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Application of Neural Network in Portfolio Product Companies: Integration of Boston Consulting Group Matrix and Ansoff Matrix

M. Khajezadeh, M. Saied Fallah Niasar, S. Ali Asli, D. Davani Davari, M. Godarzi, Y. Asgari

Abstract**—**This study aims to explore the joint application of both Boston and Ansoff matrices in the operational development of the product. We conduct deep analysis, by utilizing the Artificial Neural Network, to predict the position of the product in the market while the company is interested in increasing its share. The data are gathered from two industries, called hygiene and detergent. In doing so, the effort is being made by investigating the behavior of top player companies and, recommend strategic orientations. In conclusion, this combination analysis is appropriate for operational development; as well, it plays an important role in providing the position of the product in the market for both hygiene and detergent industries. More importantly, it will elaborate on the company's strategies to increase its market share related to a combination of the Boston Consulting Group (BCG) Matrix and Ansoff Matrix.

Keywords**—**Artificial neural network, portfolio analysis, BCG matrix, Ansoff matrix.

I. Introduction

THE BCG Matrix is a renowned analysis method, which was developed by Boston Consulting Group in 1973, to conduct strategic analysis and to compare a business's market share with their anticipated growth in the next years. This matrix also is called as a "product portfolio analysis". This approach is conducted by selecting and combining sales growth rate and market share as the two indicators to examine the product portfolio into four types as [1]:

1- Question Marks: determine high growth market with a low market share
2- Stars: determine the high in both growth and market share
3- Cash Cows: determine low growth in the market with a high market share
4- Dogs: determine the low in both growth and market share

As shown in Fig. 1, the BCG matrix applies simple two-dimensional analysis on the product portfolio; industry growth rate is the vertical axis and relative market share is the horizontal axis [2]. This approach in the 1980s was a useful framework for portfolio analysis, such that [3] suggests that no other matrix was as extensively applied as the BCG matrix. It was established for the welfare of the business organizations. It is an overly simplistic representation and has some clear limitations; [4] and [5] expressed that organizations which use this approach, make success in their business procedures. Therefore, BCG is discussed as the most well-known analyzing portfolio matrix. Furthermore, BCG can make good predictions for the future actions of an organization by emphasizing on the cash flow, and draws attention into the investment appearances. To be more concise, BCG indicates that the profit of the company is directly related to its market share. Irrespective of all BCG's advantages, it has some limitations. According to [6], there exists a challenge to decide the distinction between high and low in market share and growth rate.

The BCG Matrix makes it possible to evaluate the balance of a company's portfolio and enables the positioning of activities according to two dimensions:

- The growth rate of the market (or the strategic activity area), which is measured, for the past, from the available statistical data. It allows judging the dynamism of the activity.
- The relative market share held by the firm measured by its relative weight compared to its main competitor. It is measured by the ratio between the market share of the company (or sales) - expressed in turnover - over that of the largest competitor (or the average of those of all competitors). It provides an idea of the competitive position of the company.

On the market growth side, the company must estimate the liquidity needs (investment + working capital requirements) that can be generated by the different business areas.

On the other side of the relative market share, the company releases the levels of resources generated by the segments (profitability of each segment). The x-axis is subdivided into measures on a scale from right to left, from 0% to 100%, and where the median value is 50%.

A. Ansoff Matrix

The Ansoff Matrix is a decision matrix for strategies in diversification and growth. It was developed by H. Igor Ansoff in 1957. The Ansoff Matrix has four main strategies for selecting prominent strategies to help companies decide to apply suitable action based on current performance (Fig. 2). These four strategies are [7] in Fig. 2.

- Market Penetration: It happens when a company arrives in an existing market with current products and try to increase company revenue and obtain part of their competitor's market share through promotions, advertisements and so on.

Mohammad Khajezadeh is with the Iran University of Science and Technology, Iran, Islamic Republic Of (e-mail: khajezadeh.sina@gmail.com).

