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Determinants of Islamic Banks' Profitability Using Panel Data Analysis and ANFIS Approaches in Saudi Arabia

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ABSTRACT. The purpose of this study is to determine the relationship between profitability and financial ratios of Islamic banks in Saudi Arabia. To accomplish this goal, quarterly data of four Islamic banks from 2009 to 2017 were considered. The Artificial Neural Network (ANN) and Fuzzy System, or ANFIS (Adaptive Neuro-Fuzzy Inference System), was employed to predict the profitability of financial ratios. To determine impacts of financial ratios on the profitability measures, the study includes panel data analysis. The average prediction error for the ANFIS model of return on asset (y_1) with four rules was 0.3537%, and the return on equity (y_2) with five rules was 0.31829%. The results showed that all the explanatory variables, except stock capital gain ratio, have a significant positive relation with profitability measure of either return on asset or return on equity of Islamic banks in Saudi Arabia. However, only total equity to total asset and earning per share ratios have relation with both the profitability measures. The results of descriptive statistics, multiple regression, and ANFIS models established that successful outcome can be obtained for y_1 and y_2. Therefore, this study will be beneficial not only for the literature, but also for the investors and executives of Islamic banking.

KEYWORDS: Islamic banking, profitability, financial ratios, panel data analysis, neural-fuzzy prediction.

JEL CLASSIFICATION: G21, C33, C45

KAUJIE CLASSIFICATION: L25

1. Introduction

In order to attract individual and institutional investors staying away from interest (*ribā*[1]) into the economy, Islamic banking started in the 1970s in the world, and 1980s in Saudi Arabia (al-Harbi, 2015, pp. 14-15; Akkaş, 2017, p. 4). Islamic banking progressed both in Muslim and non-Muslim countries. After the establishment of the Islamic Development Bank in 1975, Islamic banking began to spread rapidly.

In addition to being in compliance with Islamic rules, Islamic banking economically is a financial institution based on the concept of profit-loss partnership. It contributes to the economic development of countries by increasing employment and boosting production. One of the funding methods of Islamic banking is like the one used in the venture capital trust (labor-capital partnership). This model is now widely used in the US. In addition, in their developing stage, developed countries had employed venture capital financing model intensively, especially the US, which helped improve their economy by giving a fillip to individual enterprise (Gompers & Lerner, 2001). However, when the funding methods of Islamic banks are analyzed, it is seen that the usage of the labor-capital partnership funding method is too low, and this situation can prevent the expected economic benefit of Islamic banking.

All countries, except a few like Sudan in the past, have a dual banking system, vis-a-vis both Islamic and conventional banking operate alongside. This implies that they must share the deposits in the banks, giving rise to serious competition, which is inevitable. To compete with the conventional banks and attract more deposits, Islamic banks need to distribute more dividend to the participation account holders. Therefore, the present paper, which is based on the research to find out determinants of Islamic banking's profitability, can be beneficial to many leading companies.

Conventional banks offer fixed interest rates, whereas Islamic banks give unstable dividends to customers. So, to compete with conventional banks, the dividend rate given by Islamic banks must be greater than the interest rate given by conventional banks. Otherwise, Islamic banks would have a disadvantage in competing and getting enough deposits from the public. This means that to stay ahead in competition and profitability, it is very crucial for Islamic banks to offer better rates. Therefore, there is a great need for research on the profitability of Islamic banks.

The main purpose of this study is to investigate the key internal and external financial ratios affecting profitability of Islamic banking in Saudi Arabia. Evaluation of the performance of the Islamic banking and efforts to determine the financial factors that have salutary impact on the performance of Islamic banking will be of immense benefit to investors, as well as to executives of the banks and other stakeholders.

In the literature, there are very few studies on the relationship between the profitability of Islamic banking and financial variables in Saudi Arabia. This study, in which both internal and external financial variables are applied, will assumably fill this gap. From this point of view, it can be thought that this article may be beneficial to the literature on Islamic banking in Saudi Arabia.

This article consists of six sections. Section 1 outlines objective and salient features of this study. Section 2 provides the literature review that details researches about determinants of Islamic banking's profitability. Section 3 explains the Islamic banking philosophy. Section 4 describes the research methodology and data. Section 5 presents analysis of the study and findings. Finally, Section 6 presents the conclusion of the study.

2. Literature Review

Most of the studies to determine financial and economic factors affecting profitability of banks were performed for the conventional banking system. On the contrary, there are very few studies of this type on the Islamic banking sector, especially in Saudi Arabia. The issues dealt with in the studies are described below.

Rashid and Jabeen (2016) investigated bank-specific, financial, and macroeconomic performance determinants of Islamic and conventional banks in Pakistan. They did panel data analysis by using bank level, financial and macroeconomic variables for the period 2006 to 2012. The parameters of CAMELS

(1) The definitions for all Arabic terms in the paper are given in the 'Glossary' in the intro pages.

(Capital Adequacy, Asset Quality, Management, Earnings, Liquidity, and Sensitivity to Market Risk) were used as a performance indicator (Rashid & Jabeen, 2016, p. 96). According to the results, operating efficiency, deposits, and market concentration have an impact on the performance of Islamic and conventional banks. The impact of Gross Domestic Product (GDP), overheads, operating efficiency, and lending interest rates on performance is negative for both banking types. On the other hand, bank reserves are positively related to the performance.

Noman (2015) examined the effects of bank specific macroeconomic determinants on the profitability of seven Islamic banks in Bangladesh between 2003 and 2013. Pool regression model (PRM) and generalized method of moments (GMM) were employed in the investigation process. The study shows that while credit risk, loan ratio, cost efficiency and capitalization have significant negative effect, bank size has significant positive effect on the profitability of Islamic banks in Bangladesh.

Aslam et al. (2016) investigated to find the main factors/determinants that affect the profitability of Islamic banks in Pakistan for the years 2007 to 2014. They used internal, industry specific, and external economic factors. Return on equity and return on assets were used to measure the profitability of Islamic banks. Bank size, deposits, and financing/investment were used as internal variables, market share was used as industry specific variable, while inflation and GDP were used as external economic factors. Linear regression analysis was used to check the level of importance and relationship of variables with the return on equity and return on assets as profitability. Results of the investigation showed that size, financing, and market share positively affected return on equity and return on assets. However, deposits, GDP, and inflation negatively affected return on equity and on assets.

Paulin and Wiryono (2015) examined Islamic banks in Indonesia by using quantitative analysis by using CAMELS method to determine the financial factors affecting profitability of Islamic banks. They used 6 Islamic banks' data during the 2009-2013 period and performed analysis with the use of multiple linear regression. While return on assets was used as the dependent variable, non-performing financing, operational efficiency, net interest margin, financing to deposit ratio, and allowance for earning asset and possible losses compliance, were used as independent variables. Results showed that net interest margin and allowance for earning assets and possible losses compliance had a positive impact on the return on assets, whereas operational efficiency had a negative impact on the return on assets.

Siddique et al. (2016) searched to find factors that determine the profitability of the Islamic banking industry in Pakistan. Internal and external financial variables were used in the analysis for the period from 2004 to 2012. Quarterly unbalanced panel data was used for nine Islamic banks: five full-fledged Islamic banks and four standalone Islamic branches of conventional banks. Encompassing Approach and General to Specific methodology were applied to select the most appropriate model. They found that internal factors were relatively more important than external factors. According to the results, total assets, operating expenses over total assets, number of branches, capital ratio (total equity to total asset), and liquidity from the internal variables, while inflation, and interest rate from the external variables were significantly related to the return on assets in both the long run and short run. However, only inflation did not have an impact in the short run. They also concluded that banks with high capital ratio were relatively more profitable.

Bashir (2003) analyzed how bank characteristics and the overall financial environment affected the performance of Islamic banks. By utilizing bank level data, they examined the performance indicators of Islamic banks across eight Middle Eastern countries from 1993 to1998. A variety of internal and external banking characteristics were employed to predict factors affecting profitability and efficiency. Their findings showed that high capital-to-asset, and loan-to-asset ratios had an impact on profitability. The results also indicated that implicit and explicit taxes negatively affected bank's performance and profitability, while favorable macroeconomic conditions had a positive impact.

