refrigeration and air conditioning. In the year 2013, an MSME project was obtained to make portable air conditioners, SAMC which was developed in-house, incorporating students mini and major projects with the help of mechanical staff and students. Sreyas Mobile Air conditioner, SMAC was patented, shown in figure 3, for use of fiberglass structure, body, and less heat flow losses, in 2018. By 2016 the MSME project was completed with a psychrometric test room constructed. Some trial production was done employing alumni of the institute as engineers. In 2018 a private limited company was formed, and its location of operation was to be decided and finalized which is the reason SWOT analysis is done. Instead of doing formal SWOT on one company a relative SWOT of Akella Systems, AS, with the parent institute, Sreyas, and another company, C1, which has shown interest to partner is done.

The SWOT parameters are subjectively used to analyze the situation. In this work, the parameters are sub-divided, table 1, to give ratings 0-10. The six parameters chosen are S1 for technical strength, S2 for resources availability, W1 for financial strength if it is week value is low, W2 for marketing strength of the product if it is week value is low, O is for location from the center of the city and T, threats is mainly product image which will have low value if product image is not established.

The companies are evaluated on their values, not concerning the relationship with Akella Systems, AS, has strength in research and technology, but week in all other aspects; they would like to be in R&AC business is very good and growing both in India and abroad. Threats are balanced as it has not taken any loans and employees are fresh graduates will grow with the company. They do not have resources and marketing skills mainly the location of the factory and hence the support of another company is sorted. Except for technical evaluation Akella System needs a partner to support. The first choice is Sreyas who have a good research background, finances, good opportunities as an established college, threats not any that they cannot handle. Their weak points are marketing which is not needed in an educational institute. The second location which was available is in an existing company with good financials, very good research and technology background have a good product reach. Their location is away from the city, marketing image in special areas.
### Table 1. SWOT of Companies.

| Code | Parameter     | AS  | Sreyas | C1  |
|------|---------------|-----|--------|-----|
| S1   | Technical     | 6.8 | 7.5    | 8.0 |
| S2   | Resources     | 2.0 | 6.7    | 7.2 |
| W1   | Finances      | 3.2 | 6.5    | 7.8 |
| W2   | Marketing     | 1.0 | 6.0    | 6.5 |
| O    | Location      | 1.5 | 7.0    | 4.0 |
| T    | Product Image | 2.8 | 6.2    | 6.5 |

2.1 A Flow Chart for relative SWOT Analysis

In Figure 3.1 a procedure to use polynomial regression for evaluating the relative benefit of an association between two business units, B2B. This is decided by first selecting a possible business associate conduct a linear regression and see the effect in terms of the coefficients. If $B_2 = a_0 + a_1*B_1$, where $B_1$ company wants to associate, AS, by selecting a $B_2$ company either Sreyas or C1. Constant coefficient $a_0$ gives the average difference between the two companies in terms of the selected SWOT parameters. Similarly, the slope coefficient, gives how the companies influence operation concerning the SWOT parameters selected. If Linear regression is satisfactory, you may close the decision otherwise a quadratic regression is conducted.

**Figure 3.1** A flow chart of Regression analysis of B2B SWOT

The quadratic relation is $B_2 = a_0 + a_1*B_1 + a_2*B_1^2$. Again, coefficient, $a_0$, gives the average level differences between the two business units $B_1$ and $B_2$, $a_1$ gives the influence of operating concerning the selected SWOT parameters. Next at a particular parameter the slope may change suddenly having a specific influence, for reaching the operation level of $B_2$ company with a quadratic influence of $B_1$ company. The required decision may be reached with Business unit $B_2$ with a linear or quadratic regression otherwise the next company is considered for analysis.

