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Research Article

Macroeconomic determinants of multidimensional risk of Islamic banks across the world

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ABSTRACT

Banking system crises and bank failures can have painful impacts. Being an Islamic Bank is riskier than being a conventional bank. As IBIs risk management emphasizes risk-sharing, conventional banks transfer their risk to borrowers. In our study, we have taken 4 risk factors which are Rate of Return Risk, Operational Risk, Credit Risk and Liquidity Risk, as a proxy of all the risks faced by IBIs and developed a Composite Risk Index using these major risk indicators of Islamic banks. Further, this study has proposed indicators like Size1 for liquid assets and Size2 for fixed assets, as in Islamic banks, there is no concept of money markets. The data for the research was collected from the secondary sources of Islamic banks' financial statements, the EIKON database and World development indicators. The data for 96 Islamic banks were analyzed. The data was analyzed through Python, R and Stata. This study is instrumental in using the unsupervised machine learning clustering algorithm known as KMeans to estimate the prevalent risk level of the bank by aggregating four-dimensional risk indicators to form a single indicator. Moreover, the study explored macroeconomic determinants i.e., Asymmetric Stock Market, Real Business Cycle (GDP), Regulatory Quality and Economic Globalization of the Composite Risk Index and developed a channel via which it affects the risk level of banks. The results showed that in a country, better regulatory quality, higher fixed assets and economic boom in the business cycle play an important role in reducing the risk level of Islamic banks. This study provides a quantified contribution of Islamic banking to social welfare, compared to focusing on the numbers of risk indicators only and comparing it with fixed boundaries developed for the case other indicators.

Keywords: *Composite Risk Index; KMeans; Bank Size; Islamic Banking*

1. INTRODUCTION

Significant financial sector distress has been observed in many economies during the past two decades. However, the most severe stretches of financial problems are seen in some emerging markets. The indicators providing early warnings of emerging banking crises and analyzing their changing aspects are critical to explore, specifically during the ongoing context of globalization (González-Hermosillo, 1999).

Practitioners, risk management committees have widely discussed risk management practices in Islamic Banking Institutions, researchers, investors and accountants, and it continues to remain the main focus. Islamic banks must Recognize, Control and Manage risk (Rahman et al., 2014). Al-Quran has emphasized risk management as Surah Yusuf based on the story of Prophet Yusuf, and He had the skills to interpret dreams by the grace of Allah. The dream of the King reveals that there will be a drought after seven years, and it

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will be last for seven years. Prophet Yusuf mitigated the risk by giving King a beautiful risk management solution. A huge piece of land was used to store food for seven years, then the stored food was used during a difficult time in Egypt (Mateen, 2020). According to Seerah of Prophet Muhammad (PBUH), risk management is also an example. Once, Anas Ibn Malik R.A. reported: A man said:

"O Messenger of Allah, should I tie my camel and trust in Allah, or should I leave her untied and trust in Allah?"

Prophet Muhammad (PBUH) replied to Anas Ibn Malik R.A.,

“Tie her and trust on Allah.” (Sunan Al-Tirmidhi) (Mateen, 2020).

The legal maxim of "No reward without risk Al-Ghurm Bil Al-Ghunm" means that a person cannot expect any profit without assuming risk (loss) in whatever undertakings. It is a common practice that every business is associated with risk, rewards, and uncertainties. In short, there is no reward without taking risk and high risk means high profit (Saiti & Abdullah, 2016).

In Islamic banks, the association of the bank and its customers is not just like an association between the creditor and debtor; rather, it is like one between investor and entrepreneur. Islamic banks fall prey to more risks in comparison with conventional banks. After the Global Financial Crisis (GFC), risk management has gained more insights. As (Rahman & Shahimi, 2010) maintained, a weak risk management system might result in the collapse of a bank due to its severe impacts.

Based on risk-related issues, Islamic banks differ from conventional banks as, on the one hand, these banks face risks like one faced by conventional banks, while on the other hand, these banks have their unique risks while complying with Shari'ah. The financial statements generated by Islamic banks differ from those of conventional banks. For example, in Islamic banks, the cash held is strictly referred to as the cash item, while in conventional banks, the cash is referred to as either cash or other interest-based assets (AAOIFI and CB). (Rahman et al., 2014).

Being an Islamic Bank is riskier than being a conventional bank. As IBIs risk management emphasizes risk sharing, conventional banks transfer their risk to borrowers. Concerning these, the existing models to determine banks' risk are based on a single risk indicator and focus on traditional internal and external factors. While, to improve the quality of the early warning model for financial crises, there is a need to use state of the art methods to simultaneously assess multiple indicators of banks' risk and provide relative effects of modern banking and macroeconomic indicators.

1.1. Risk Management Framework in Islamic Banks:

Risk management is the key objective of financial management in Islamic Banks. A study proposed a model that categorized the systematic, unsystematic, and a group with systematic-unsystematic risks faced by the Islamic Banks (IBs). Fig. 1 elaborates that systematic risk consists of Business risk, which is further classified into Rate of Return Risk and Displaced Risk. Governance risk lies under unsystematic risk, which comprises Shariah

Risk, Reputation Risk and Operational Risk. Further, Credit Risk, Market Risk and Equity Risk are determinants of Financial Risk. While, Liquidity & Solvency Risk and Hedging Risk fall under Treasury Risk (Al Rahahleh et al., 2019).