Palas et al. (2017) analyzed the impact of some selected bank-specific and macroeconomic variables on the profitability of all the seven Islamic banks in Bangladesh by applying panel data for the period

from 2003 to 2014. Results of the analysis showed that some of the bank-specific and macroeconomic variables had a significant impact on the profitability of Islamic banks. According to the findings, capital and size of the banks were the bank-specific variables affecting profitability. Besides, GDP as a macroeconomic variable had a significant impact on the potential return of the Islamic banking industry.

Javaid and al-Aalawi (2018) examined the internal and external determinants contributing to the profitability of Islamic banks in Saudi Arabia. They made the analysis by applying unbalanced panel data and robust fixed effect model of regressions, and used the data of bank specific, industry specific, and macro-economic variables for the period from 2000 to 2013. They found that bank characteristics, industry characteristics, and macroeconomic variables played a significant role in determining Islamic banks' profitability. Their results showed that while capital adequacy and leverage ratios had a positive effect, operating expenses had a negative effect on the profitability.

Abdillah et al. (2016) investigated the factors affecting the profitability and liquidity of the Bank Muamalat Indonesia, Bank Syariah Mandiri, and Bank Mega Syariah. In the analysis, they used return on assets ratio as a dependent variable and also indicator of profitability. Quick ratio, capital, non-performing financing, and operating expense divided by operating revenue ratio factors were employed as independent variables. Multiple regression analysis method and quarterly data from 2008 to 2015 were applied. They found that while the quick ratio and operating expense divided by operating revenue had a negative and significant effect on profitability, capital had a positive and significant impact on profitability.

3. Islamic Banking System

The main purpose of establishing an Islamic bank is to develop usage of Islamic rules in financial transactions, banking activities, and related businesses (Aziz, 2017, pp. 344-345). Asset-backed financing is one of the most significant features of Islamic financing. Therefore, money is not a subject matter of trade in Islam, except in some special cases (Usmani, 1998, p. 12). In other words, one of the main ideas Islamic banking has been developed on is that money should be used only for the exchange of goods and services (Ali et al., 2018, p. 21).

Islamic banking principles which are determined by Islamic law are classified into five categories. First, the profit and loss sharing which is not a separate principle, but results from the prohibition of *ribā* is the most significant feature of Islamic banking. The provider of capital funds (lenders) and the entrepreneur (borrowers) share business risk in return of sharing profits and losses (Khediri et al., 2015, p. 77). Since interest is forbidden in Islamic banking, fund suppliers are transformed from creditors to investors. The provider of funds and the entrepreneur share partnership risks as they share the profits and losses (van Greuning & Iqbal, 2008, p. 18).

Second, the whole transaction must be based on real economic activities that includes tangible assets (Khediri et al., 2015, p. 77). Islam does not see money as a subject of trade, except in special circumstances. Money does not have intrinsic utility and it is just a medium of exchange. In Islam, financing activities are always based on illiquid assets which form real assets and inventories (Usmani, 1998, p. 12).

Third, the prohibition of *ribā*, or interest, is one of the most important aspects of Islamic banking. Islamic law defines *ribā* as an excess amount of money that must be paid by the borrower to the lender along with the principal amount (Khediri et al., 2015, p. 77). More clearly, any predetermined, positive, and fixed proportion depending on the maturity and the principal amount is taken into account as *ribā* and is forbidden.

Fourth, the prohibition of *gharar* and *maysir*. They respectively mean excessive uncertainty and excessive risk or gambling (Khediri et al., 2015, p. 78). In other words, Islamic financial rules discourage stowing and forbid operations that have features of risks, excessive ambiguity, and gambling (Usmani, 1998, p. 11).

Fifth, the prohibition on financing of illicit sectors. Some business activities that are not in compliance with the Islamic law are prohibited in the Islamic banking. These prohibited business activities are related to food (production and sales of alcoholic beverages, pork products, and tobacco), gambling (casinos, on-line gambling, lottery schemes), entertainment (video, magazines, online material, strip clubs), immoral and illicit trades (prostitution, drugs) (Khediri et al., 2015, p. 78).

Based on Islamic principles, some funding methods have been developed for Islamic banking. These methods can be classified into two main categories. The first group of funding methods includes *mushārakah* and *muḍārabah* contracts that are the main funding products of Islamic banking. These are based on partnership contracts of profit and loss sharing principle (Léon & Weill, 2017, p. 55). The *mushārakah* contract has some particular features. Some of these are: the ratio of profit to be delivered to the parties must be accepted at the time of signing the contract; the rate of profit for each partner must be specified as a proportion of net profit; the rate of profit for each partner must conform to the proportion of capital invested by him (however, there is a difference of opinion among Islamic scholar about this principle); and each partner suffers the loss exactly proportional to his invested capital (Usmani, 1998, pp. 23-24). In *muḍārabah* contract, the lender – the Islamic bank – provides the capital while the borrower provides labor and know-how. Profits from this contract are shared by both parties, but only the lender is liable to bear the loss (Léon & Weill, 2017, p. 55). In other words, the *muḍārabah* funding method is a partnership where one partner gives money to the other partner for investing it in a trading enterprise. The first partner who is called "*rabb al-māl*", makes the investment and the other partner who is called "*muḍārib*" is exclusively responsible for the management and work (Usmani, 1998, p. 31).

The second group of funding method generally consists of *murābaḥah* and *ijārah*. *Murābaḥah* is based on mark-up sale, that is, the Islamic bank buys a property for the customer and sells it to the costumer with a price that includes the original cost and a specified profit. The buyer can pay the bank in installments (Léon & Weill, 2017, p. 55). The simple meaning of *murābaḥah* in Islam is a sale. The single characteristic separating *murābaḥah* from the other type of sales is that the seller in *murābaḥah* clearly tells the buyer how much the cost is and how much profit is going to be added to the cost (Usmani, 1998, p. 65). *Ijārah* in Islamic banking is like the conventional leasing contract, in which a bank buys a property and leases it to the customer for a specified period and specified rent (Léon & Weill, 2017, p. 55).

Murābaḥah and *ijārah* are not the original funding methods of Islamic banking; these were adopted by Islamic banks at a later stage. In this case, Islamic bank works as an agent or owner of the product bought from the seller to conduct the *murābaḥah* or *ijārah* process. This increases the competition between conventional and Islamic banks and causes the rents and profits to decline (Arshed et al., 2017, p. 2).

There is increasing evidence that the *murābaḥah* funding method is applied more intensively than the *muḍārabah* and *mushārakah* funding methods in the Islamic banking system in the world. While a very small share of assets of Islamic banking, around 5%, is based on *muḍārabah* and *mushārakah*, most of the assets are based on *murābaḥah*. This means that Islamic banking practices are in favor of risk-free funding practices, instead of risky funding methods based on profit and loss sharing (Ariffin et al., 2015, p. 244). Therefore, it can be stated that because of the lack of usage of profit-loss sharing funding methods, namely, *muḍārabah* and *mushārakah*, the benefits of improving macroeconomic growth expected from Islamic banking can decrease.

The Islamic banking system has improved quite rapidly in both Muslim and non-Muslim countries during the last thirty years. Almost, all countries have dual banking systems, that is both Islamic banking and conventional banking systems operating together (Khediri et al., 2015, p. 77). Since Islamic banking is growing very fast, now almost every country has some form of Islamic banking activity by having Islamic windows in conventional banks (al-Harbi, 2015, p. 17).

The Saudi Arabian banking system consists of 25 banks, 12 domestic and 13 branches of foreign banks, as of 2018. Four national banks follow Islamic banking systems in their operations. The assets of 12 domestic Saudi banks represent roughly 90% of the GDP. Islamic banks held roughly 65% of the assets of the total banking system in 2018. The four Islamic banks in Saudi Arabia are Al-Rajhi, Alinma, Al-Jazeera, and Al-Bilad banks. Al-Rajhi is an Islamic bank since 1988, Alinma bank was founded in 2006, Al-Jazeera was founded in 1975, and is an Islamic bank since 2002, and Al-Bilad was established in 2004. The leading Islamic bank in Saudi Arabia is the Al-Rajhi bank and is the largest Islamic bank in the world in terms of total assets in compliance with Islamic law with more than 551 branches spread all over the world (Islamic Research and Training Institute, 2020, pp. 27-32).