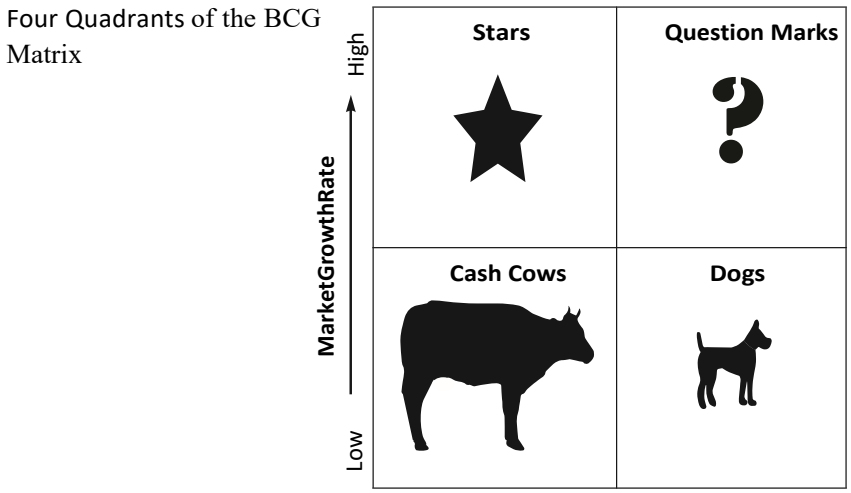

Fig. 1 Schematic of BCG Matrix

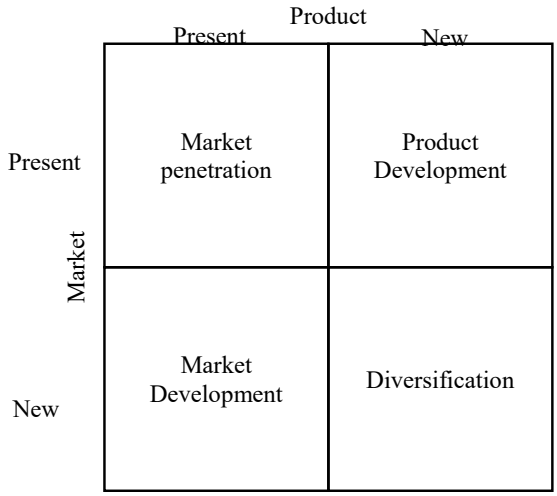

Fig. 2 Ansoff Matrix

- Product Development: It occurs when a company wants to market a new product to existing and new customers. This strategy can be an essential orientation for companies to stay competitive since new products lead them to achieve new customers.
- Market Development: It occurs when a company tries to market the present products to new audiences and markets which is conducive to earn more revenue. For examples, firms can attain these conditions by exporting or marketing their products in a new region.
- Diversification: It occurs when a company markets new products to new audiences and regions. This strategy has two forms, related and unrelated diversification. Related diversification means that the company remains in a market or industry with which we are familiar. For example, an FMCG firm diversifies into new related products (i.e., the food industry). Unrelated diversification is when the company has no previous industry or market experience. For example, an FMCG firm invests in the energy business.

This study will apply a combination of the Ansoff Matrix and BCG model and try to highlight the detailed analysis for existing industries and then suggest a strategic directions recommendations model. In practice, while the company intends to increase market share, the distribution in the Ansoff Matrix needs to be changed. It should be noted that this study concerns company data from 2013 to 2016. This hybrid model reveals the efficacy of a company's analysis based on their portfolio, not only at a given moment but also at the evolution over time and through the type of product and complicated market, which leads to find the most balanced position of the company's portfolio. During this study, it was attempted to investigate the behavior of top player companies in the detergent industry and to recommend strategic orientations. The study began by positioning each company in the Ansoff and BCG matrices and to obtain patterns using Neural Network. For reasons of confidentiality of data, the name of the company under study will not be divulged.

Artificial Neural Network (ANN) is a computing tool in the field of artificial intelligence that mimics the behavior of the brain. ANNs have found numerous applications in solving real-world problems in various fields of science, business, and industry. One primary advantage of ANN is its high ability coupled with the simplicity of its application.