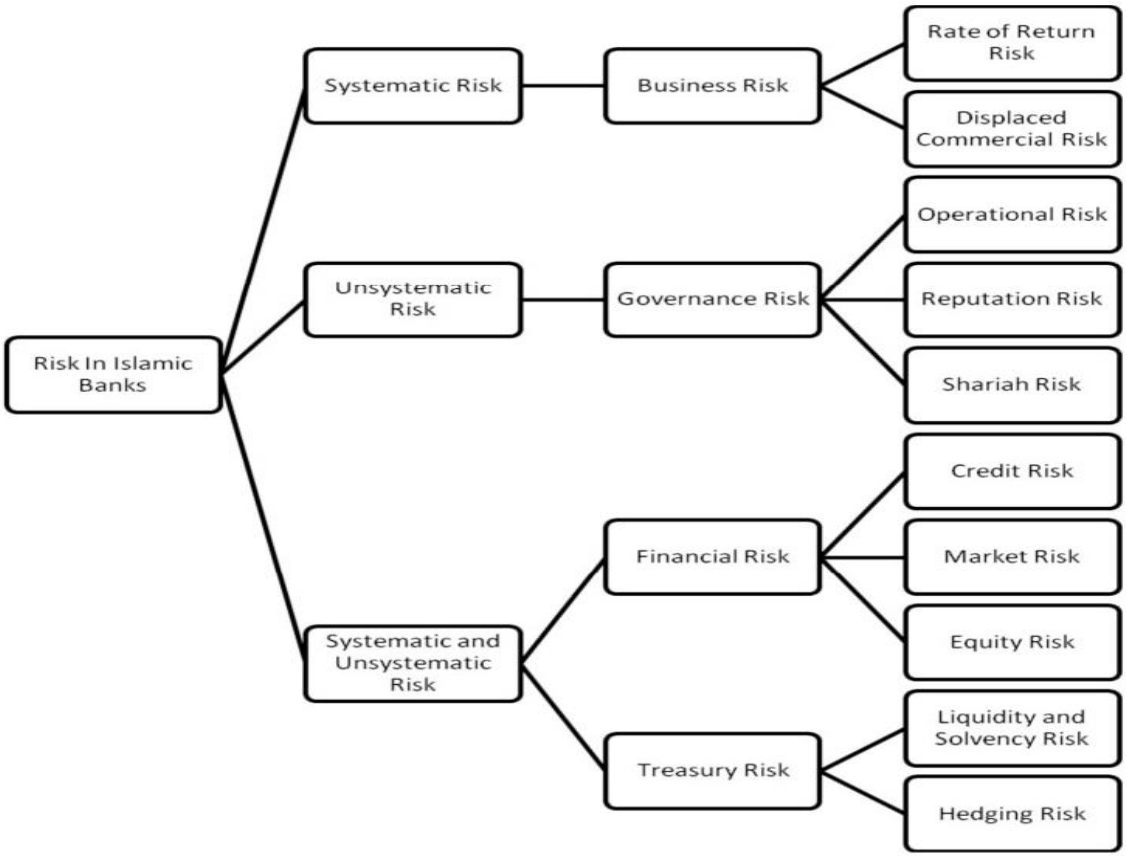

Fig. 1. Risk structure of Islamic Banks

Source: (Al Rehahleh et al., 2019).

This study takes the Rate of Return Risk as a proxy for Business risk, Operational Risk as a proxy for Governance Risk, Credit Risk as a proxy for Financial Risk and Liquidity Risk as a proxy for Treasury Risk to develop a wholistic indicator of Islamic Banking risk.

A survey of the empirical literature showed that they normally examined the determinants of credit risk and liquidity risk using either internal or external factors as explanatory variables. However, a few studies used both internal and external variables for Islamic banks risks (Safiullah & Shamsuddi, 2018). Previous studies have overlooked the risk factors that are different from the conventional Banking Framework, and as per the researcher's knowledge, this is the first study which devises a composite model for Risk factors faced by IBIs.

2. LITERATURE REVIEW

The models of earliest failure established since the 1970s were mainly developed using “Multivariate Discriminant Analysis” (MDA). After that, the studies also used isotonic separation, Bayesian belief networks, split-population survival time models and neural networks. In fact, regulatory practices of banking organizations have been consistently

used some of these models. Moreover, the predictions related to the failure of banks have been extremely researched since 1960s. Several methods of statistics have been applied to solve bankruptcy prediction problems in banks and firms, including neural network, factor analysis (FA), probit, logistic regression (logit), multiple regression, quadratic discriminant analysis (QDA), MDA, and linear discriminant analysis (LDA) (Othman & Asutay, 2018).

The dealers of stock market invest in an issued share of a company to gain enough return resulting either from the cash dividend paid by the company or a change in share price. The market received the information from different data sources (Didar et al., 2018), thus the expectations of investors changed by change in stock prices in the capital market. Due to this information, the market predicts potential variations in business profit and expectations of investor changes while affecting their investment decision. However, it affects the stock prices in the capital market and, thus, their market returns also changes (Zraqat, 2019). Investment in the stock market brings a high level of risk because its high sensitivity to variations either in the external environment or within the company. An investor needs caution while investment decision in capital market to any potential loss prevention. Forecasting future returns on equity investors is a way to prevent losses (Hapsoro et al., 2020). The stock's return analyzed the risk of different companies by predictions. However, the most important way used to analyze the business performance is an unsystematic risk analysis.

