Duration model for maturity gap risk management in Islamic banks

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Duration model for maturity gap risk management in Islamic banks

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Abstract

Purpose – The purpose of this paper is to propose models of duration for maturity gap risk management in Islamic banks.

Design/methodology/approach – A thorough review of literature on duration modeling, duration measurement in Islamic banks and *Shariah* compliance has been conducted to set parameters to develop *Shariah*-compliant maturity gap risk management mechanism.

Findings – Models based on durations of earning assets and return bearing liabilities using various rates of return earned and paid, benchmark rates and industry standards commonly used by Islamic and conventional banks.

Practical implications – Increased *Shariah* compliance has threefold impact. Firstly, it will increase trust of customers. Secondly, it will help improve profitability by reducing non-*Shariah* compliance penalties from the regulators. And finally, it will enhance market capitalization and returns stability to investors because of enhanced customer base, increased level of trust and increased profitability.

Originality/value – This research proposes *Shariah*-compliant maturity gap risk management models based on the concept of duration according to recommendations of Bank for International Settlements. As there is no such maturity gap risk management mechanism that meets the requirements of *Shariah* using benchmarks that are common between Islamic and conventional banks; therefore, this research presents risk management solutions that can be applied simultaneously in the entire banking sector.

Keywords Islamic banks, Earning assets, Return bearing liabilities, Duration model, Maturity gap risk management

Paper type Research paper

1. Introduction

Islamic banks operate simultaneously with conventional banks all around the world except in Iran and Sudan (Chattha and Alhabshi, 2018). According to a report of Islamic financial services board, the assets of Islamic financial institutions exceeded over US$2tn at the end of 2017. This expansion in the business of Islamic banking is significantly different from their conventional counterparts (IMF, 2017). However, Islamic banks face similar kind of risks, i.e. credit risk, operational risk, market risk, rate of return risk and base rate risk, etc. (IFSB-I, 2015). Although, risks are similar but their effect on banking structure is significantly different (Chattha, 2013).

Out of many risks affecting Islamic banks, rate of return risk gets its roots from various benchmark and market rates (IFSB-16, 2014). This is because Islamic banks use several conventional benchmarks for pricing of their products (Zaheer *et al.*, 2013). Accordingly, there exist significant risks to earnings if benchmark rate is not properly managed (IFSB-16, 2014). Keeping in view the gravity of benchmark rate risk dynamics, regulators all around the world require banks to develop policies against its exposure (Chattha and Alhabshi, 2018).

JEL classification – C32, C33, C34, G21, G28, P43

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With a view that Islamic banks have significantly different structures while working in the same environment, there is a need for separate set of financial measures for their analysis and management of risks (Entrop *et al.*, 2009). Measures that take into account benchmark rates, industry standards and book values for performance assessment, shock assessment and comparison (Entrop *et al.*, 2009; Chattha and Bacha, 2010). Such measures that are based on earning assets and return-bearing liabilities that are primary causes of rate of return risk. Considering the importance of rate of return risks in Islamic financial institutions, IFSB has set guiding principles in six sub-categories (Chattha and Alhabshi, 2018).

The purpose of this study is to propose mechanism for maturity gap risk management in Islamic banks by developing *Shariah*-compliant duration models of earning assets and return bearing liabilities. By doing so, our research shall benefit Islamic financial industry on the following grounds:

- Basel Committee of Banking Supervision (BCBS) requires banks to adopt market-based maturity gap risk management measures preferably based on duration that have standardized application for all banking regulators. (BCBS, 2004)
- *Shariah* compliance discourages excessive leverage to ensure less gharrar (Mohammad and Ashraf, 2015).
- *Shariah*-compliant firms have better operational performance (Farooq and Alahkam, 2016).
- Stocks of *Shariah*-compliant firms provide better return stability to investors (Abbes and Trichilli, 2015; Wan Ismail *et al.*, 2015; Azmat *et al.*, 2016; Uizani, 2017; Lusyana and Sherif, 2017).
- Enhanced *Shariah* compliance increases ability of banks to withstand crisis (Rizvi *et al.*, 2015).
- *Shariah* compliance increases trust and confidence of existing and prospective customers of respective institutions (Ashraf *et al.*, 2015).
- Islamic banks are in need of *Shariah*-compliant measures of risk management (Rashid and Jabeen, 2016; Hassan and Aliyu, 2008; Chattha and Alhabshi, 2018).

This research shall proceed by taking insightful review of literature on performance analysis of Islamic banks, their comparison with conventional counterparts, review of literature on various duration models and finally a review of minimum financial benchmarks for *Shariah* compliance. This shall lead us to first setting benchmarks for a model of duration; secondly, to setting parameters of *Shariah* compliance for a financial model, which is duration in the case of this research and finally to *Shariah*-compliant mechanism of maturity gap risk management.

The methodology for development of a *Shariah*-compliant model of duration for management of maturity gap risk has been explained in the flowchart drawn in the following Figure 1.