The fundamental part of an ANN is a neuron, which serves as a unit for processing information. To process information using an ANN, three primary characteristics need to be defined. The first is network topology, which determines how the nodes and connecting lines are arranged and can be feedforward or feedback networks. The second is related to the method of determining the weights of connecting lines, which is called learning. There are three types of learning, namely supervised learning, unsupervised learning, and reinforcement learning. To consider complexities and nonlinearities in the model, the third element that is the activation function is also embedded in the structure of the

ANN.

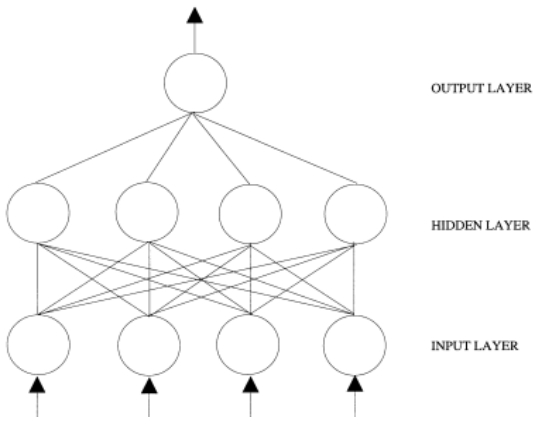

Fig. 3 Schematic of Artificial Neural Network

Based on their remarkable characteristics, ANNs prove to be great tools in the area of forecasting. They are data-driven, therefore requiring fewer assumptions compared to model-based methods. This feature makes them highly favorable and sometimes the only option in real-world conditions. They can serve as alternatives in the cases where the relationship between variables is unknown or very complex to model. An artificial neural network works by receiving inputs, learning from inputs, and producing outputs. This way, ANN can be viewed as a function. Looking at Fig. 4, the input layer for forecasting is the set of independent variables, and the output layer is the dependent variable(s). Therefore, this study seeks to use ANN to help in strategic decisions. It is based on the Boston Consulting Group's (BCG) or growth/share matrix. Using the portfolio of products, we have data such as the brand, product, whether it is an existing or new product, relative market share, and relative market growth. A sample of the historical data as depicted in this paper consists of six independent variables, including the year, brand, product, existing and new market, and relative market share and market growth rate.

This model shall finally help to draw the relationship between the BCG and Ansoff matrices. Specifically speaking, we can decide how to improve the share/growth (in the BCG Matrix) by controlling the strategic decisions of market penetration, product development, market development or diversification (in the Ansoff Matrix). One issue to address is the architecture of the network. The network in this paper has three layers, namely, an input layer, a hidden layer, and an output layer. In the process of learning, the weights and other parameters are calibrated. The goal is to minimize the forecasting error, which is calculated by mean absolute percentage error (MAPE). The structure of hidden layer was determined by testing the effect of a different number of neurons in the hidden layer on MAPE. As Fig. 3 shows, 10 hidden neurons can be selected. The transfer function for hidden nodes is the sigmoid function. For the training function, the Levenberg-Marquardt optimization algorithm was used.

II. Methodology

In this study, three years of sequential sales data of five varied product groups based on the detergent and hygiene industries are investigated. Then, ANN algorithm is used to predict the market growth evaluation indicators. This approach is trying to generate reasonable link between Ansoff Matrix and BCG Matrix context, and eventually, based on the expected growth rate, the strategic orientation of a company toward achieving competitive position in market. What follows is the procedure to tackle our solution methodology sequentially:

Step 1: Gather the sequential sales data of company "A" in two industries (detergent and hygiene) followed by five product categories in the period of 2015-2018.

Step 2: Determine both market leader share and market growth rate for each product category-derived Ansoff Matrix for each industry.

Step 3: Apply the ANN algorithm to achieve the variation percent share in four dimensions of the Ansoff Matrix.