The development and prosperity in the banking sector have been reflected in the rise in banking risks that may also be exposed to financial institutions (Saleh & Abu-Afifa, 2020). Banking financial institutions and banks produced intense competition as a result hike in systematic risk. For example, the intense banking sector competition and the propensity to provide distinguished services for adopting a risk-taking method to investment returns maximization and market value increase (Saleh & Abu-Afifa, 2020). These methods may obstruct the achievement in the objectives of banking institutions due to the distinctiveness of their several banking services in control terms. However, it was essential for institutions to hold the capacity and potentially exposed risks by banks and identification of their size and nature, as the chances of occurrence of these risks. The market return and company of banking institutions may expose financial hardship. Therefore, the banks need to be familiar with the consequences and get benefits by managing risk by determining the optimal risk size they can afford.

The stock market return is affected by credit risk, as investors analyze the intensity of credit risk before any decision of investment because this risk affects the future cashflows and bank's performance, as reserve ratio loss of loan to total loans and bad loans to total loans influence the indicators of profitability (Noman et al., 2015; Munangi & Bongani, 2020). The stock market returns and stock prices will be affected by expected future earnings. The inability of banks to meet obligations to others, hurts profitability of banks and share prices, respectively, especially when the inability to liquidate the assets immediately at an acceptable cost (Ruziqa, 2013; Misman et al., 2015). It causes variation in stock market returns and financial markets dealers related to banks' liquidity provision ability in future, as it is linked with dividends (Warad & Al-Debi'e, 2017).

Islamic banks are distinguished from commercial banks in terms of liquidity, credit, and insolvency risks. Islamic banks face higher liquidity risks while lower credit and insolvency risks. At the same time, these banks are indistinguishable in terms of operational risks from conventional banks. The results have also been conducted for random effect analysis. Moreover, the up-gradation in the attributes of SSB members by uplifting their size, proportion, and academia positively and significantly reduce the insolvency and operational risks in Islamic banking. These risks also rise with the rise of SSB members' reputations with their proportion. Further, it was found that the attributes of SSB are not concerned with the credit and liquidity risks of Islamic banks (Safiullah & Shamsuddin, 2018).

The requirements of Shariah Compliance offer sole conditions to find out the firm's performance under restricted conditions. The study investigated the effects of Shariah-Compliance on the risk resilience incurred by non-financial firms. The study took a sample of 2160 firms across six regions and analyzed the results using a dynamic panel system wherein the investigations show that the Shariah-Compliant firms have lower risk exposure. This risk can is measured using the total risk and resilience of the firm by percent deviation from maximum values of associated sales, goods costs, operating expenses and share price. These effects were higher when the US was exposed to the subprime crisis. The results of the study showed the moderating effect of socio-cultural norms. Additionally, tests showed that it is indebted to serious penalties if the firm loses its Shariah-compliance status. This is the first study investigating the Shariah compliance effects on non-financial firms. The study also proceeded part in capital structure and corporate governance as it provided that restrained resources are beneficial for carrying out firm activities. The study's findings gave importance to the firms and further insights into Shariah-compliance details (Cheong, 2020). This paper's findings also provided significant value to firms looking to capitalize on the 1.8 billion-strong Muslim market with further insight into the details of Shariah compliance.

The study on current developments related to risk management in the literature posed by Islamic Banking and Finance was carried out by (Al Rahahleh et al., 2019). The study analyzed the risks associated with Islamic banks and then compared them with those associated with conventional banks. The study shed light on the characteristics of risks and the exposure of the risks by Islamic banks as compared to those faced by conventional banks. Moreover, a framework based on systematic and unsystematic classification of risks faced by Islamic banks was proposed. The study explored the business risk associated with governance and treasury risk. A researcher found that in Malaysia, financial expansions and bank capital negatively affected the credit risk levels, while the capital buffer, size, lagged CR and financial quality positively affected the credit risks of Islamic banks (Al Rahahleh et al., 2019).

Liquidity risk in the banking system is affiliated more with the Islamic mode of banking than conventional and hybrid banking systems, which referred that the Islamic mode of banking is more vulnerable to liquidity risk as compared to the conventional and hybrid banking systems (Mohammad et al., 2020). The study also found a correlation between credit risk and liquidity risk, and credit risk was negatively significant with liquidity risk.

Further liquid asset ratio of respective banks also correlated with liquidity risk exposures but was insignificant. Moreover, the researcher found a positive and significant correlation between the long run debt and liquidity risk exposure.

The exposure of Liquidity risk in the Islamic mode of banking has different interpretations as defined and interpreted by Islamic laws by Islamic scholars. As, bay al-dayn (sale of debt), Islamic banking law is inefficient as it lacks the managerial approach to managing liquidity risks throughout the globe. Islamic banks have lower liquidity risks which results in higher stability of Islamic banks, if there is a lower liquidity risk, it will first improve the stability, after which, in order to generate more profits, bank management usually tends to start taking risks due to which the initial positive impact dismissed and there will be an increase in bank instability (Hassan et al., 2019).