2. Review of literature

2.1 Literature on Islamic banks

Although discussing the impact of changes in monetary policy on financial institutions researchers find that the response of Islamic banks to changes in monetary policy is similar to large conventional banks (Zaheer *et al.*, 2013), however, a study on 128 banks finds that privately owned Islamic banks provide more protection to their equity holders as compared to state owned banks (Daher *et al.*, 2015). In a research about comparison of volatility and persistence in Islamic and conventional banks, it has been reported that Islamic banks are

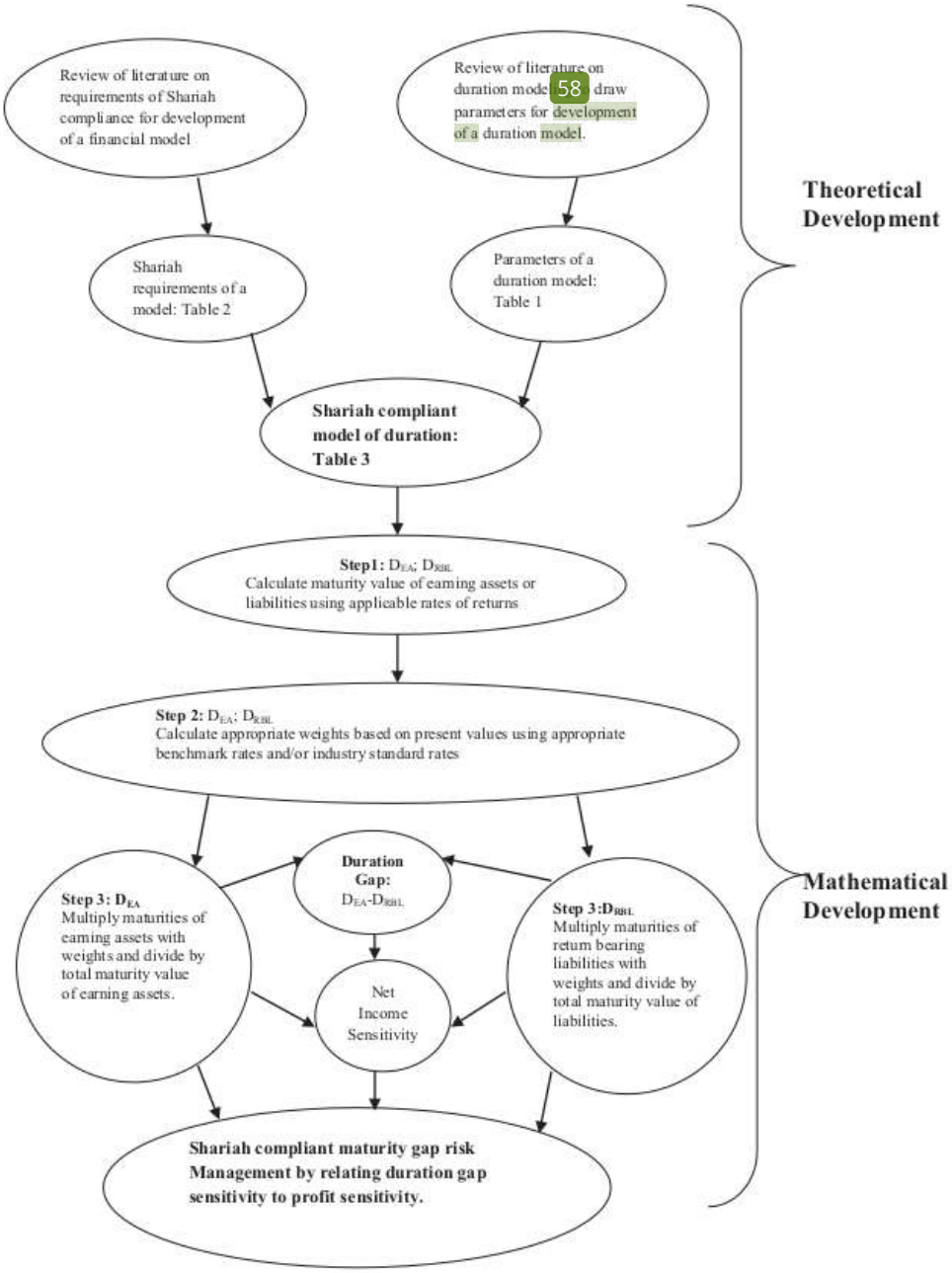

Figure 1.
Methodology flowchart

more resilient toward uncertainties but their resilience varies with the model of Islamic financial system in a country (Fakhfekh *et al.*, 2016). Beltrame *et al.* (2016) report highly negative correlations between interest rates and returns of Islamic banks, however, they recommend that negative effects of such scenarios can be mitigated with growth in profit

sharing investment accounts. This leads to the finding that Islamic banks also receive effect from variations in interest rates.

Sadiq *et al.* (2017) and Shah and Masood (2017) find that Islamic banks in Pakistan are less cost efficient because of excess liquidity, inadequate support and cut throat competition from conventional banks. Hamza and Saadaoui (2018) in their work on Islamic banks report that changes in interest rates negatively affect financing of Islamic banks. Although results in performance analysis of Islamic and conventional banks are similar but discussing the usage of credit risk transfer techniques it has been discovered that implementation of credit risk management techniques is similar in both contexts rather there exist *Shariah* compliance constraints in the case of Islamic banks (Saeed and Ayub, 2017).

The impact of credit and liquidity risks has been analyzed in a few researches with findings that both these kind of risks do not have any relationship; therefore, they needs to be addressed differently (Trad *et al.*, 2017; Ghenimi *et al.*, 2017). Similar results have also been reported by Safiullah and Shamsuddin (2018) who find that Islamic banks possess higher liquidity risk but lower insolvency and credit risks. In addition, about operational risk it has been reported that in Islamic banks it declines with increase in number and qualification of members of *Shariah* supervisory board (Safiullah and Shamsuddin, 2018). The relationship between sukuk and conventional bonds has been analyzed in terms of factors that affect correlations between the two. The results suggest that money and stock market liquidities along with credit information are the factors affecting volatilities of sukuk and conventional bonds in emerging markets almost similarly (Bhuiyan, 2017). Nawaz and Farzana (2018) analyze management of investment risk in Islamic and conventional banks and report similarity.