Step 4: Identify new strategies based on the modified Ansoff Matrix that is derived from the previous steps. In the following, to demonstrate the application of the proposed model, a case study is discussed.

Case study investigation:

Step 1) BCG Matrix

The BCG Matrix is developed (Table I and Fig. 4) based on the sales data of the company in the detergent and hygiene industries.

TABLE I
BCG Matrix Input Data

Product	Market growth	Market share	Leader market share	Relative market share	
A	3.0%	10.0%	35.0%	0.29	
B	5.0%	25.0%	40.0%	0.63	
C	4.5%	25.0%	30.0%	0.83	Detergent Industry
D	7.0%	23.0%	35.0%	0.66	
E	6.8%	40.0%	35.0%	1.14	
F	3.0%	40.0%	35.0%	1.14	
G	5.0%	17.0%	40.0%	0.43	
H	4.5%	17.0%	30.0%	0.57	Hygiene Industry
I	7.0%	15.0%	35.0%	0.43	
J	6.8%	12.0%	35.0%	0.34	

As it is shown in Fig. 4, the company in all categories of the detergent industry except "E," is not in the proper position and has less market share related to the top competitor. Interestingly, this scenario is also remarked in the "F" category of the hygiene industry. These conditions are driven by the lack of appropriate strategies to obtain market shares. Irrespective of these issues, the company is ranked as a market leader in the hygiene industry and placed in the cash cows BCG matrix dimension. This product category is defined as funding for the other categories and company business portfolio. Nevertheless, referring to the BCG matrix and deviation in market shares (Table II) can conceive that the company does not carry out suitable strategies in the detergent

and hygiene industries. It is suggested that the company must achieve at least 25% growth in category "A" to approximate the leader market share. Therefore, effective measures must be taken to achieve the proper share for each industry. Ansoff Matrix analysis would be one of the alternatives to drive suitable orations and improve industry functions and relative market shares in both industries.