According to the theory of Islamic banking principles, the Islamic banking mode operates and finances differently from the conventional and hybrid banking systems. It contains assets and liability management complications while working in the global banking system. Therefore, this banking system is attributed to the financing gap, resulting in liquidity risks (Mohammad et al., 2020). Lowering the lending and financing activities to tighten the finance gap will effectively avoid liquidity risks. For this purpose, banks must follow sterner standards to avoid the complexities of capital regulations. Banks must adopt a stricter screening process for their borrowers to avoid liquidity risk exposures

During the financial crisis, there was a negative relationship between credit risk and liquidity in Islamic banks, while during the post-financial crisis, the same negative relation was observed not in the Islamic banks but also in conventional banks. The best possible reasons for this relationship could be either high or low credit or liquidity risks in banks. Moreover, the negative relationship in Islamic banks could be the customer's behaviour in Islamic banking or the governance mechanism (Hassan et al., 2019).

The external context in which a firm exists in case of credit risks, may not be possible to adopt a single policy that fits all scenarios. Also, under such circumstances, a firm fails to support credit-relevant standardization. Hence countries must improve their sustainability performance as these countries can provide financial stability to all the businesses that are carried out in the respective countries (Abdul Razak et al., 2020). Country sustainability is also important in corporate sustainability and credit risk association. (Hoepner et al., 2016; Stellner et al., 2015). As corporations are bound to social structures, the financial benefits that stem from CSR activities will be greater if an institutional void is present (Ghoul et al., 2017; Xiao et al., 2018). Moreover, IBIs are exposed to displaced commercial risk and rate of return risk (Zainol, 2015).

2.1. Literature related to Macroeconomic Variables:

The study explored the relationship between Credit Risk, macroeconomic determinants, and political institutions. The study took data from 1998 to 2016 from South Africa. ARDL method employed for long-run and short-run analysis. GDP was negatively significant, while gold prices were positively significant to Credit Risk. Moreover, the study also elaborated on the downfalls of the ratings by rating agencies, i.e., S&P's, Moody and Fitch.

The macroeconomic variables of the study were GDP, Gold prices, interest rates, bank size and political institutions (Zhou & Tewari, 2019).

The researcher identified the most important macroeconomic determinants of Credit Risk in the scenario of the banking system in Algeria. The data was taken from 1980 – 2014. Ordinary Least Square (OLS) and Granger Causality Test are employed for the data. The research findings were that financial development, money supply, and political stability were positive, and GDP was negative and significant to banks' credit risk in Algeria. The study variables were Non-performing loans, unemployment, credit, financial development, GDP, investment, money supply, political stability, and real exchange rate (Marouf & Guellil, 2017).

A study against the fulfilment of master's degree requirements in Kyrgyzstan explored the macroeconomic factors directly related to the credit risk faced by banks. Many econometric models were used. The study's empirical findings indicated that GDP growth rate negatively while Exchange rate, corruption and political instability positively affect the credit risk of newly developed Kyrgyzstan banking systems. The data period was 2003 to 2016. (Haji-Zada, 2017).

A macro prudential approach was developed by (Messai & Gallali, 2019), which elaborated the most important factors that determine the Non–performing loans. The relationship between credit risk determinants and non-performing loans was analyzed using the panel vector autoregressive (PVAR) approach. The study employed data from 2000-2011. Findings revealed a bi-directional causal relationship between credit risk and macroeconomic variables. The macroeconomic variables of the study were unemployment rate, non-performing loans, and GDP growth rate and stock-price index.

The researcher analyzed the credit risk, macroeconomic factors and profitability of banks in Turkey. The data of 7 banks from 2007-2015 was taken. Panel data analysis was conducted to investigate the relationship between bank-specific variables and macroeconomic variables with Credit Risk. The macroeconomic variables of the study were Inflation and GDP growth rate (Makki, 2018).

In his study, Rahman et al. (2020), examined the effect of trade openness on risk-taking behaviour of banks. The study employed a panel data of 899 banks from BRICS (Brazil, Russia, India, China, and South Asia) for the period 2000 to 2017. The study's empirical findings showed that high trade openness lowers the risk taking of banks and vice versa.

Governance has been an important factor that decreases and moderates the liquidity risk. It provides stable and reliable settings for the economic environment, which enhances the functions and operations of Islamic banking (Mohammad et al., 2020). The study examined the academic positions, size, and reputation of members of SSB for risk measurement in Islamic banking (Safiullah & Shahmsuddin, 2018). Upgradation in the attributes of SSB members through uplifting their size, proportion, and academia positively and significantly reduce the insolvency and operational risks in Islamic banking.

Okoro et al. (2017), explored the impact of trade openness on the profitability of Commercial Banks in Nigeria. The data employed for the study was from 1990- 2015. The variables for

the study were interest rate, trade openness real exchange rate had an insignificant impact on the dependent variable profitability.

Duraj and Moci (2015), analyzed that economic growth has a positive and significant relationship to the high current profitability of banks. While, economic growth is negatively related to a high past level of bank profitability. The impact of economic growth, money supply and stock market capitalization remained insignificant in relationship with the profitability of banks in Philippines (Sufian & Chong, 2008). The researcher analyzed a study to distinguish between Islamic and Conventional Banks of Gulf Cooperation Council (GCC) based on k-means, 26 logit financial ratios and neural networks (Olson & Zoubi, 2008).

The study estimated the set of equations for non-interest income, net-interest income, operating costs, profit before taxes and provisions for the banks from the major countries that are industrialized and evaluated the effects of shocks to financial and macroeconomic factors on the profitability of banks (Albertazzi & Gambacorta, 2009).