The size and capital expansions in Islamic banks positively affect profitability but negatively affect liquidity (Ghenimi *et al.*, 2017). In another study on performance analysis of banking sector it has been found that profitability of banks is affected similarly in case of Islamic and conventional banks in response to changes in interest rates (Ahmed *et al.*, 2018). Chattha and Alhabshi (2018) report that Islamic banks respond similarly to changes in interest rates because they use similar benchmark rates for pricing of their financial products. The impact of variations in capital adequacy has also been examined in case of Islamic and conventional banks where it has been found that highly capitalized banks react positively toward changes in capital adequacy (Narmeen *et al.*, 2018). The study, however, did not report any difference between Islamic and conventional banks (Narmeen *et al.*, 2018).

Although discussing the issue of political risk in Islamic and conventional banks it has been reported that Islamic banks are lesser exposed to political risk as compared to their conventional counterparts (Belkhir *et al.*, 2018). The issue of corporate governance and disclosure has also been addressed in some researches where it has been reported that conventional banks have better governance and voluntary disclosure as compared to Islamic banks (Neifar and Jarboui, 2018). Improvement in this areas can win more confidence that will enable Islamic banks enhance their businesses (Neifar and Jarboui, 2018). In another research, comparing transparency required by accounting and *Shariah* standards it has been reported that *Shariah* standards require more transparency (Khammasi and Jedidia, 2018).

Jawadi *et al.* (2018) analyze impact of uncertainties, for instance, climate change, business cycles etc., on Islamic and conventional indices and found that uncertainties affect both indices to higher extent. Islamic banks have also been compared in terms of size, i.e. whether there exists any difference between the performance and efficiency of larger and novice Islamic banks where researchers find no difference as there exists in case of conventional banks (Islam and Sultana, 2019).

Islamic banks have been subject to various techniques of conventional finance for their analysis. Chattha and Alhabshi (2018) conduct a compact graphical analysis of various conventional finance techniques used for performance assessment of Islamic banks that has been depicted in Figure 2.

2.1.1 Research gap-I. Having analyzed Islamic banking research literature on risk performance analysis it can be argued that research on risk management in Islamic banks has not taken any dimension toward development of *Shariah*-compliant measures for their specific analysis. Their analysis is currently based on replicating conventional banking techniques that suffer from various limitations because of difference in their structures (Chattha and Alhabshi, 2018). There is therefore a need to develop measures focusing structures of Islamic banks. Keeping in view the need, we endeavor to propose *Shariah*-compliant mechanism for performance based maturity gap risk management of Islamic banks. This mechanism shall be based on *Shariah*-compliant model of Macaulay's duration using values of earning assets, return-bearing liabilities, relevant rates of return earned and paid, benchmark rates and industry standards.

2.2 Literature on various duration models and their applications

Macaulay (1938) and Hicks (1939) present the concept of duration in different ways. After their works, several models have been developed corresponding to particular requirements and scenarios that all focus on immunization and risk management against interest rate uncertainties. Macaulay (1938) argues that to determine the "essence" of time to maturity of an asset it is inadequate to use number of years to maturity. To address the concern he introduces a measure that he terms as "duration" where he suggests to have weighted average maturity in case there are more than one future cash flows relating to an asset. According to Macaulay (1938) two applicable weights are "present values" and "future values," but he regards "present values" as more appropriate. Bierwag *et al.* (1978) explain duration as weighted average period over which the returns are received; however, the choice of weights depends on the purpose for which the duration is to be calculated.

"According to them, the purposes of a duration measure are as follows:

- to obtain a more useful indicator of the time characteristic of a particular payment stream, such as cash flows relating to bonds;
- to relate changes in interest rates to changes in the capital value of particular payment streams, such as cash flows relating to bonds, so as to provide a better understanding of the underlying mathematical relationships; and

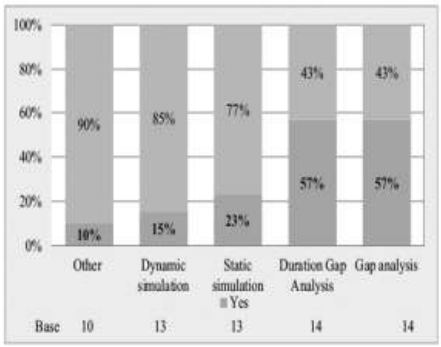

Figure 2. Graphical summary of techniques used for analysis of Islamic banks

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- to construct portfolio strategies that immunize against the risk associated with unexpected changes in interest rates."

They further formulate three rules for variations in duration for a given change in a basis point, that is to say, a change in price would be greater, if:

(1) the coupon rate is lower;

(2) the market yield is lower; and

(3) the maturity is longer.

Samuelson (1945) and Hicks (1946) apply duration model to show that weighted average equality of payments and receipts can be used to immunize a financial institution against possible unexpected changes in security prices. Redington (1952) and Wallas (1959) use the concept in application of theories of actuarial sciences. Fisher and Weil (1971) apply the concept in valuing zero-coupon bonds. They introduce the concept of immunizing bond portfolios that is applicable for immunizing the financial institutions against fluctuations in interest rates. To achieve immunization, they propose to create such a portfolio whose planning period equals its duration depending on the assumed stochastic future interest rates. Hopewell and Kaufman (1973) introduce the notion that duration is related to prices of bonds and varies accordingly.