4. Methodology of the Study

4.1 Financial Variables and Ratios

In this study, it was intended to determine financial ratios that are related to the profitability of Islamic banks in Saudi Arabia. Profitability measures of return on assets (y_1) and return on equity (y_2) ratios are applied as dependent variables. The independent variables used in the analysis consists of bank level and market level financial ratios. Bank level variables are: total equity to total assets (x_1), net income to operating income (x_2), and customer deposits to total assets (x_3). The market level variables are: stock capital gains (x_4), price to earnings (x_5), market value to book value (x_6), and earnings per share (x_7) ratios.

Total equity to total assets ratio (x_1) is considered as capitalization or leverage ratio. While a high ratio means that the bank is performing well and is strong enough to deal with the financial difficulties, a low ratio would mean that the bank has capital adequacy problem because of its poor performance. Some of the studies, such as Siddique et al. (2016), Bashir (2003), Palas et al. (2017), Javaid and al-Alawi (2018), and Abdillah et al. (2016), found that total equity to total assets ratio has a positive effect on the profitability. Hence, in this study, we explore the impact of total equity/total assets on the profitability.

Net income to operating income (x_2) ratio is chosen to observe if total operating expenses have an effect on profitability. Since net income is calculated as total operating income minus total operating expenses, it is expected that net income to operating income ratio has a positive effect on the profitability.

Customer deposits to total assets (x_3) ratio shows that if this ratio increases, the portion of equity decreases. Therefore, based on the finding of the researches that equity has a positive effect on the profitability, it can be said that customer deposit has a negative effect on profitability. So, like the result of Aslam et al. (2016), negative effect of customer deposit on profitability is expected in this study.

Stock capital gain (x_4) ratio shows the return obtained by the increase of stock price in the market. Since the increase of a firm's profitability encourages rise of the stock price, it is implied that stock capital gain has a positive effect on profitability.

Price to earnings (x_5) ratio indicates the portion of stock price to earning amounts obtained from one stock. Like stock capital ratio, an increase of this ratio also supports a rise in the stock price. So, a positive effect of this ratio on the profitability is expected.

Market value to book value (x_6) ratio shows the portion of the market value of total stocks to the book value of equities of a company. Since the market value of a company increases based on the prospect of a company's high profitability in future, this implies that this ratio has a positive effect on the profitability.

Earnings per share (x_7) demonstrates the earning amount obtained from one stock. This variable is also based on the profitability. So, it is expected that earnings per share have a positive effect on profitability.

4.2 Model for Panel Data

In this study, to determine the effect of bank-based and market-based financial ratios on the profitability of Islamic banks in Saudi Arabia, along with the other methods, panel data analysis was caried out. There are three types of panel models which are: pooled, fixed effect, and random effect models. Based on the features of the data used in this article, pooled model was chosen as an appropriate model.

Pooled model does not take into account the feature of panel data and assumes error term as identically and independently distributed, and uncorrelated with independent variables. However, fixed effect model considers that unobserved firm specific effects, which are not included in the regression, are correlated with the independent variables; while random effect model considers that this intercept effect is uncorrelated with independent variables. In order to select a proper model, Breuch-Pagan Lagrange Multiplier Test (1980) and Hausman Test (1978) are used. First, the Breuch-Pagan Lagrange Multiplier Test is used to determine which one of the pooled or fixed and random models is appropriate, and then the Hausman test is applied to determine whether fixed effect or random effect model is suitable (Noman, 2015, p. 15).

As Nunes et al. (2009, p. 698) mentioned in their study, ordinary least squares (OLS) regression is a proper way to make estimation of the profitability determinants. Conversely, if the null hypothesis that

non-observable individual effects are not relevant is rejected, it can be said that an OLS regression is not the most proper way to analyze the relationship between profitability and its determinants. However, a correlation can be between the non-observable individual effects of banks and profitability determinants. In case there is no correlation between the non-observable individual effects of banks and profitability determinants, then the most appropriate method to make estimation is the random effect panel model. Similarly, in case of correlation between the non-observable individual effects of banks and profitability determinants, the most suitable method to make estimation is fixed effect panel model.

In this study, in order to determine which panel model is appropriate, Breusch-Pegan Lagrange Multiplier Test (1980) was employed and based on the results, OLS panel model was chosen to make estimation and the following basic linear regression models were applied:

$$y_1 = 3.18 + 0.174x_1 + 0.507x_2 - 0.011x_3 - 0.088x_4 - 0.03x_5 - 0.01x_6 + 0.521x_7 + e \quad (1)$$

$$y_2 = -1.39 + 0.128x_1 + 0.001x_2 + 0.136x_3 - 0.008x_4 + 0.005x_5 + 1.010x_6 + 0.013x_7 + e \quad (2)$$

Where, y_1 is the net income divided by total asset; y_2 is the net income divided by total equity; x_1 is the total equity divided by total asset; x_2 is the net income divided by operating income; x_3 is the customer deposits divided by total assets; x_4 is the stock capital gain; x_5 is the price earnings ratio; x_6 is the market value divided by book value; x_7 is the earning per share, and e is the error term that expresses the effect of all other variables apart from the independent variables that were used in the model.

Two different profitability measures of y_1 and y_2 are utilized as dependent variables in the panel data regression model. Seven independent variables of financial ratios are employed to determine their effects on each of the profitability measures of y_1 and y_2.

4.3 ANFIS Approach for Profitability of Ratio Analysis

The objective of developing an ANFIS model is to analyze the profitability of assets (y_1) and profitability of equity (y_2) ratios, depending on parameters such as total equity to total assets, net income to operating income, customer deposits to total assets, stock capital gains, price-earnings, market value to book value, and earnings per share ratios. The ANFIS model was developed based on first order Sugeno fuzzy model that has the learning capability of hybrid learning algorithm. This hybrid learning algorithm can decrease the dimension of the search space investigated by the steepest descent method and can also significantly decrease the time required to attain convergence. Fuzzy If-Then rules were employed for the computing framework of fuzzy set and systems, and fuzzy reasoning procedure (al-Ghamdi & Taylan, 2015, p. 35). The ANFIS model developed for profitability rate of assets (y_1) contains five rules, including five membership functions (MFs) assigned to each input parameters. However, the ANFIS model developed for profitability of equity ratios (y_2) contains four rules, and four membership functions. In this study, the input parameters of ANFIS are selected based on the preprocessing of original data obtained from the banking system. Kablan (2009, p. 106) developed a rule-based ANFIS model generated on the linear Sugeno fuzzy approach for consequent parameters. These parameters are identified by using least square method and premise parameters are adopted by using gradient descent approach. Tarno et al., (2013, p. 495) developed an ANFIS model that composes artificial neural network and fuzzy system to predict the financial time series data accurately. They determined that the effectiveness of ANFIS depends on many factors such as the input parameters, the selection of membership functions (MFs,) and the generated rule base.

For instance, determining the optimal number of clusters affects the number of rules and the membership functions (MFs). Determining the type of MFs depends on the relations of input and output parameters. If the relations are nonlinear, Gaussian MFs may give better consequences. The large number of MFs for each input space might be a drawback for an ANFIS design, besides the parametric learning and structure learning problems dealing with the partition on the input-output universes (Taylan & Darrab, 2011). To overcome the drawback of ANFIS approach during rule generation, fuzzy sub-clustering algorithm is usually employed. Hence, the rules are generated based on the clustering of input and output data set obtained from the financial ratios of banks. In this approach, the number of rules is taken equal to the number of output parameter's clusters regardless of

the number of input parameters. For the ANFIS formation, a cluster range must be stipulated to specify the scope of impact of the cluster. However, identifying small cluster limit may generate several clusters of data sets, and might produce so many rules (Taylan & Darrab, 2012). This can result in higher number of MFs that might affect the optimality of outcomes with lower accuracy. The number of additional MFs does not increase the efficiency of the fuzzy model. The inclusion of each data in each fuzzy set is defined by a membership degree obtained from membership functions (Taylan, 2011).