3. Polynomial Regression

When we have large data and we want to see a trend we fit a curve and see how the two values on the x-axis and y-axis are related. If they have a constant increasing or decreasing relationship a linear polynomial of degree one fits. If there is a change in the relationship a quadratic relation might fit of...
2nd order polynomial. Higher-order polynomials like cubic and higher are also possible as the data distribution demands. Apart from polynomial Harmonic, Exponential and Logarithmic and some combinations of these are possible to obtain the required accuracy and precision of fit. In this study, linear and Quadratic polynomial fits are used. Let a linear 1st-degree polynomial (1) and a quadratic 2nd-degree polynomial (2) be as given below

\[ y = a_0 + a_1 x \quad (1) \]
\[ y = a_0 + a_1 x + a_2 x^2 \quad (2) \]

We might use this polynomial to fit into our \( n \) data sets of \( \{ x_i, y_i; i=1, \ldots, n \} \). We will have to find the coefficients \( a_0, a_1 \) for the linear fit of the equation to the \( n \) sets of data or we can try a quadratic fit where we need to find \( a_0, a_1, a_2 \), these coefficients from the given set of values of \( \{ x_i, y_i; i=1, \ldots, n \} \).

Cramer has given the matrix equations which will define a \( k \)th order polynomial to obtain the coefficients. Matrix \([M]\) of size \((k+1) \times (k+1)\) size is as shown in equation (3)

\[
\begin{bmatrix}
\sum_{i=1}^{n} x_i \cdots \sum_{i=1}^{n} x_i^{k+1} \\
\sum_{i=1}^{n} x_i^2 \cdots \sum_{i=1}^{n} x_i^{k+2} \\
\vdots \\
\sum_{i=1}^{n} x_i^{k^2} \cdots \sum_{i=1}^{n} x_i^{2k} \\
\end{bmatrix}
\]

Defining a \( \{Y\} \), column matrix of size \((k+1) \times 1\) as in equation (4)

\[
\begin{bmatrix}
\sum_{i=1}^{n} y_i \\
\sum_{i=1}^{n} x_i y_i \\
\vdots \\
\sum_{i=1}^{n} x_i^k y_i \\
\end{bmatrix}
\]

Also, we can define a coefficients column matrix, \( \{a\} \), again a \((k+1) \times 1\) size in equation (5)

\[
\begin{bmatrix}
a_0 \\
a_1 \\
\vdots \\
\vdots \\
a_k \\
\end{bmatrix}
\]

The equation of the polynomial coefficients can be obtained from \([M]\{a\} = \{y\}\).

Cramer has given the equation to obtain the \( k \)th coefficient by calculating the ratio of the determinants of the matrices as given in equation (6).
\[ a_i = \frac{\text{det}(M_i)}{\text{det}(M)} \]  

(6)

Where matrix \([M_i]\) is obtained by replacing the \(i\)th column of matrix \([M]\) with the column \([y]\).

This method was used by defining \(x_i\) from the SWOT values of the business unit, AS; and SWOT values of the business unit Sreyas for \(y_i\) in case1. Similarly, in case 2 the \(x_i\) values remain of the business unit AS; \(y_i\) values are taken from the SWOT values of business unit C1. The linear equation (1) and quadratic equation (2) is obtained by substituting the coefficients \([a]\) obtained from regression equation (6). The results of data and fitted values are plotted and discussed to obtain the decision.

The error of fit is given by

\[ \varepsilon = \sqrt{(y - y')^2} \]  

(7)

The % fitness is calculated as

\[ \frac{(y - y')}{y'} \ast 100. \]  

(8)

4. Results and Discussion

The data of SWOT for the business units Akella Systems, AS, and the two possible companies, Sreyas and C1 are analyzed and some rating is given in digital values ranging from 0 to 10. When it gets the highest desired performance it will get 10 and 0 if it has no value in this parameter. Sreyas Institute is a very well established engineering institute which is inside the Hyderabad City hence it had a good rating of 7.0 whereas the factory the second unit C1 is away from city hence had a rating of 4.0, whereas AS is yet to have a permanent operation location hence a row rating of 1.5. Whereas the S1 technical rating of all three business units is good the difference in rating is due to longevity.

In all parameters other than Technical Akella Systems has a low rating as a new company. Both of the other units are well established; Sreyas in the education field and C1 in manufacturing and get similar ratings on other parameters. The requirement is not a perfect fit as improvement is sort by Akella systems to overcome its weaknesses. The fit provides a moderated value to take a decision.