Boquist *et al.* (1975) apply duration model on bonds and stocks and suggest that duration model of bonds is not applicable on stocks; therefore, a different model for measuring duration of stocks is required. Livingston and Caks (1977) revisit duration model of Macaulay (1938) and find that although duration is a function of yield curve but yield curve is not a function of duration. Therefore, yield curve should not be adjusted in response to duration. They report that there exists a problem of coupon rate in duration models that should be solved with forward rates. Cooper (1977) finds that if yield curves move in parallel shifts, duration model might not account for all portfolio risks. Bierwag (1977) suggests five grounds for a duration model to be applicable on financial institutions:

(1) There will be different assumptions about stochastic changes in interest rates.

(2) The immunized portfolio to be related to term structure of interest rates.

(3) Simple random shift may be immunized by purchasing a single coupon bond and complex shit may be immunized by buying a portfolio of bonds with different interest rates and maturities.

(4) There should be separate models for discrete and continuous investments.

(5) The applications on static and dynamic portfolios are similar in nature.

Bierwag (1977) also suggests that changes in term structure of interest rates occur in multiplicative fashion; hence, he devises a different duration model based on multiplicative assumptions. However, the results of both multiplicative and additive models are different only beyond maturities of 20 years. He introduces continuous duration models based on one-time additive models, multiplicative models and mixed additive-multiplicative models. Khang (1979) introduces a duration model where yield on shorter maturity bonds had more changes than that of longer maturity bonds.

Ingersoll *et al.* (1978) in their work prove that Macaulay's duration gives significant results only in case of flat yield curves, i.e. in static environment. They propose a duration measure in case interest rate is affected by multiple shocks and yield curve changes its places. Following similar works Cox *et al.* (1985) and Cox *et al.* (2005), available in 1978,

present a theory of term structure of interest rates. They indicate that anticipation, risk aversion, investm alternatives and preference about timing of consu on play role in determination of term structure of interest rates that ultimately affects current prices and stochastic properties of contingent claims including bonds. Cox *et al.* (1979) use their interest rate theory and devise a mechanism for an alternative measure of duration allowing several shocks encompassing shapes and locations of the yield curve.

Blocher and Stickney (1979) apply duration model for risk assessment in cap l budgeting and find that in the context of capital budgeting duration model can be used for gauging the risk of changes in required interest rates as well as risk of liquidity. Bierwag *et al.* (1982) propose single- and two-state duration models where prices of one and two securities, respectively, can be used as reference securities for estimating duration. Reitando (1991) introduces multivariate duration with the purpose to accommodate non-parallel movements that do not depend on the mathematical movements of yield curve.

Bowden (1997) finds that im ization should be based on areas along the yield curve that are more sensitive. Babbel *et al.* (1997) analyze th pact of default risk on duration and find that default risk reduces respective duration. Navarro and Nave (1997) present a two-factor duration model and conclude that in c of extra ordinary and unexpected movements in yield curves two-factor model should be used to approximate term structure of interest rates. Duan *et al.* (1999) compare conventional techniques of duration with option based models on duration gaps of banks and find that option based models take into account stochastic interest rates and avoid overestimation of gaps as might exist in case of conventional duration techniques.

Beck *et al.* (2000) find that yield and duration of whole portfolios are not necessarily equal to the weighted average of yield and duration of each individual asset. They integrate funds management and capital adequacy with duration and find that managing risks keeping these three factors together helps not only keeping the rate of return on assets ab that of liabilities but also the dollar value of assets above dollar value of liabilities. Wu (2000) presents a new stochastic duration measure based on Vasicek and CIR models and finds that long run stochastic models bring superior results as compared with tradit l Macaulay's model. Zheng *et al.* (2003) devise an alternative duration measure based on generalization of Macaulay's duration on non-flat term structure of securities. They argue that duration calculated in such a way is a better contender for assets and liabilities management of financial institutions as it does not follow any particular pattern of interest rates changes.

Zainol and Hj. Kassim (2012) recommend sensitivity and stress testing based risk measures for Islamic banks as are applied in conventional financial institutions. Craig and Dinger (2014) find that in financial institutions, retail interest rate durations are affected by changes in money market and policy rates since the last change in retail interest rate. They argue that size of a bank, its market share and its geographical scope also significantly affect duration of financial institutions when retail interest rates change. Jiang and Sun (2015) use duration measures to check stock price sensitivities to interest rate changes and find that stocks that pay higher dividend have longer maturities but also have greater price declines in case of interest rate falls. Chattha and Alhabshi (2017) apply conventional duration and convexity models on the data of 50 Islamic banks from 13 countries and find that low benchmark rates give rise to strategic implications that may include negative variations in profitability, excessive risk takin and improper credit decisions.

Zaremba (2017) addresses the ncern of immunization problem with a single liability discharge. He divides shifts of term structure of interest rates into many classes and introduces the notion of dedicated duration. He reports that with his concept of du tion returns on bond portfolios can be maximized. Mohrschladt and Nolte (2018) propose a new

risk factor based on equity duration and find that new risk factor carries significant risk premium in cross section asset pricing models. Chattha and Alhabshi (2018) apply duration models consistent with the works of Koch and MacDonald (2009) and Chattha and Bacha (2010) and find that Islamic banks are more vulnerable as compared to their conventional counterparts. Alandejani *et al.* (2017) apply discrete duration models in their analysis of Islamic banks from 56 GCC countries. They report that Islamic banks have higher rates of failure and therefore have shorter time of survival. Huseynov (2018) compares gap and duration methods in his study on Islamic banks and finds that if gap between assets and liabilities is positive then assets will lose more as a result of rise in interest rate and the liabilities will lose more in case of negative gap. Beccacece *et al.* (2018) analyze IFRS 13, B25 and IFRS 13, B26 methods of expected present value calculations and find that the results are approximately proportional to Macaulay's duration of expected inflows rather than life of the project. This follows that risk results of the projects depend not only on the total term and total cash flows of the project but also on the timing of cash flows as demonstrated by Macaulay. Having performed extensive review of literature, we establish the following parameters for a duration model as given in Table I hereunder.