Aluko and Ajayi (2018), studied the determinants development of banking sector in sub-Saharan African countries. The study used a panel of 25 countries from 1997 to 2014. The study employed a composite index of banking sector development. The results revealed that instantaneous trade, capital openness and population density promote banking sector development, whereas financial liberalization hampers the development of the banking sector. Moreover, the study revealed that population density, trade openness and institutional quality growths the depth of the banking sector. Furthermore, the study revealed that simultaneous openness to capital and trade and law boosts the stability of the banking sector, whereas economic growth, inflation, land area, and financial liberalization badly affect the banking sector stability.

Several studies also presented models like ANGELS, Risk based Credit Rating and CAMELS+S (Cheong, 2020; Munawaroh & Azwari, 2019; Noor et al., 2018; Oktaviansyah et al., 2018). These studies have ignored one or other risks faced by Islamic banks. This study fills this gap by presenting a model that covers all the risks faced by IBIs by developing a composite Index and then categorizing the banks according to the Composite Index of Risks developed.

The study investigated the effects of factors that are specific to Islamic banking activity relating to financial performance. the study used a sample of 50 Islamic banks from 12 countries. Panel data from the period of the last quarter of 2013 to the third quarter of 2019 was utilized for the study. The empirical results of the study demonstrated a very significant relationship among all the explicative variables and the dependent variable. The financial performance was positively related to liquidity and bank size, while it is negatively related to asset quality, operational efficiency and bank capitalization (Ltaifa et al., 2021).

In Islamic banks, there is no concept of money markets. Previous studies used bank size as a variable and ignored this aspect, and the study filled this gap and analyzed Bank Size in two parts. This study has categorized Bank size in two ways: by liquid assets and by fixed assets to analyze its exposure.

3. METHODOLOGY:

The study employed Unsupervised Machine Learning to discrete the Risk factors, which is the most recent research methodology. Unsupervised machine learning deals with data that is not labelled and analyses it through K means (Stewart et al. 2017). Further, the study used the Multinomial Logit Model (Pinder, 1996; Lawrence & Arshadi, 1995; Bolton, 2010).

The data for the research was collected from the secondary sources of financial statements of Islamic banks, the EIKON database and World development indicators. The data for 96 Islamic banks was analyzed by studying reports of international Islamic banking institutes like (World Islamic Economic Forum, IRTI, INCEIF etc.) The data was analyzed through Python, R and Stata.

3.1. THEORETICAL FRAMEWORK:

The study developed a Composite Risk Index using major risk indicators of Islamic banks. This process is done using an advanced method devised in Machine Learning. In our study, we have taken 4 risk factors which are Rate of Return Risk, Organizational Risk, Credit Risk and Liquidity Risk (Zainol, 2015; Berger & Bouwman, 2009, Mohammad et al., 2020) as a proxy of all the risks faced by IBIs.

The study explored macroeconomic determinants of the Composite Risk Index and developed a channel via which it affects the risk level of banks. The study employed Asymmetric Stock Market (Arshed & Kalim, 2021), Real Business Cycle (GDP) (Albertazzi et al., 2009), and Regulatory Quality which are worldwide governance indicators (Sufian & Chong, 2008) and Economic Globalization (Rahman et al., 2020). The study analyzed the Asymmetric Stock Market in increasing and decreasing ways and made two proxies for the variable. For the real business cycle, the study used the GDP, and economic globalization includes trade and flow of capital.

The bank size positive coefficient shows that growth in bank assets increases the banking industry vulnerability (Fiordelisi et al., 2013). In this study, we categorized the bank size in two ways: liquid assets and fixed assets, which clearly defined the exposure as there is no concept for money markets in IBIs. The conceptual framework is shown in Fig. 2, for which the data sources are mentioned in table 1.

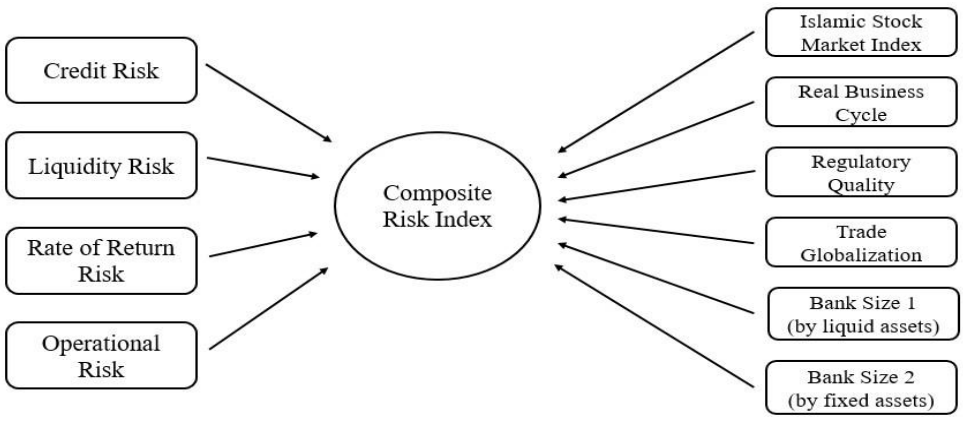

Fig. 2. Theoretical Framework

3.2. STATISTICAL TREATMENT

3.2.1. Ordinal Regression Analysis:

Since the developed index is ordinal and it has more than two categories, so the study used the Multinomial Logit Regression Model (Pinder, 1996; Lawrence et al., 1995) to estimate the probability of a bank for a risk.