The performance of a fuzzy model depends on the work's parameters, their complexity, and type of training algorithm called the artificial neural networks. An ANFIS model has a defuzzification process and can generate crisp numerical consequences for the financial ratios. The following steps are needed to establish a neuro-fuzzy model: (i) linguistic statements were used to define input and output parameters; (ii) the input and output universes were used to decide the fuzzy partition; (iii) the membership functions were selected for the input and output parameters; (iv) the fuzzy set rules were identified; (v) inference mechanism was designed; and (vi) a defuzzification method was selected to obtain crisp values.

4.4 Data

To search profitability determinants of Islamic banking in Saudi Arabia, bank-based and market-based financial ratios were utilized. The bank-based financial ratios were calculated from the financial statements of Islamic banks in Saudi Arabia. There are four Islamic banks in Saudi Arabia – Al-Rajhi Bank, Alinma Bank, Al-Jazeera Bank, and Al-Bilad Bank. All these banks' data were used in the analysis. The data used to calculate market-based financial ratios were taken from the stock exchange (Tadawul) of Saudi Arabia. Stata-15 statistic program was used to perform the analysis and quarterly financial ratios data were used during the period of 2009 and 2017.

5. Analysis of the Study

In order to determine the impacts of financial ratios on the profitability measures, analysis of the study includes descriptive statistics, Pearson's correlation test, unit root test, Breusch-Pegan Lagrange Multiplier Test, Breusch-Pegan and Cook-Weisberg Test, Wooldridge Oto-Correlation Test, and OLS Panel Regression. Table 1 shows mean, standard deviation, minimum and maximum value of profitability measures of the Islamic banks in Saudi Arabia during the 2006-2017 period with quarterly terms.

Before starting the analysis, Pearson's correlation test was applied to make sure if there is multicollinearity among the independent variables. That is, testing if there is any independent variable influencing the other independent variables. Table 2 shows the Pearson's correlation coefficient matrix. As can be seen from table 2, the highest positive coefficient is 0.6626. This means that the independent variables are not highly correlated with each other and so there is no multicollinearity problem.

In order to understand if the variables are stationary, Im-Pesaran-Shin (2003) Unit Root Test was applied. As can be seen from table 3, all variables are stationary at the level because of their low p-values which are lower than 0.05.

The result of the Breusch and Pagan Lagrange Multiplier test is shown in table 4. As the probability value of 1.00 is higher than the 0.05 value, Breusch and Pagan Lagrange multiplier test is rejected for both y_1 and y_2 analysis. It means that there is no significant difference across the bank, and thus, the OLS model is more appropriate than fixed or random effect models for both y_1 and y_2 analysis.

The result of the Breusch Pagan and Cook-Weisberg Test for heteroskedasticity is given in table 5. Since the p values are lower than 0.05, both models have heteroscedasticity.

Based on the Wooldridge auto-correlation test results (given in table 6), y_1 model does not have autocorrelation because its p value is lower than the 0.05 critical value. However, the y_2 model has autocorrelation because its p value is greater than 0.05.

In order to determine the financial ratios and their effects on the profitability measures of y_1 and y_2, based on the heteroskedasticity and autocorrelation test results, the Eicker-Huber-White estimator is employed for an unbalanced data of four Islamic banks during the period 2006-2017, with quarterly terms, in Saudi Arabia and its results are given in the table 7. R-square of the y_1 model in the table is 0.83, which

indicates that the explanatory power of the model is good enough, but R-square of the y_2 model is 0.99, which means that the explanatory power of the model is much better.

Total equity to total assets (x_1) is positively and significantly related to both y_1 and y_2. This result is in agreement with the results of Siddique et al. (2016), Bashir (2003), Palas et al. (2017), Javaid and al-Alawi (2017), and Abdillah et al. (2016).

Although the net income to operating income (x_2) ratio has a positive and significant impact on y_1 with a very high coefficient of (0,507), it does not have a relation with y_2. Since net income equals operating income minus operating expense, the result of a positive effect on y_1 seems rational.

While the customer deposits to total assets (x_3) ratio does not have a relation to y_1, it has a positive and significant relation (0,136) to y_2. The stock capital gain (x_4) ratio does not have a relation to both y_1 and y_2. The price-earning (x_5) ratio does not have a relation with y_1, but it has a positive and significant relation to y_2 even though it is very low (0,005).

Like our expectation, market value to book value (x_6) has a very high (1.01) positive and significant relation to y_2. Similarly, as per our expectations, the earning per share (x_7) ratio has a positive, significant, and high (0,521) relation to y_1. It also has a positive, and significant, but very low (0,0133) relation to y_2.

The R-square values (y_1: 0.8379; y_2: 0.9966) indicate that y_2 is a much better proxy for profitability measure than y_1. It can be seen from table 7 that bank-based and market-based financial ratios explain 0.8379 percent variability of y_1, and 0.9966 percent variability of y_2.

Table (1) Descriptive Statistics of the Variables

	Mean	Variables	Min	Max
$\mathbf{y_1}$	0.0055	0.0052	-0.0142	0.0372
$\mathbf{y_2}$	0.3716	4.1401	-0.0827	53.9656
$\mathbf{x_1}$	0.2035	0.1603	0.0001	0.9575
$\mathbf{x_2}$	0.3953	0.3248	-1.1210	2.8746
$\mathbf{x_3}$	0.7191	0.1611	0.0163	0.8504
$\mathbf{x_4}$	0.0026	0.1890	-0.7271	0.7403
$\mathbf{x_5}$	113.2543	419.1038	-262.4985	4934.809
$\mathbf{x_6}$	5.4589	47.0953	0.4448	610.5886
$\mathbf{x_7}$	0.6287	0.6381	-0.8279	3.5651

x_1 stands for total equity divided by total assets; x_2 stands for net income divided by operating income; x_3 stands for customer deposits divided by total assets; x_4 stands for stock capital gain; x_5 stands for price earnings ratio; x_6 stands for market value divided bay book value; and x_7 stands for earning per share ratio.

Source: Authors' own computations.

Table (2) Correlation Matrix of The Independent Variables

	$\mathbf{x_1}$	$\mathbf{x_2}$	$\mathbf{x_3}$	$\mathbf{x_4}$	$\mathbf{x_5}$	$\mathbf{x_6}$	$\mathbf{x_7}$
$\mathbf{x_1}$	1.000						
$\mathbf{x_2}$	-0.1138	1.000					
$\mathbf{x_3}$	-0.881	0.0934	1.000				
$\mathbf{x_4}$	-0.0163	0.1073	0.0335	1.000			
$\mathbf{x_5}$	0.2716	-0.1611	-0.2798	-0.0899	1.000		
$\mathbf{x_6}$	-0.1108	0.0288	-0.0051	0.0281	-0.0211	1.000	
$\mathbf{x_7}$	-0.3079	0.6626	0.255	0.0258	-0.2021	0.0762	1.000

Source: Authors' own computations.

Table (3) Results of Im-Pesaran-Shin Unit Root Test

Variables	Level Test Statistics	P-Value
y_1	-5.157	0.000 ***
y_2	-3.879	0.000 ***
x_1	-4.945	0.000 ***
x_2	-4.142	0.000 ***
x_3	-6.083	0.000 ***
x_4	-5.999	0.000 ***
x_5	-4.047	0.000 ***
x_6	-3.640	0.000 ***
x_7	-1.937	0.026 ***

******* represents significance at 1%.

Source: Authors' own computations.

Table (4) Breusch Pegan and Lagrange Multiplier (BP-LM) Test

	ROA Model	ROE Model
chibar 2(1) :	0.000	0.000
Prob > chibar2 :	1.000	1.000

Source: Authors' own computations.