2.2.1 Research gap 2. Having explored literature on various duration models, we formulate the following research gaps:

- Islamic banks have different structure that requires different risk measures.
- Duration models proposed for banks should take market values as weights. However, as there do not exist market values for all of the assets and liabilities of financial institution, particularly Islamic banks; therefore, there is a need to develop models based on alternative weights.
- Existing models take into account expected values of financial variables, which involve excessive gharrar in Islamic context.

2.3 Financial benchmarks for Shariah compliance

Islamic banks have unique risk characteristics based on *Shariah* compliance (Ahmed and Khan, 2007). The risks to banking structures of Islamic banks are the same as faced by their conventional counterparts because they exist in competition to each other but the nature of impact is altogether different (Chattha, 2013). An Islamic bank cannot use an instrument for risk mitigation in which all parameters, i.e. the cash payment and delivery of commodity are postponed because of appearance of gharrar and riba (Ahmed and Khan, 2007; Hassan *et al.*, 2013). Furthermore, with regard to *Shariah* compliance there exist requirements consisting of debt to equity ratio not exceeding 33 per cent, account receivable to total assets ratio not exceeding 49 per cent and if the organization is complying these parameters, the mixture of non *Shariah*-compliant income in *Shariah*-compliant income is permissible only up to 5 per cent (Ho *et al.*, 2011, 2012, 2014). This will be termed as 5,33,49 rule in our research. From this information, we formulate parameters of a financial model for Islamic banks.

2.3.1 Parameters of a financial model for Islamic banks

- It should incorporate realized rates of returns earned and paid, benchmark rates, interbank offered rates (IBORs) and industry standards.
- Avoiding all future based transaction rule applies to a financial model as well. Accordingly, the financial model should avoid incorporating variables that can give rise to excessive gharrar, i.e. the model should not include all future value-based variables. For the purpose of a model, this condition shall be applied in such a way that future based variables should not be more than 50 per cent of the total variables

Table I.
Parameters for a duration model

Authors	Gap addressed	Findings and recommendations
Macaulay (1938) and Hicks (1939)	Essence of duration of term to maturity	The essence of term to maturity must be calculated using "present values" as weights Future values are not appropriate weights
Bierwag (1977)	Requirements of duration model of financial institutions	Different assumptions for stochastic changes in interest rates Immunized portfolio to be related to "term structure" of interest rates Simple and random shits are to be treated differently. Simple by trading a single coupon bond and complex by trading bonds with varying interest rates and maturities Separate models for discrete and continuous assets Similar applications on static and dynamic portfolios
Bierwag (1977)	Nature of duration models	Additive, multiplicative or both
Bierwag *et al.* (1978)	Purposes of a duration model	"To obtain a more useful indicator of the time characteristic of a particular payment stream, such as a bond, To relate changes in interest rates to changes in the capital value of particular payment streams, such as bonds, so as to provide a better understanding of the underlying mathematical relationships and To construct portfolio strategies that immunize against the risk associated with unexpected changes in interest rates"
Bierwag *et al.* (1978)	Rules for variations in duration models	The price change increases with lower coupon rate; The price change increases with lower market yield and The price change increases if the maturity is longer
Ingersoll *et al.* (1978)	Use of duration models in static or dynamic environments	Recommended models for use in dynamic environment
Bierwag *et al.* (1982)	Single or double rate duration models	Recommended use of single or double rate duration models according to requirements
Reitando (1991)	Models for parallel and nonparallel shifts	Recommended multivariate models to accommodate nonparallel shifts of yield
Beck *et al.* (2000)	Yield and duration of individual assets and portfolio	Duration of whole portfolio does not necessarily equal weighted average yield of all individual assets

used in the model and the composition of variables should not give rise to results of which more than 50 per cent will be expected.

- The composition of variables in the model should not give rise to overall results that breach the 5,33,49 rule.
- As the returns earned and paid are determined at the end of the period, therefore, model shall use only realized values not the expected values as are used in the case of Macaulay's duration model.
- The model shall function backwards, i.e. it will calculate values from end of the year to beginning of the year. It is because the model uses realized values. The values so calculated shall be termed as "Reversed Present Values."
- Models should be proposed for intra-year and inter-year risk analysis and management.

3. Objective

Having reviewed the literature, our objective is to present *Shariah*-compliant mechanism for maturity gap risk management in Islamic banks. A mechanism incorporating the following:

- the concept of duration as developed by Macaulay (1938) and later studies and recommended by Bank for International Settlements, IFSB and other regulatory authorities;
- alternative more relevant weights based on realized values of returns earned and paid;
- money market benchmarks;
- industry standards;
- dedicated maturity of each class of assets;
- complying with parameters of a duration model as formulated in the Table I and Section 2.31 of this manuscript; and
- complying with section 4.3 of IFSB-13 (IFSB-13, 2012), which requires regulators of Islamic banks to implement robust risk management strategies.

4. Proposed model

Having established parameters and assumptions, we are now in a position to propose our mechanism for maturity gap risk management in Islamic banks. This shall be achieved first by proposing *Shariah*-compliant models of duration of earning assets and return bearing liabilities. The models so developed shall be further used in Saunders and Cornett's (2007) mechanism to assess impact of changes in duration, relevant rates of returns earned and paid, benchmark rates and industry standards on net income of an Islamic bank.