3.2.2. Correlation Analysis:

The study analyzed correlation to compare existing risk indicators, new indicators, and bank stability.

3.2.3. Estimation Model:

Risk Ranking$_{it}$ =

$$= \alpha_0 + \alpha_1 RBC_{it} + \alpha_2 SMI_{it} + \alpha_3 RQ_{it} + \alpha_4 EG_{it} + \alpha_5 Size1_{it} + \alpha_6 Size2_{it} + \varepsilon_{it}$$

Where:

c = country, i = banks, t = time

Here in the multinomial logit model, the above equation will be estimated n-1 times in which n is the number of risk categories identified by the KMeans method. The first category will be kept as a baseline. While in each regression, the odds of selecting the next category with the baseline category will be estimated.

Table 1. List of Variables:

Variables	Proxy	Reference
Liquidity risk (LR)	FGR = AL – ACD / ATA, Where: FGR stands for financing gap ratio, AL is average loans, ACD stands for average core deposits, ATA is average total assets	(Saunders & Cornett, 2008; Mohammad et al., 2020)
Credit risk (CR)	The ratio of loan loss provisions to gross loans.	(Berger & Bouwman, 2009; Mohammad et al., 2020)
Operational risk (OR)	$K_{BIA} = \frac{\Sigma(GI_{1,\dots,n} x \alpha)}{n}$ where: KBIA = the capital charge under the BIA. GI = annual gross income, where positive, over the previous 3 years. n = number of the previous 3 years for which gross income is positive. a = 15 % which is set by the Committee, relating the industry-wide level of required capital to the industry-wide level of the indicator.	(Abdullah, Shahimi, & Ismail, 2011)
Rate of return risk (RR)	Rate on investment/ total investment	(Zainol, 2015; Abedifar, Molyneux & Tarazai, 2018)
Stock Market (SMI)	Respective Country Stock Market Index	(Arshed & Kalim, 2021)
Real Business Cycle (RBC)	The data of GDP will be used to calculate cyclic fluctuations.	(Yiğitbaş, 2016)
Regulatory Quality (RQ)	This indicator a specific form of institutional quality which effects the Islamic banks	Worldwide governance indicators

Variables	Proxy	Reference
Economic Globalization (EG)	It determines the flow of goods and services which are relevant for IBs which are dealing in goods and services	KOF index
Bank Size	$Size_1$ = Natural Logarithm of Liquid Assets $Size_2$ = Natural Logarithm of Fixed Assets	Ltaifa et al. (2021)

4. RESULTS AND DISCUSSIONS

Table 2 provides a description of the variables used in the study. Here, $Size_1$, $Size_2$, SMI, and EG have mean values larger than standard deviations, and this shows that they are under dispersed in the sample while other variables are over dispersed. Using the data on four major risks (LR, CR, OR and RR), this study has developed the categorization based ordinal scale to identify the bank's level of risk. The number of ordinal categories is determined by the Elbow method, shown in Fig. 3. According to this, since the line changes from steep to flat at level 4, this method proposes that 4 categories of the four-dimensional data could be constituted, reducing the within sum squares error.

Table 2. Descriptive Statistics

Variables	LR	CR	OR	RR	Size1	Size2	SMI	RBC	RQ	EG
Median	-0.180	0.008	2.212	0.010	8.057	6.068	229.7	0.009	0.570	73.319
Mean	-0.181	0.015	5.929	0.018	8.208	5.881	312.9	0.014	0.278	70.815
Std.Dev	0.262	0.026	11.492	0.022	1.959	2.536	260.9	0.051	0.670	13.364