Table (5) Breusch Pegan and Cook-Weisberg Test for Heteroskedasticity

	ROA Model	ROE Model
chibar2 (1):	8.38	17.37
Prob > chibar2:	0.004	0.000
chi2 (7):	153.66	166.27
Prob > chi2:	0.000	0.000

Source: Authors' own computations.

Table (6) Wooldridge Auto-Correlation Test

	Model (y_1)	Model (y_2)
F(1,3):	22.123	0.942
Prob > F:	0.0182	0.4033

Source: Authors' own computations.

Table (7) OLS Panel Regression Results

Independent Variables	Return on Asset (y_1)		Return on Equity (y_2)	
	Coefficient	*Prob.*	*Coefficient*	*Prob.*
x_1	0.174	0.002 ***	0.128	0.000 ***
x_2	0.507	0.022 **	0.001	0.888
x_3	-0.011	0.707	0.136	0.000 ***
x_4	-0.088	0.257	-0.008	0.131
x_5	-0.03	0.301	0.005	0.009 ***
x_6	-0.006	0.536	1.010	0.000 ***
x_7	0.521	0.041 **	0.0133	0.004 ***
Cons	3.18	1.000	-1.39	1.000
R-square:	0.8379		0.9966	
Wald chi2(7):	837.44		47981.21	
Prob > chi2:	0.000		0.000	
F(2, 3):	.		F(7, 162):	7310.54

*** represents significance at 1%, ** at 5%, and * at 10% respectively.

x_1 stands for total equity divided by total assets; x_2 stands for net income divided by operating income; x_3 stands for customer deposits divided by total assets; x_4 stands for stock capital gain; x_5 stands for price earnings ratio; x_6 stands for market value divided by book value; and x_7 stands for earnings per share ratio.

Source: Authors' own computations.

6. Accuracy Test for Prediction Function of Profitability of Assets (y_1) and Profitability of Equity (y_2)

Based on the results of the analysis, the prediction function of return on asset (y_1) is structured as below.

$$y_1 = 3.18 + 0.174x_1 + 0.507x_2 - 0.011x_3 - 0.088x_4 - 0.03x_5 - 0.01x_6 + 0.521x_7 + e \quad (3)$$

After estimating dependent variable (y1) by using the prediction function given in equation 3, the following results were obtained. In table 8, the predicted dependent variable values and observed dependent variable values are compared to see the estimation accuracy of the model. As it is seen, almost all of the predicted and observed values have the same sign of positive or negative which means that the prediction accuracy of the model is very high.

Based on the results of the analysis, the prediction function of return on equity (y_2) is structured as below.

$$y_2 = -1.39 + 0.128x_1 + 0.001x_2 + 0.136x_3 - 0.008x_4 + 0.005x_5 + 1.010x_6 + 0.013x_7 + e \quad (4)$$

After estimating dependent variable (y2) by using the prediction function given in equation 4, the following results were obtained. In table 9, predicted dependent variable values and observed dependent variable values are compared to see the estimation accuracy of the model. As it is seen, all of the predicted and observed values have the same sign of negative which means that the prediction accuracy of the model is perfect.

Table (8) Observed and Predicted Profitability Values of y_1

Predicted Profitability* (y_1)	Observed Profitability (y_1)
0.961155554	1.582780169
0.503199061	0.592000122
0.764665037	0.587943456
0.246538433	0.001631045
0.355544597	-0.16075521
0.775977837	0.152343762
0.074558603	1.967701367
-0.554645399	-0.48713972
-0.211033625	-0.04531514
-0.504058201	-0.24504394
-0.944711689	-0.91394863
-0.19503369	-0.48691495
0.920810133	1.461727451
-1.860940429	-1.82087834
-0.113634288	-0.22196735

***** They are found by replacing randomly chosen independent variable values in the prediction function for the fifteen quarters.

Source: Authors' own computations.

Table (9) Observed and Predicted Profitability Values of y_2

Predicted Profitability* (y_2)	Observed Profitability (y_2)
-92.14715071	- 0.0715047
-105.382958	-0.0774221
-107.0213787	-0.0753476
-97.48823275	-0.0800457
-39.61477746	-0.0497934
-104.6361237	-0.0799423
-74.75136736	-0.0755471
-84.61953471	-0.085874
-96.00785386	-0.0807084
-80.07889694	-0.0820789
-103.9639443	-0.0886615
-99.07124763	-0.0822544
-105.5144028	-0.0637830
-90.35142308	-0.0909404
-83.51045474	-0.0855148

***** They are found by replacing randomly chosen independent variable values in the prediction function for the fifteen quarters.

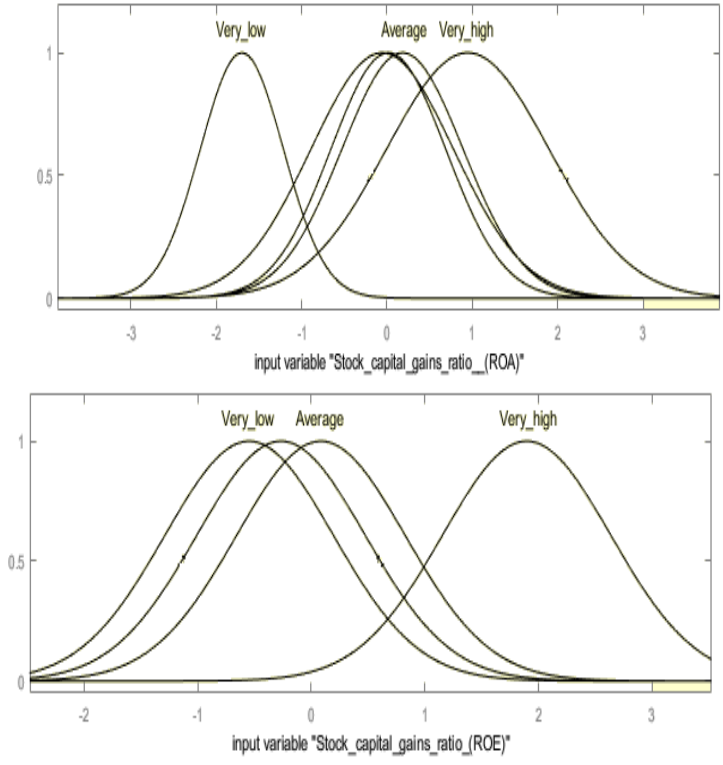
Source: Authors' own computations.

6.1 Analysis of ANFIS Model for Financial Ratios

A fuzzy model includes the dynamic relations of input and output parameters of a real-life problem established by a set of fuzzy implications. Fuzzy '*If-Then*' rules are the implications representing the linguistic relationships of inputs and outputs parameters (Taylan, 2011). The number of rules has an essential effect on how fine a control level can be achieved on the parameters. Fuzzy rules consist of MFs or numerical crisp values, and an ANFIS is shaped by fuzzy rules and their term sets. Gaussian membership functions are used to define fuzzy terms. On the other hand, fuzzy rules are used in the inner loop of ANFIS to fine-tune the fuzzy model and achieve clear results of profitability of equity ratios (y_2), and the profitability of assets (y_1) ratios. The Back-Propagation Multilayer Perceptron (BPMLP) algorithm is an adaptive networks performing learning process of y_1 data. In this study, two first order Sugeno ANFIS models were developed based on the learning capability of the BPMLP algorithm. The main goal of these ANFIS models is the prediction of the profitability of equity ratios (y_2), and the profitability of assets (y_1), using certain input data. The data set were divided into three parts: training, testing, and validation. The training data set includes 100 readings called financial ratios which served in model building, the testing data set were 35, and likewise 30 data were used for validation of the fuzzy model.

Fuzzy rules map the input output parameters that are constituted from fuzzy linguistic variables and term sets. Fuzzy rules are the backbone of FIS (fuzzy inference system) and the most important part of fuzzy modelling and fuzzy reasoning, while also identifing the approximate reasoning to derive consequences. Fuzzification is the beginning step of FIS for mapping the relations of input and output sets in a specified universe. A fuzzy term set is identified by MFs called mathematical expressions. In this study, Gaussian membership functions are used to specify the membership degrees. Two parameters (c, σ) are used to specify the Gaussian membership functions; 'c' shows the MFs center, and 'σ' is used for the MFs width.