4.1 Duration model for earning assets

4.1.1 Step-1. Calculate maturity values of earning assets using rates of returns earned on specific earning assets in respective maturities as hereunder:

$$\sum_{j}^{J}\sum_{i}^{N_j} P_{EAij}\left(1 + ror_{EAij}\right)^{t_n} \quad (1)$$

4.1.2 Step-2. Calculate present values as described in Table II of this manuscript using IBORs. This is because all Islamic banks use IBORs as benchmark rates for pricing of their earning assets:

$$\left(1 + IBOR_{ij}\right)^{-t_n} \tag{2}$$

4.1.3 Step-3. formulation of proposed model. In proposed model, the duration of earning assets has been computed by taking a ratio of summation of weighted average time to maturity of earning assets to total maturity value of earning assets, where the time to maturity has been indicated by "$t_{n,}$" and the weights have been designated by present values of earning assets as indicated by the function $\left[\frac{\sum_j^J \sum_i^{N_j} P_{EAij}\left(1+rorEA_{ij}\right)^{t_n}}{\left(1+IBOR_{ij}\right)^{t_n}}\right]$. The divisor is maturity value of earning assets $\sum_j^J \sum_i^{N_j} P_{EAij}\left(1 + ror_{EAij}\right)^{t_n}$. The proposed model for duration of earning assets has been formulated as under:

Sr. no.	Parameters	Compliance
1	It should incorporate realized rates of returns earned and paid, benchmark rates, IBORs and industry standards	The proposed model is based on rates of return earned, paid and applied benchmarks instead of expected rates based on expected yield curve
2	Avoiding all future based transaction rule applies to financial model as well. Accordingly, the financial model should avoid incorporating variables that can give rise to excessive gharrar, i.e. the parameters should not include all future valued based variables. For the purpose of a model, this condition shall be applied in such a way that future based variables should not be more than 50% of the total variables used in the model and the composition of variables should not give rise to results of which more than 50% are expected	The models are based on book value of assets and liabilities. For instance in denominator book value of assets and liabilities have been incorporated instead of expected present values
3	The composition of variables in the model should not give rise to overall results that breach the 5,33,49 rule	Has to be ensured while applying the model
4	As the returns earned and paid are determined at the end of the period, therefore model shall use only realized values not the expected values as are used in the case of Macaulay's duration model	The models are based on realized rates
5	The model shall function backwards, i.e. it will calculate values from end of the year to beginning of the year. It is because the model uses realized values. The values so calculated shall be termed in our research as "Reversed Present Values"	In step 3 the model calculates factor based on "Reversed Present Values" i.e., the real period taken to up to final value of certain asset or liability
6	Models should be proposed for intra-year and inter-year risk analysis and management	For assets and liabilities having maturity of one year and beyond similar model can be applied on static and dynamic rate assets and liabilities

Table II.
Table for compliance with parameters for a model for Islamic bank

$$D_{EA} = \sum_{i=1}^{n} \frac{\left[\frac{\sum_j^J \sum_i^{N_j} P_{EAij}\left(1+ror_{EAij}\right)^{t_n}}{\left(1+IBOR_{ij}\right)^{t_n}}\right] \times t_n}{\sum_j^J \sum_i^{N_j} P_{EAij}\left(1+ror_{EAij}\right)^{t_n}} \quad (3)$$

4.2 Duration model of return bearing liabilities

4.2.1 Step-1. Calculate total maturity value of return bearing liabilities using rates of returns paid on specific return bearing liabilities in respective maturities as hereunder:

$$\sum_j^J \sum_i^{N_j} P_{RBLij}\left(1+ror_{RBLij}\right)^{t_n} \quad (4)$$

4.2.2 Step-2. Calculate present values using weighted average rates of returns paid on return bearing liabilities in the deposit market:

$$\left(1+IBAR_{RBLit}\right)^{-t_n} \quad (5)$$

4.2.3 Step-3 formulation of proposed model. In proposed model the duration of return bearing liabilities has been computed by taking a ratio of summation of weighted average time to maturity of return bearing liabilities to total maturity value of return bearing liabilities, where the time to maturity has been indicated by "t_n," and the weights have been designated by present values of return bearing liabilities by the function $\left[\frac{\sum_j^J \sum_i^{N_j} P_{RBLij}\left(1+ror_{RBLij}\right)^{t_n}}{\left(1+IBAR_{RBLit}\right)^{t_n}}\right]$. The divisor is maturity value of return bearing liabilities $\sum_j^J \sum_i^{N_j} P_{RBLij}\left(1+IBAR_{RBLit}\right)^{t_n}$. The proposed model for duration of return bearing liabilities has been formulated as under:

$$D_{RBL} = \sum_{i=1}^{n} \frac{\left[\frac{\sum_j^J \sum_i^{N_j} P_{RBLij}\left(1+ror_{RBLij}\right)^{t_n}}{\left(1+IBAR_{RBLit}\right)^{t_n}}\right] \times t_n}{\sum_j^J \sum_i^{N_j} P_{RBLij}\left(1+ror_{RBLij}\right)^{t_n}} \quad (6)$$

In above models the following abbreviations have been used:

ror_{EAij} = All applicable rates of returns for various maturity periods of respective earning assets;

$IBOR_{ij}$ = All applicable interbank offered rates for various maturity periods of various earning assets;

$\sum_j^J \sum_i^{N_j} P_{EAi_j}$ = Total of all earning assets at various rates and maturity brackets;

ror_{RBLij} = All applicable rates of returns paid for various maturity periods of respective return bearing liabilities;

$IBAR_{RBLij}$ = All applicable interbank average rates for various maturity periods of various return bearing liabilities;

$\sum_j^J \sum_i^{N_j} P_{RBLi_j}$ = Total of all return bearing liabilities at various rates and maturity brackets;

t_n = Terms to maturity of specific asset or liability;

D_{EA} = Duration of earnings assets; and

D_{RBL} = Duration of Return Bearing Liabilities.