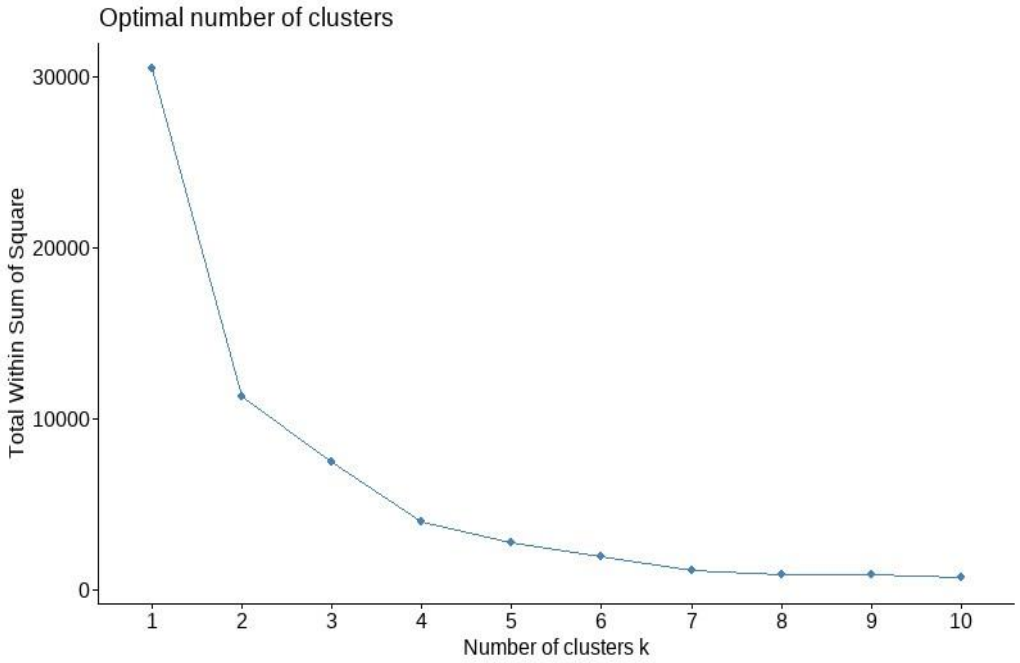

Fig. 3. Elbow Method for KMeans Cluster Identification

Based on the newly developed cluster identifier, table 3 provides its statistics. In the four categories, most of the sample resides in category 1, and the lowest resides in category 4. Based on the patterns of a mean value of LR, CR, OR and RR, it can be noticed that the higher category has a higher incidence of risk for the bank. Further, this data categorization has explained 52.5% of the variation (heterogeneity) in the LR, CR, OR and RR.

Table 3. KMeans Machine Learning Cluster Method

Cluster Number	1	2	3	4
Cluster sizes	128	41	50	13
		Cluster Means		
LR	-0.15	-0.15	-0.19	-0.55
CR	0.01	0.01	0.01	0.10
OR	0.57	2.16	22.81	5.67
RR	0.01	0.06	0.00	0.02
% Cluster Heterogeneity Accounted For	56.15%	15.36%	14.57%	13.91%
Between Cluster Heterogeneity		52.5%		

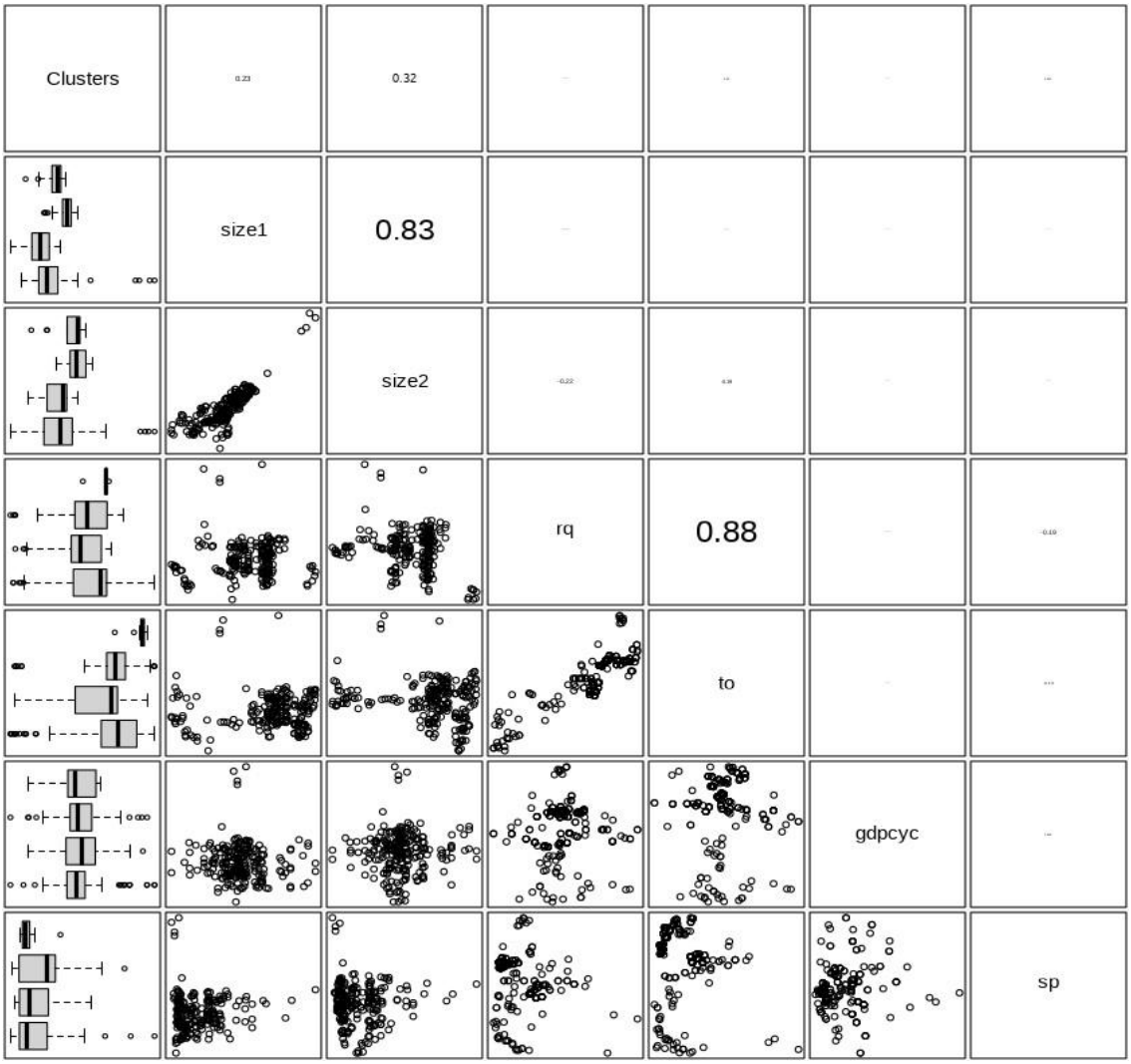

Fig. 4. Clustering and its association with independent variables

Fig. 4 shows the box plot of the variables shown in each row categorized for each risk category in the first column. These box plots show how independent variables are dispersed in each category. Further, from the second column onwards, the scatter plot is shown for the risk categories and the independent variables, and here only $Size_2$ has a prominent association with the risk categories, which are the results confirming the study by (Ltaifa et al., 2021). Further, table 4 provides the multinomial logit model with odd ratio

estimates while comparing risk types 2, 3 and 4 with risk type 1. Here r squared showed that the proposed variables successfully explain the variations in the risk category by 22%, and the significant Chi-Square confirms that the overall model is fit.