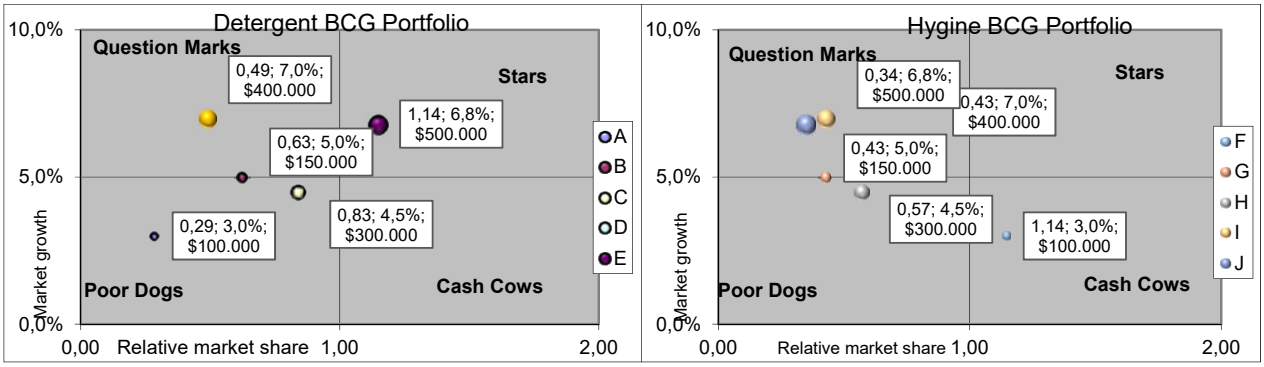

Fig. 4 Schematic of the BCG Matrix for the available data

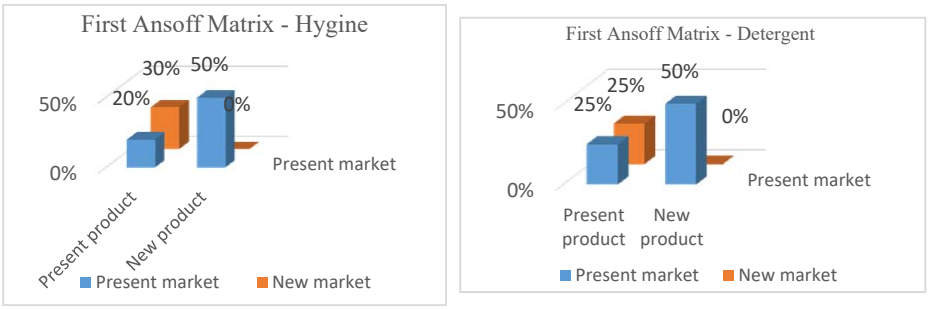

Fig. 5 First Ansoff Matrix for both Hygiene and Detergent industries

TABLE II
MARKET SHARE DEVIATION OF EACH PRODUCT IN TWO INDUSTRIES

Hygiene		Detergent	
Product category	Market share deviation	Product category	Market share deviation
F	-15.0%	A	25.0%
G	23.0%	B	15.0%
H	13.0%	C	5.0%
I	20.0%	D	18.0%
J	23.0%	E	-5.0%

Step 2) Ansoff Matrix – ANN algorithm application

Conducting the business portfolio analysis of company "A" based on the mention categories and industries (detergent and hygiene), reveals the following matrix as the current Ansoff Matrix of the company (Fig. 5).

According to sales data for 2014 to 2016, the parameters of each of the dimensions of the Ansoff Matrix are defined as follows: i = product, j = company, t =period time, X_{ij}^t= relevant share to leader, Y_{ij}^t= relevant growth to industry.

Ansoff Matrix	
Z	L
M	K

Also the decision values are:

$$Z_j = f(X_{ij}^t, Y_{ij}^t)$$
$$M_j = f(X_{ij}^t, Y_{ij}^t)$$
$$L_j = f(X_{ij}^t, Y_{ij}^t)$$
$$K_j = f(X_{ij}^t, Y_{ij}^t)$$

Based on the results of the calculation and analysis of the ANN algorithm, the prediction growth rate in each industry for detergent and hygiene are respectively, 11.6% and 14.8%. According to the available dashboards for different market growth, the final Ansoff Matrix is obtained. Fig. 6 shows the result.

According to the final Ansoff Matrix (Fig. 6), for the detergent industry, the company must enhance the market penetration strategy within its business portfolio strategies to achieve 11.6% growth. Whereas in the first Ansoff Matrix (detergent), this share was about 25% and the company applied a product development strategy more than the other strategies. Through calculating the deviation value of each of the matrix dimensions from the final issues (Fig. 6), the percentage change in each quadrant of the matrix is determined, which is shown as in Table III for the detergent industry.

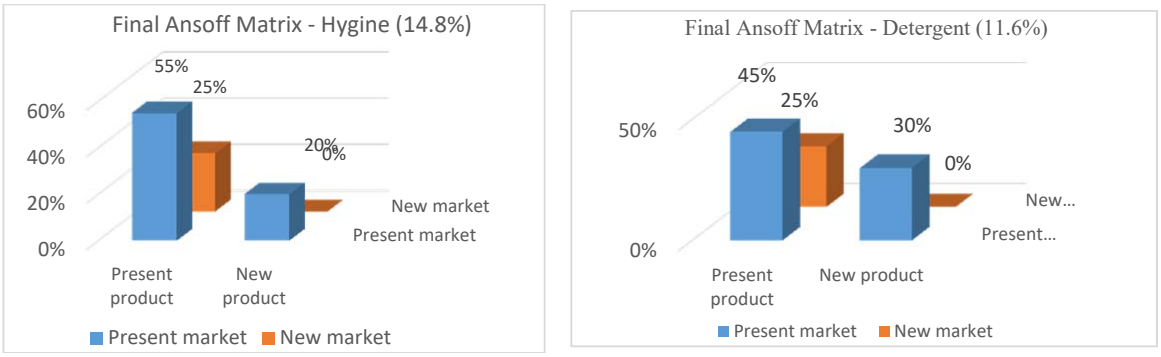

Fig. 6 Final Ansoff Matrix for both Hygiene and Detergent industries

TABLE III
THE PERCENTAGE CHANGE IN EACH SEGMENT OF THE ANSOFF MATRIX IN DETERGENT

Detergent		
Variation rate	Present product	New product
Present market	20%	-20%
New market	0%	0%