The functions of durations expressed in equations (3) and (6) imply that if changes in ROR_{EA} or ROR_{RBL} of an Islamic bank are lower than their benchmarks and industry standards, i.e. IBOR or IBAR, respectively, as proposed in this study, the duration of earning assets and return bearing liabilities will decrease and vice versa. However, this decrease in duration of earning assets and return bearing liabilities will have different impact on net income of an Islamic bank. That is to say, decrease in duration of earning assets will decrease the net income, whereas the decrease in duration of return bearing liabilities will increase the net income.

Having established functions for *Shariah*-compliant models of duration of earning assets and return bearing liabilities, duration gap of a financial institution can be measured in terms of Saunders and Cornett (2007):

$$\text{Duration Gap} = D_{EA} - D_{RBL} \tag{7}$$

The overall change in net income of an Islamic bank can also be measured using Saunders and Cornett (2007) function for change in net income of a financial institution, which states that change in net income of a financial institution is negatively related to change in interest rates that can be measured using the following function:

$$-\Delta NI_S = \left[D_A \times A \times \frac{\Delta R}{(1+R)}\right] - \left[D_L \times L \times \frac{\Delta R}{(1+R)}\right] \tag{8}$$

where:

ΔNI = Change in net income;
D_A = Duration of assets;
D_L = Duration of liabilities;
A = Assets;
L = Liabilities;
ΔR = Change in rate of interest; and
R = Rate of interest.

The essence of expression in equation (8) is the fact that if there is no change in interest rate, i.e. ΔR equals zero there will be no change in net income of a financial institution, i.e. $-\Delta NI$ will equal zero as well. However, in an Islamic bank, change in net income does not depend on interest rates. Accordingly, impact of changes in benchmark rates, rates of returns earned and paid and industry average rates on net income of an Islamic bank can be measured using the relationship in function (8) above with *Shariah*-compliant variables as under:

$$\Delta NI_S = \left(D_{EA} \times EA \times \frac{1+\Delta ROR_{EA}}{(1+\Delta IBOR)} - 1\right) - \left(D_{RBL} \times RBL \times \frac{1+\Delta ROR_{RBL}}{(1+\Delta IBAR)} - 1\right) \tag{9}$$

where:

ΔNI = Change in net income
D_{EA} = Duration of earning assets
D_{RBL} = Duration of risk bearing liabilities
EA = Earning assets
RBL = Return bearing liabilities
ΔROR_{EA} = Change in rate of return on assets

JM2

$\Delta IBOR$ = Change in IBORs;
ΔROR_{RBL} = Change in rate of return on liabilities; and
$\Delta IBAR$ = Change in industry average rates of return on liabilities.

Using above function, change in net income of an Islamic bank can be forecasted in response to change in any single factor or all factors as a whole.

Function (9) implies that if change in ROR_{EA} is lower than change in IBOR or change in ROR_{RBL} is higher than change in IBAR, the net income of an Islamic bank will decrease by an amount of ΔNI and vice versa.

5. Conclusion

We have proposed models for duration of earning assets and return bearing liabilities and a model for measuring change in net income of Islamic banks against changes in various rates of return earned and paid, benchmark rates and industry standards. The models comply with Section 2.31 of this research that has been explained in Table II hereunder.

The compliance of models with parameters in Table I has been given in Table III hereunder.

The proposed models are also robust as recommended by Chattha and Alhabshi (2018) who recommend that Islamic banks should have their own benchmarks, because in case Islamic banks develop their own benchmarks these models can be applied without any further change simply replacing common benchmarks with Islamic ones. The models also comply with the recommendations of Ahmed and Khan (2007) and Hassan *et al.* (2017) who argue that model for an Islamic bank should not base on all such variables that have expected values.

As this is a ground breaking study in this area because there are no *Shariah*-compliant models of maturity gap risk management based on duration of earning assets and return rearing liabilities; therefore, models require through implementation along with backward and forward testing to prove their suitability. The proposed models are also required to be tested in the contexts of Islamic and conventional banks to evaluate and compare the results for suitability in both banking structures to meet the requirements of BCBS (2004).

The models bring forward huge area of study, research and practical implementation for researchers, academics and policy regulators for performance analysis and risk management regulations of Islamic banks in particular and banking sector in general. These models meet various objectives as mentioned in the introduction.

6. Research benefits

Shariah-compliant financial modeling is a brand new concept in the realm of Islamic economics that is primarily driven by Islamic banking. Its benefits include increase in trust and perception of customers who are looking for *Shariah*-compliant solutions. It will also help avoid non-*Shariah* compliance penalties from the regulators. Last, as it has been established over the period of time that *Shariah* compliance provides better operational performance Farooq and Alahkam (2016); return stability Kamarudin and Sarman (2015), Azmat *et al.* (2016), Uizani (2017) and crisis resilience Rizvi *et al.* (2015); therefore, use of *Shariah*-compliant financial models shall enhance *Shariah* compliance in all these three dimensions that will lead to increased market capitalization and value to the stockholders.