Figure (1) Gaussian MFs for y_1 and y_2



Source: Prepared by authors.

Figure 1 depicts the Gaussian MFs for the parameter 'stock capital gains' ratio of asset and ratio of equity. As the parameter 'stock capital gains' ratio is a fuzzy variable, its fuzzy linguistic term set might be {very low, low, average, high, and very high}. The mathematical equation of MF for the fuzzy linguistic term 'average' can be constituted as given in Eq. 5.

$$Gaussian\ (x, c, \sigma) = e^{-1/2\left(\frac{x-c}{\sigma}\right)^2} \tag{5}$$

$$\mu(Stock\ capital\ gains\ ratio\ of\ ROA) = \mu_{average} = \begin{cases} 0 & x < -2\ and\ x > 2 \\ e^{-1/2\left(\frac{x-0.2}{0.5}\right)^2} & -2 \le x \le 2 \end{cases}$$

A fuzzy rule set is the collection of fuzzy '*If-Then*' rules. The Sugeno fuzzy modeling approach suggests an efficient way to produce fuzzy rules obtained from the data set of parameters. In a Sugeno model, fuzzy rules have typically the following form.

IF x_1 *is B AND* x_2 *is C ,..., THEN* $y_n=f_n(x_1, x_2,...,x_m)=$ $b_nx_1+c_nx_2+d_nx_3+...k_nx_m + r_n$ (6)

Where B and C are the antecedent of fuzzy term sets, whereas $y_n=f_n(x_1, x_2,...,x_m)$ is the consequent function. The input parameters $(x_1, x_2,...x_m)$ are depicted as polynomial functions $f_n(x_1, x_2,...,x_m)$, but they can be any function as long as they roughly illustrate the yield of the fuzzy model given in Eq. 6, within the domain stipulated by the rule sets.

6.2 The Profitability of Assets Ratio (y_1)

As it appears in the rule set given in Eq. 6, the fuzzy reasoning procedure can produce crisp outputs; 'y' shows the profitability of assets ratio via weighted averages. Sometimes, the weighted average operator is substituted with the weighted sum operators 'y_n', presented in the rule. The subsequent input-output space, and the schemes of the membership functions (given in fig. 1), shows the complexity of ANFIS model and demonstrates that it might be stipulated by the consequent equation fuzzy rules. The firing strength of each fuzzy rule can be observed from the fuzzy model. It is important to note that not all rules are fired to achieve the profitability of assets ratios when the input parameters: '*total equity to total assets ratio, net income to operating income ratio, customer deposits to total assets ratio, stock capital gains ratio, price-earnings ratio, market value to book value ratio, and earnings per share ratio*' are used in the fuzzy model. Table 10 illustrates the profitability of assets ratios for certain input factors. Hence, the set of fuzzy rules identifying the relations of input-output domain for multi-input single output banking systems profitability-based assets ratio can be presented as follows.

Rule1: IF ' total equity to total assets ratio (x_1) *is -1.27, AND net income to operating income ratio* (x_2) *is 1.18, AND customer deposits to total assets ratio* (x_3) *is 0.752, AND stock capital gains ratio* (x_4) *is 0.268, AND price-earnings ratio* (x_5) *is 0.464, AND market value to book value ratio* (x_6) *is 1.95, AND earnings per share ratios ratio* (x_7) *is 0.32, THEN The profitability of assets ratio is -0.332.*

Rule 2: IF ' total equity to total assets ratio (x_1) *is 4.355, AND net income to operating income ratio* (x_2) *is 1.296, AND customer deposits to total assets ratio* (x_3) *is 3.924, AND stock capital gains ratio* (x_4) *is -0.29, AND price-earnings ratio* (x_5) *is -0.184, AND market value to book value ratio* (x_6) *is -0.09, AND earnings per share ratios ratio* (x_7) *is -0.578, THEN The profitability of assets ratio is 3.281.*

Table (10) The Profitability of Assets Ratio (y_1) and y_2 for Certain Input Factors

x_1	x_2	x_3	x_4	x_5	x_6	x_7	'y; y_1'	'y; y_2'
-0.168	0.926	0.071	-0.635	-0.240	-0.095	0.981	1.546	-0.071
-0.090	0.879	-0.004	1.449	-0.230	-0.091	0.864	1.387	-0.073
-0.224	0.768	-0.062	-1.133	-0.235	-0.095	0.688	1.088	-0.074
1.763	-0.190	-1.936	0.040	0.077	-0.096	-0.878	-0.453	-0.088
0.225	0.798	-0.021	0.625	-0.232	-0.097	1.381	1.467	-0.076
0.116	7.632	0.040	1.692	-0.251	-0.088	4.602	6.069	-0.049
-0.164	0.715	0.210	-0.764	-0.249	-0.104	0.932	1.090	-0.074
-0.219	0.428	-0.082	-0.327	-0.245	-0.104	0.550	0.592	-0.077
0.064	0.162	-0.146	-0.928	-0.188	-0.093	0.081	0.223	-0.082
-0.009	-0.289	-0.044	-0.500	-0.117	-0.088	-0.463	-0.269	-0.085
0.029	-0.489	0.008	-1.837	-0.106	-0.098	-0.667	-0.559	-0.087
4.355	1.296	-3.924	-0.290	-0.154	-0.090	-0.578	3.253	-0.084
3.874	-4.024	-3.482	0.070	-0.885	-0.089	-1.064	-1.821	-0.091
2.614	-1.159	-2.868	-0.854	11.504	-0.094	-0.982	-1.032	-0.090

Source: Author's own computations.

In this part of the work, the firing strength of rule#3 is 1, hence, $w_3=1$. The firing strengths of the other rules are as follow: $w_1=w_2=w_4=w_5=0$. The linear functions' weighted sum of profitability of assets ratio is always a crisp value; the overall crisp output 'y' was determined as the weighted average of each fired rule's output. Hence, a complete rule with antecedents and consequences for the profitability of assets ratio can be established as follow:

IF total equity to total assets ratio (x_1) is 0.47, AND net income to operating income ratio (x_2) is 1.21, AND customer deposits to total assets ratio (x_3) is 0.815, AND stock capital gains ratio (x_4) is 2.51, AND price-earnings ratio (x_5) is 1.60, AND market value to book value ratio (x_6) is 0.561, AND earnings per share ratios ratio (x_7) is 0.0291, THEN The profitability of asset ratio is $y= 0.126x_1+0.361x_2+0.921x_3 - 0.215x_4+0.279x_5+0.851x_6 -0.875x_7$, where 'y' refers to the probability of assets ratio and is found to be -1.542 after the rules are fired.

6.3 The Profitability of Equity Ratio (y_2)

Similarly, if 'y' shows the profitability of equity ratio using weighted averages, then the input-output space of equity ratio can be identified by the schemes of the MFs (given in Fig. 1). The firing strength of each fuzzy rule appears during the compositional rule of inference observed from the fuzzy model. However, it is important to note that not all rules are expected to be fired for achieving the profitability of equity ratio (y_2). The same input parameters of y_1 are used for the y_2. Hence, the fuzzy rules classifying the relationships of input-output domain for banking systems' profitability of equity ratio can be presented as follows.

Rule1: IF ' total equity to total assets ratio (x_1) is 1.22, AND net income to operating income ratio (x_2) is -1.29, AND customer deposits to total assets ratio (x_3) is -0.621, AND stock capital gains ratio (x_4) is 0.523, AND price-earnings ratio (x_5) is 1.51, AND market value to book value ratio (x_6) is 0.0191, AND earnings per share ratios ratio (x_7) is 0.252, THEN The profitability of equity ratio is -0.0738.