It was mentioned that within the detergent industry, the company should decrease its share of the new product category (product development strategy) in 20% to obtain 30% share for its business portfolio strategies, which means that 30% of business strategies are included in the product development strategy. On the other hand, using market penetration strategies, the company should increase the share of its existing products in the present market to 20% which leads to strengthening its main market. Eventually, based on the final Ansoff Matrix in the detergent industry, most of the company orientations must be chosen based on penetration in the market. In this regard, among all five categories, the company can select one competitive product category, in which it has core competency to develop some new products and sustain the present market and then to expand the present market share. The rest of the product categories use market penetration and development strategies, which finally leads to 11.6% growth in the detergent industry market share.

Similar to this condition, some analysis is arbitrated in the hygiene industry. The primary hygiene Ansoff Matrix shows that the company is concentrated more on the present market and new products. In this industry, according to the ANN analysis, expected market growth for 2018 would be 14.8%, which demands that the company reduce the share of its product and market development strategies respectively, 30% and 5%. These hygiene industry portfolio deviations are presented as in Table IV.

TABLE IV
PERCENTAGE OF CHANGE IN EACH SEGMENT OF THE ANSOFF MATRIX IN HYGIENE

Hygiene		
Variation rate	Present product	New product
Present market	35%	-30%
New market	-5%	0%

Similar to the detergent industry, the company must apply a market penetration strategy more than the other orientations; the share of this strategy should increase to 35%, as an alternative solution the company must have 5% and 30% reductions in their development strategies. With regards to this fact in the hygiene industry, the company could gain 14.8% increase at market share through entering to present market with competitive attributes and new product categories, then follow the penetration and expanding strategies for the other products.

III. CONCLUSION

The literature review shows the importance of using both the Ansoff Matrix and BCG Matrix to determine strategy orientation. In this paper, three years' sequential sales data for five varied product groups based on the detergent and hygiene industries are executed. After that, the ANN algorithm is taken to provide the new application of the Ansoff Matrix. This approach attempts to provide a profitable link between the Ansoff and BCG matrices. Eventually, the expected growth rates are entered in this model and then the strategic orientation of a company to achieve in a competitive position in the market was defined.

REFERENCES

[1] Chen, Yuanping, Dengsheng Wu, Jianying Sun, Fengxia Wang, Wenbin Jiao, (2015), "Design, and Implementation of a Scientific Research Funds Analysis Model Based on Boston Matrix", Procedia Computer Science, Volume 55, 2015, Pages 953-959.
[2] Temmerman, R. (2011). Stars, Problem Children, Dogs and Cash Cows: Evocative Terminology. In Multilingual Business Communication, SYNAPS. *Journal of Professional Communication*, *26(2), 48-61*.
[3] Morrison, A., & Wensley, R. (1991). Boxing Up or Boxed in?: A Short History of the Boston Consulting Group Share/Growth Matrix. *Journal of Marketing Management, 7(2), 105-29.*
[4] Burgelman, R. A., Maidique, M. A., & Wheelwright, S. C. (2000). Strategic Management of Technology and Innovation (3rd Ed.). New York: McGraw-Hill.
[5] Lu, H., & Zhao, L. (2006). Integrating GIS and BCG Model for Marketing Strategic Planning. The 11th Annual Conference of Asia Pacific Decision Sciences Institute. Hong Kong.
[6] Whittington, R., Johnson, G., Scholes, K. (2008). Exploring Corporate Strategy. 8nd Edition. Harlow: Prentice Hall.
[7] Ansoff, Igor (1957), "Strategies for Diversification," *Harvard Business Review* 35(2):113–124.