The order of SWOT parameters of AS is taken on the x-axis is given in order of increasing rating as 1. W1, Marketing; 2. O, Location; 3. S2, Resources; 4. Product Reach, T; 5. Finance, W1 and 6. Technical, S1. This order and values are maintained in both cases in comparison with Sreyas and C1 business units.

4.1 Case1: Akella system SWOT parameters comparison to Sreyas

The Linear regression is done with the 6 independent SWOT parameters of \(x\), AS, and obtained the dependent SWOT parameters of \(y\), Sreyas the linear equation obtained is

\[ Y = 6.116 + 0.185x. \]

As the coefficient of \(x\) is less than 0.5, 0.185 the SWOT of Sreyas company has more effective in this association. The initial shift upwards of the constant-coefficient, 6.116 shows that Sreyas is above AS in all the parameters by this amount.
Figure 4. Akella Systems SWOT compared with Sreyas with a Linear Fit

The regression equation fit and excel equation both match hence a perfect fit. This line is a reference to how the actual data points of each SWOT parameter vary about a possible linear relation. The variation is studied in each case from this reference line. We do not want the actual data to fall in the line, we evaluate the variation and see how it affects the association.

The Linear fit, figure 4, of Akella Systems on the x-axis with Sreyas, the y-axis shows an $R^2 = 1$, a perfect fit. The X-axis has the SWOT points of Akella Systems the technical capability of Akella Systems in their area of work, refrigeration, and air conditioning, is good and meets with Sreyas capability of 7.5 and needs no assistance in this area. All other areas of the SWOT Akella system are weak and provide a possible improvement of 1. W2, Market 5.3 = (6.3-1.0) up to 2. O, Location of 4.9 = (6.4-1.5). the actual difference is 5.5 = (7-1.5) but the linear fit moderates the value. Overall, the advantage for a start-up company Akella Systems can gain SWOT value of business opportunity by about 5 points in this association.

Figure 5. Akella Systems SWOT compared with Sreyas a quadratic fit.
The results of quadratic fit by the regression are shown in, figure 5. The quadratic fit using regression and the linear fit of MS Excel differ with a goodness of fit of $R^2 = 0.903$. So, it reveals that a linear fit is sufficient for the analysis.

4.2 Case2: Akella system Comparison of SWOT parameters with C1

Here, the fit of the linear fit of the data by MS excel, with the quadratic regression model has a goodness of fit of $R^2 = 1$. The linear equation has $y = 0.421x + 5.453$. The initial average of C1 company in all the SWOT parameters is better by 5.453. The coefficient of variable x is 0.421 nearer to 0.5 which means there is a very slight influence of the AS over C1 company in these parameters.

![Graph showing SWOT comparison between AS and C1](image)

The comparison of SWOT parameter values of Akella Systems is compared with business unit C1, figure 6, a manufacturing company with great R&D basis there is a possibility to learn on 6. S1, technical aspects also in this association. The possibility of locational advantage is, 4.6 = (6.1-1.5). Overall improvement in the non-R&D areas of SWOT about 4.5 values. Compared to about 5.5 when compared to the Sreyas association.
Figure 6. Akella Systems SWOT compared with C1 with a linear fit.

The comparison of SWOT parameter values of Akella Systems is compared with business unit C1, figure 6, a manufacturing company with great R&D basis there is a possibility to learn on 6. S1, technical aspects also in this association. The possibility of locational advantage is, 4.6= (6.1-1.5). Overall improvement in the non-R&D areas of SWOT about 4.5 values. Compared to about 5.5 when compared to the Sreyas association.

Figure 7. Akella Systems SWOT compared with C1 a quadratic fit.
The fitment of Quadratic is better by 1.2% over the linear fitment in AS to C1 comparison, figure 7. The improvement is in the lower five values of importance for decision-making. The important location has a similar 5.9 -1.5= 4.4 points benefit in the association with this business unit. The decision is based on the non S1 SWOT parameters as Akella Systems is technically capable. Based on the location of the Sreyas in the city, the decision was to operate the company in the Sreyas Institute of Engineering and Technology. The non-SWOT analysis for taking the decision was to transfer technology to students and to operate with young engineers.