Rule 2: IF ' total equity to total assets ratio (x_1) is 0.597, AND net income to operating income ratio (x_2) is 0.0661, AND customer deposits to total assets ratio (x_3) is -0.227, AND stock capital gains ratio (x_4) is -0.945, AND price-earnings ratio (x_5) is 0.853, AND market value to book value ratio (x_6) is -0.0146, AND earnings per share ratios ratio (x_7) is 1.21, THEN The profitability of equity ratio is -0.858.

For the prediction of profitability of y_2, the firing strength of rule#2 is $w_2=1$. The firing strengths of the other rules are as follow: $w_1=w_3=w_4=w_5=0$. As the profitability of equity ratio is always a crisp numerical value, the overall crisp output 'y' can be determined. Hence, a complete rule with antecedents and consequences for the profitability of equity ratio can be written as follows.

IF total equity to total assets ratio (x_1) is 0.284, AND net income to operating income ratio (x_2) is 0.507, AND customer deposits to total assets ratio (x_3) is -0.172, AND stock capital gains ratio (x_4) is 1.3, AND price-earnings ratio (x_5) is 0.396, AND market value to book value ratio (x_6) is 0.0463, AND earnings per share ratios ratio (x_7) is -0.028, THEN The profitability of equity ratio is $y=0.413x_1+0.593x_2 -0.541x_3 -0.974x_4+0.643x_5+0.472x_6 -0.997x_7$, where 'y' is the profitability of *equity* ratio and is found to be -0.60514 after the rules are fired.

6.4 Comparing the Performance of Developed Models

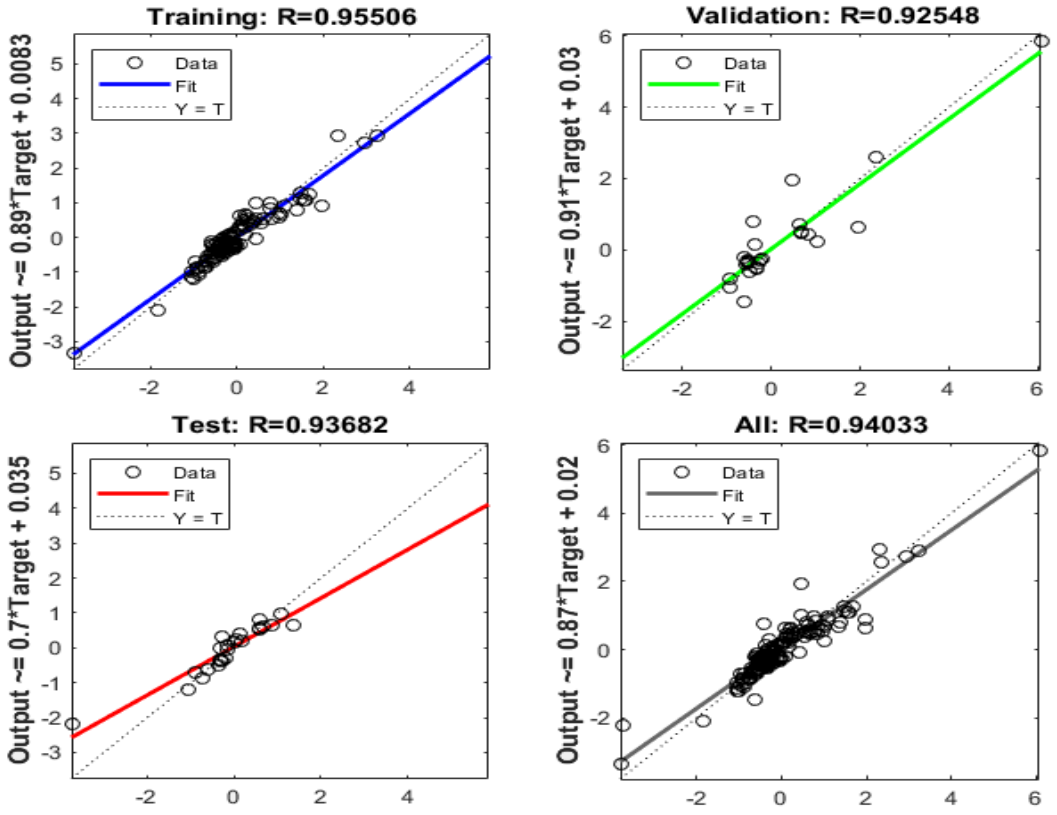
The weights of algorithm were verified from the input data, 100 were used for training, 35 were used for testing, and 30 for validation of the ANFIS model developed for profitability of y_1 and y_2. The training errors were determined for the observations by differencing the observed data (O_t) and the predicted data (P_t) obtained from profitability of fuzzy inference system. The BPMLP algorithm optimizes the learning procedure by propagating the error to improve the strength of the ANFIS model. The training error was recorded as the mean squared error (MSE) of the trained model of each epoch. Eq. 7 was employed for the calculation of MSE.

$$MSE = \frac{1}{n}\sum_{t=1}^{n}(O_t - P_t)^2 \qquad (7)$$

In order to minimize the training process error, the gradient vector is initially obtained and calculated from the derivative beginning from the output layer identified toward backward, layer by layer, until the input layer is achieved. As the modelling process is completed using ANFIS, another goal of this study is to compare the performance models with the other approaches. In this work, several ANFIS models were developed depending on their rule base of including 4, 10, and 20 rules each. Considering the training error, the ANFIS model that has 4 rules gave the best outcomes with minimum error for y_1, and that which has 5 rules gave the best results for the y_2, among the examined ANFIS models. Training error was 0.462% for the profitability measure y_1, and 0.618% for the profitability measure y_2.

On the other hand, figure 2 shows the training, testing, and validation correlation coefficients (R) of y_1. The value of the correlation coefficient is 0.95506 for training, 0.92548 for validation, and 0.93682 for testing of y_1. Similarly, the value of the correlation coefficient was found to be 0.99945 for training, 0.96974 for validation, and 0.99775 for testing of y_2. It should be noted that a very high value of the correlation coefficient of determination does not mean that the parameters are computed with great certainty. The large value of R merely indicates the higher degree of correlation with the data best fit for the model. High-level correlation coefficient of determination value is expected to produce relatively small measuring error and a fit that operates throughout the data points (Taylan et al., 2020). These findings also illustrate that the factors have high degree of correlation with each other, however involving a shift in one factor will approximately lead to variations in the other factors.

Figure (2) The Training, Testing, and Validation Correlation Coefficients of y_1



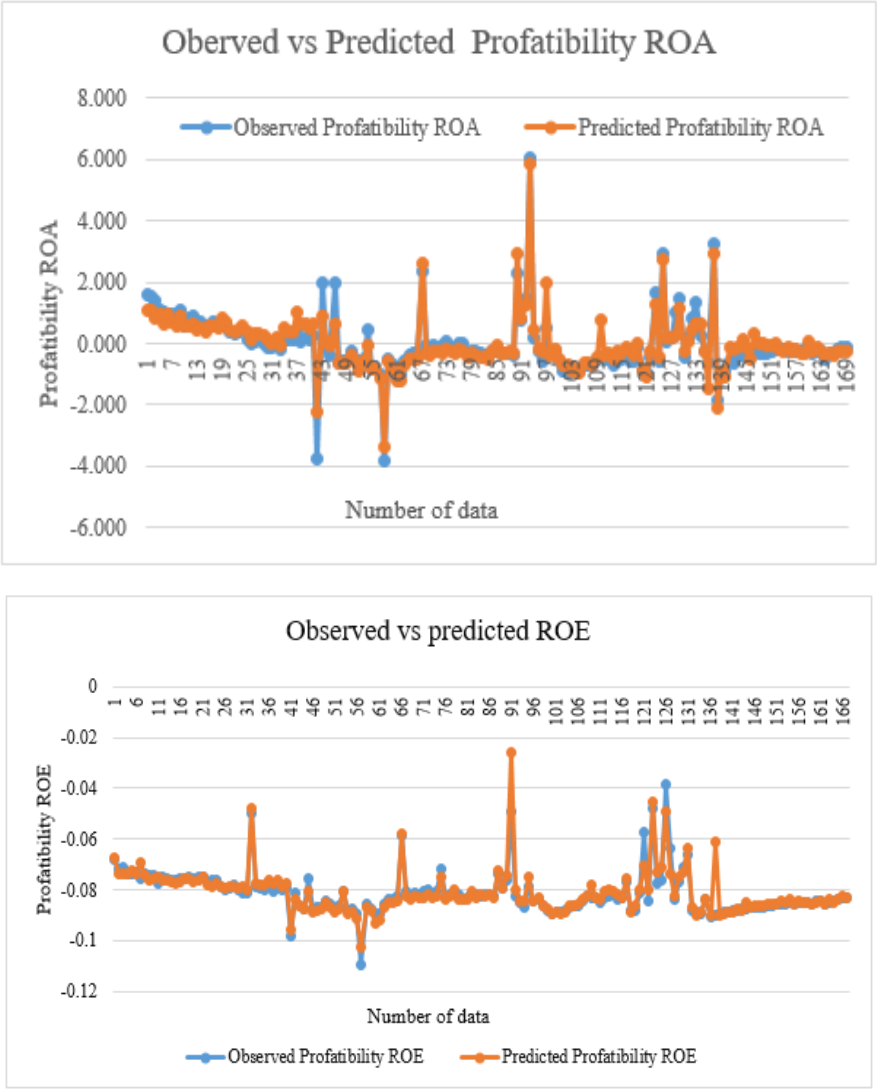
Source: Prepared by authors.