While, comparing the odds of the bank moving to the second category compared to the first category, an increase in $Size_2$ and EG plays a positive role in increasing the risk level, these results for EG (trade openness) were also observed by Aluko and Ajayi (2018), while $Size_1$, RQ and RBC reduce the odds of moving to category 2. Lastly, SMI plays no role in changing the risk category, which is also analyzed by (Sufian & Chong, 2008).

Further, while comparing the odds of the bank moving to the third category compared to the first category, $size_2$, EG and RBC play a positive role in increasing the risk while RQ reduces the odds of risk increase. Lastly, SMI plays no role, and $Size_1$ is insignificant.

Lastly, when comparing the odds of the bank moving to the fourth category compared to the first category, $Size_2$, and EG play a role in increasing the risk category and $Size_1$, RQ, and RBC play a role in keeping the bank in category 1. Lastly, SMI is insignificant.

Table 4. Multinomial Logit Model of Risk of Islamic Banks

Variables	Relative Risk Ratios (Prob)		
	Level 2 vs Level 1	**Level 3 vs Level 1**	**Level 4 vs Level 1**
Size1	0.206 (0.00)**	1.000 (0.99)	0.072 (0.00)**
Size2	2.161 (0.00)**	1.447 (0.02)*	6.842 (0.00)**
RQ	0.389 (0.00)**	0.463 (0.00)**	0.251 (0.00)**
EG	1.083 (0.00)**	1.049 (0.00)**	1.499 (0.00)**
RBC	0.031 (0.00)**	1.732 (0.00)**	0.001 (0.00)**
SMI	1.000 (0.00)**	1.000 (0.01)*	1.000 (0.73)
Psuedo R Squared	0.224	AIC	447.86
Chi Squared	116.899	P value	0.001**
Sample	232		

*** significant at 1% * significant at 5%*

5. CONCLUSION

In Islamic banks, the association of the bank and its customers is not just like an association between the creditor and debtor; rather, it is like one between investor and entrepreneur. The Islamic banks fall prey to more risks in comparison with conventional banks. After the Global Financial Crisis (GFC), risk management has gained more insights. As (Rahman & Shahimi, 2010) maintained, a weak risk management system might result in the collapse of a bank due to its severe impacts.

Being an Islamic Bank is riskier than being a conventional bank. As IBIs risk management emphasizes risk sharing, conventional banks transfer their risk to borrowers. Concerning these, the existing models to determine banks' risk are based on a single risk indicator and focus on traditional internal and external factors. While, to improve the quality of the early warning model for financial crises, there is a need to use state of the art methods to simultaneously assess multiple indicators of banks' risk and provide relative effects of modern banking and macroeconomic indicators.

The data for the research was collected from the secondary sources of financial statements of banks, the EIKON database and World development indicators. The data for 96 Islamic banks was analyzed. The data was analyzed through Python, R and Stata. This study is instrumental in using the unsupervised machine learning clustering algorithm known as KMeans to estimate the prevalent risk level of the bank by aggregating four-dimensional risk indicators to form a single indicator.

This study takes Rate of Return Risk as a proxy for Business risk, Operational Risk as a proxy of Governance Risk, Credit Risk as a proxy for Financial Risk and Liquidity Risk as a proxy for Treasury Risk (Zainol, 2015; Saunders & Cornett, 2008; Berger & Bouwman, 2009; Mohammad et al., 2020) to develop a wholistic indicator of Islamic Banking risk i.e., Composite Risk Index. This indicator can create ease in assessing the ordinal level of the risk status of the bank for the relevant stakeholders. This study has further used this single variable ordinal assessment of Islamic banking risk to find market-based determinants.

Further, this study has proposed indicators like $Size_1$ for liquid assets, $Size_2$ for fixed assets, as in Islamic banks, there is no concept of money markets, and there is true ownership of assets. Moreover, Bank size categorizes into two ways: liquid and fixed assets to analyze its exposure to nominal and real factors. In addition, Regulatory quality, Real Business Cycle Effect, Economic Globalization and an increasing portion of Stock market index are proposed as indicators as well.

The results showed that in a country, better regulatory quality, higher $size_2$ and economic boom in the business cycle play an important role in reducing the risk level of Islamic banks. This study expected to provide a quantified contribution of Islamic banking in social welfare. As compared to focusing on the numbers of risk indicators only and comparing it with fixed boundaries developed for the case other indicators. To relevant stakeholders like SBP and Government, this study will propose a strategy to boost Islamic financing through Risk Management.

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Conceptualization, F.R. and N. A.; methodology, F.R.; software, N.A.; validation, N.A.; formal analysis, F.R.; data curation, F.R.; writing—original draft preparation, F.R.; writing—review and editing, N.A.; All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest:

Not applicable.

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