5. Extension of the SWOT relative decision making to ML-AI applications.

The amount of data of business units considered in this example is only two, Sreyas and C1 which were compared relatively to the SWOT 6 parameters for decision making on placing its operation in a partnering company. In a wider scenario there may be very large, tens, hundreds, thousands of options available. Like locating a company globally, finding the right vendor for a part, finding the right employee for a job, finding optimum military operation, etc. In such cases, the data may not have a defined distribution or a curve to fit. In this study, even a linear fit was enough to give decisive information. The curve was a normalized set of values giving a mean distance from the Akella system values to the compared company. This distance was enough to decide. This distance can be estimated as a metric. We do not want the distance to be less, if both companies are the same there is no benefit or advantage for a start company as there is nothing to gain, the further the distance possibility of growth for Akella Systems to obtain a quick gain in business. The present study can be used as a training set, with a metric defined based on the objectives required. This metric can be used on a larger data set, with different distributions of data. And check on a test data set to validate the algorithm and implement it on larger data in the application in future use. This approach of Machine learning might prove useful in complicated data and decisions.

Table 2. A weighted SWOT of Companies.

| Code | Parameter   | B1  | B2  | W  | W*B1 | W*B2 |
|------|-------------|-----|-----|----|------|------|
| S1   | Technical   | R11 | R21 | W1 | R11*W1 | R21*W1 |
| S2   | Resources   | R12 | R22 | W2 | R12*W2 | R22*W2 |
| W1   | Finances    | R13 | R23 | W3 | R13*W3 | R23*W3 |
| W2   | Marketing   | R14 | R24 | W4 | R14*W4 | R24*W4 |
| Om   | Location    | R1m | R2m | Wm | R1m*Wm | R2m*Wm |
| Tn   | Product Image | R1n | R2n | Wn | R1n*Wn | R2n*Wn |

\[
\sum_{i=1}^{n} W_i = 1.0
\]

In table 2., a weighted rating is shown which will give importance to the, n, SWOT parameters chosen. The weighting for each parameter is chosen by the importance company B1 has an interest in obtaining from company B2. The overall sum of all weights should be =1. This will normalize the total effect of the relationship. This method will be used in our future studies of relative SWOT analysis.

Conclusion

A standard SWOT managerial method is used for the analysis of evaluating possible options of the company to decide on its operational location. Two options, one in an institute and the other in a company were evaluated. Modeling a relative polynomial regression of SWOT analysis of both companies was developed. Linear regression and a quadratic regression fit are provided for the two SWOT data. The linear regression model is also validated with a linear model of MS excel they have 100% equation of the regression model. The linear fit says \(y=a_0+a_1x\) where \(x\) is the company Akella
System, AS. The constant-coefficient $a_0$ gives on an average how much the associated company is better than AS. For Sreyas college, $a_0$ is 6.116 and for C1 company it is 5.453. This value gives Sreyas has slightly better overall position compared to company C1. The coefficient of $x$, $a_1$ gives how the parameters change concerning AS. If $a_1=0.5$ both companies have equal influence on each other. If $a_1>0.5$ then the associated company has more of an effect on AS. In this data both the fits have $a_1<0.5$ so AS has more influence; concerning Sreyas it is 0.185 so Sreyas SWOT parameters have more influence on the relationship compared to C1 where the coefficient of $x$, $a_1=0.421$. Quadratic curve fitting accuracy is not so critical as the curve is used to decide the relative distance parameter-wise between Akella Systems and the partnering company. Technical competence was good among all companies. Deciding factor was the location and nearness to the city, on other parameters both Sreyas and C1 were having a similar distance to Akella Systems. Presently AS is operating in the institute with student support in development and operation. Finally, this method can be tried where large data of relative comparisons are required in deciding on SWOT analysis taking the ML method.

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