On the other hand, the performance of the developed ANFIS models of y_1 and y_2 were assessed and compared based on the average prediction error and the residual ranges. Eq. 8 was employed to calculate the average prediction error.

$$Average\ prediction\ error\ \% = \frac{\sum|Observed\ ROA\ value - Predicted\ ROA\ value|}{\sum|Observed\ ROA\ value|} x100 \quad (8)$$

The average prediction error for the ANFIS model of y_1 with 4 rules was calculated as 0.3537%. Similarly, it was determined for the ANFIS model of y_2 with 5 rules and was found to be 0.31829%. The residuals of each ANFIS models were calculated by differencing between the experimental and the predicted values of profitability of y_1 and y_2. They have ranged from -1.5437 to 1.3256 for the ANFIS model of y_1, whereas from -0.05190 to 0.13193 for the ANFIS model of y_2.

Figure (3) The Observed and Predicted Profitability of y_1 and y_2



Source: Prepared by authors.

As a result, figure 3 shows the observed and predicted profitability of y_1 and y_2 obtained from ANFIS models with 4 and 5 rules, respectively. In fact, the coefficient of correlation between experimental and the predicted data of profitability of y_1 and y_2 were also determined. Also given are the predicted values based on the ANFIS model with 10 and 20 rules. These were used to estimate the average prediction error of each model. The error percentage associated with these two ANFIS models were calculated to be 3.15%, and 4.26% for the profitability of y_1 and y_2, respectively.

7. Results and Conclusion

This study tried to determine financial factors that explain the profitability of Islamic banks in Saudi Arabia. Four Islamic banks' quarterly data from 2009 to 2017 were analyzed with the OLS panel data and an ANFIS model composed of Artificial Neural Networks (ANN) and Fuzzy system. While two measures of profitability of y_1 and y_2 were used as dependent variables, bank-based and market-based financial ratios were used as independent variables in the analysis.

On the other hand, the ANFIS model is composed of the first order Sugeno fuzzy approach that has learning capability using hybrid learning algorithm. A defuzzification process was employed to generate crisp numerical consequences for the financial profitability ratios.

Results of the panel data analysis indicate that y_2 is a better measure of profitability of Islamic banks in Saudi Arabia because of its higher R-square value. The results also showed that total equity to total asset (x_1), and earnings per share (x_7) ratios have a positive and significant relation to both profitability measures of y_1 and y_2. While net income to operating income (x_2) ratio has a positive and significant relation to only y_1 profitability measure, customer deposits to total assets (x_3), price-earnings (x_5), and market value to book value (x_6) ratios have a positive and significant relation to only y_2 profitability measure. However, stock capital gain (x_4) ratio does not have any significant relation to both y_1 and y_2 of Islamic banks of Saudi Arabia.

Thus the conclusion of this article is that the total equity to total asset (x_1) ratio has a positive effect on dependent variables of both y_1 and y_2, and is similar to the findings of Siddique et al. (2016), Bashir (2003), Palas et al. (2017), Javaid and alAlawi (2017), and Abdillah et al. (2016). Since, the amount of equity in the banks shows riskiness of the bank, this result seems logical. Namely, when equity of the banks increases, default risk decreases. As a result of that, by increasing bank's capital, return on equity and return on assets also increases.

Another finding in this analysis is that the net income to operating income has a positive effect on the return on assets. Therefore, it can be interpreted that since net income equals operating income minus operating expense, the finding of positive effect on the y_1 is an expected result.

Unlike the finding of Aslam et al. (2016), it was found that customer deposit to total asset ratio had a positive effect on the return on equity.

Another result found in the analysis is that market value to book value has a positive high effect on the return on equity. This can be explained by the idea that the increase of market value to book value comes from the expected high profitability of a company.

The positive effect of earnings per share ratio on the return on asset and return on equity can be expressed by the increase in demand to the bank. That is, by the increase of earnings per share of the bank, demand for the bank's shares rises, which causes increase in customer deposits. Increase in customer deposits causes the bank to decrease the dividend rate of the participation accounts which yields more return on both equity and assets.

Finally, an important result of the study is that both bank-based financial ratios and market based financial ratios have a positive and significant impact on the profitability of Islamic banks in Saudi Arabia. Moreover, the positive effect of equity on the profitability is obvious based on this and other studies.

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محددات ربحية المصارف الإسلامية باستخدام تحليل البيانات المَقْطعية وأساليب الاستدلال التَّكَيُّفي في المملكة العربية السعودية

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المستخلص. تَهْدفُ الدراسة إلى تحديد العلاقة بين الربحية والنسب المالية للبنوك الإسلامية في المملكة العربية السعودية. ولتحقيق هذا الغرض، تم النظر في البيانات ربع السنوية لأربعة بنوك خلال الفترة ٢٠٠٩م - ٢٠١٧م. تم استخدام نموذج الاستدلال التَّكَيُّفي (ANFIS) المكون من شبكات عصبية اصطناعية للتنبؤ بربحية النسب المالية. ومن أجل تحديد تأثيرات النسب المالية على مقاييس الربحية تضمنت الدراسة تحليل البيانات المقطعية. كما تم حساب متوسط خطأ التنبؤ لنموذج (ANFIS) لعائد الأصول (y1) بأربعة ضوابط بمقدار (٠,٣٥٣٧٪) وتم العثور عليه لنموذج (ANFIS) لعائد حقوق الملكية (y2) مع خمسة (٥) ضوابط بمقدار (٠,٣١٨٢٩٪). أظهرت نتائج الدراسة أنه في حين أن جميع المتغيرات التفسيرية باستثناء نسبة مكاسب رأس المال للأسهم لها علاقة إيجابية مع مقياس الربحية للعائد على الأصول أو العائد على حقوق الملكية في المصارف الإسلامية في السعودية، إلا أن نسبة إجمالي حقوق الملكية إلى إجمالي الأصول وربح السهم لهما علاقة بمقاييس الربحية. أظهرت نتائج الدراسة المستندة إلى أدوات الإحصاء الوصفي، والانحدار المتعدد، ونماذج (ANFIS) أنه يمكن الحصول على نتائج ناجحة من متغيرات (y1) و (y2) . بناءً عليه يَعتقد مُعدوُ الدراسة أنها ستكون مفيدة ليس من الناحية العلمية فحسب، ولكن من الناحية العميلة بالنسبة للمستثمرين والمدراء التنفيذيين في المصارف الإسلامية.

الكلمات الدَّالة: المصرفية الإسلامية، الربحية، النسب المالية، تحليل بيانات القطاع، التنبؤ العصبي.

تصنيف JEL: G21, C33, C45

تصنيف KAUJIE: L25