7. Future research implications

Shariah-compliant maturity gap risk management mechanism proposed in this study has profound future research implications. It is recommended for analyzing the effects of

Authors	Recommendations of authors	Compliance
Macaulay (1938) and Hicks (1939)	The essence of term to maturity must be calculated using "present values" as weights. Future values are not appropriate weights	Used present values as weights
Bierwag (1977)	Different assumptions for stochastic changes in interest rates Immunized portfolio to be related to "term structure" of interest rates Simple and random shits are to be treated differently. Simple by trading a single coupon bond and complex by trading bonds with varying interest rates and maturities Separate models for discrete and continuous assets Similar applications on static and dynamic portfolios	Used term structure of rates of return and term structure of offered rates; separate models for continuous assets
Bierwag (1977)	Additive, multiplicative or both	Additive models
Bierwag *et al.* (1978)	"To obtain a more useful indicator of the time characteristic of a particular payment stream, such as a bond, To relate changes in interest rates to changes in the capital value of particular payment streams, such as bonds, so as to provide a better understanding of the underlying mathematical relationships and To construct portfolio strategies that immunize against the risk associated with unexpected changes in interest rates"	Relates changes in interest rates to book values of assets and liabilities
Bierwag *et al.* (1978)	The price change increases with lower coupon rate The price change increases with lower market yield and The price change increases if the maturity is longer	Lower benchmark interest rates will increase duration whereas lower rates of return will decrease duration
Ingersoll *et al.* (1978)	Recommended models for use in dynamic environment	As the model uses term structure of offered rates therefore can be used in dynamic environments
Bierwag *et al.* (1982)	Recommended use for single or double rate duration models according to requirements	Multiple rates used according to requirements.
Reitando (1991)	Recommended multivariate models to accommodate nonparallel shifts of yield	Rates of return and rates of interest used simultaneously
Beck *et al.* (2000)	Duration of whole portfolio does not necessarily equal weighted average yield of all individual assets	Application of models

Table III. Compliance of duration models with parameters in Table I

changing in net stable funding ratio, liquidity coverage ratio and the effects of regulations from Basel committee of banking supervision, Islamic financial services board and specific countries. Research is also required to examine on and off balance sheet items within each maturity brackets and their overall impact on financial standing and resilience. The mechanism may also be extended to examine modified duration and convexity, to analyze long-term impact on financial standing and resilience.

An important shortcoming in the analysis of Islamic banks is the shortage and inconsistency of data of longer periods. This is because Islamic banking is in different stages of development around the globe. Some countries are in advanced stages for instance, Malaysia and UAE, some in the middle for instance, Pakistan, Bangladesh and Indonesia, and some in the early for instance, most of the Central Asian and Western countries. This gives rise to unbalanced data for significant analysis. There is therefore a need to continuously conduct short- and medium-term analyses focusing various countries and regions to form an adequate base for new implementers of Islamic banking to rectify structural shortcomings that have been encountered by the countries that are through to advanced stages of implementing Islamic banking. The present study is an attempt in this direction as well to comply the maturity gap risk management measures of Islamic banking with *Shariah*.

Islamic banks are increasingly adopting big data, blockchain, robo advisors and artificial intelligence, etc. to keep up with the agility of dynamic banking environment. Challenges of fast transformation into fintech are leading to enhanced needs to ensure compliance with *Shariah* along with holistic risk management. Keeping in view the expected dynamism in *Shariah* risks stemming from digital transformation, this research provides a mechanism to integrate *Shariah* compliance with fintech adoption that will be helpful for Islamic banks to make them *Shariah* competitive, *Shariah* efficient and *Shariah* compliant.

Finally, as recommended by Zainol and Hj. Kassim (2012), the mechanism and models proposed in this study are recommended to be applied in fixed and variable rate scenarios with more severe stress testing that includes lowering capital buffers, severe benchmark and rate of return shocks and the effects of country specific regulations to examine soundness and resilience of Islamic banks in varying economic conditions.

References

Abbes, M.B. and Trichilli, Y. (2015), "Islamic stock markets and potential diversification benefits", *Borsa Istanbul Review*, Vol. 15 No. 2, pp. 93-105.

Ahmed, H. and Khan, T. (2007), "Risk management in Islamic banking", *Handbook of Islamic Banking*, Edward Elgar, Cheltenham, pp. 144-160.

Ahmed, A., Rehan, R., Chhapra, I.U. and Supro, S. (2018), "Interest rate and financial performance of banks in Pakistan", *International Journal of Applied Economics, Finance and Accounting*, Vol. 2 No. 1, pp. 1-7.

Alandejani, M., Kutan, A.M. and Samargandi, N. (2017), "Do Islamic banks fail more than conventional banks?", *Journal of International Financial Markets, Institutions and Money*, Vol. 50, pp. 135-155.

Ashraf, S., Robson, J. and Sekhon, Y. (2015), "Consumer trust and confidence in the compliance of Islamic banks", *Journal of Financial Services Marketing*, Vol. 20 No. 2, pp. 133-144.

Azmat, S., Jalil, M.N., Skully, M. and Brown, K. (2016), "Investor's choice of Shariah compliant 'replicas' and original Islamic instruments", *Journal of Economic Behavior and Organization*, Vol. 132, pp. 4-22.

BCBS (2004), "*Principles for the Management and Supervision of Interest Rate Risk*", Bank for International Settlement, Basel.

Babbel, D.F., Merrill, C. and Panning, W. (1997), "Default risk and the effective duration of bonds", *Financial Analysts Journal*, Vol. 53 No. 1, pp. 35-44.

Beccacece, F., Tasca, R. and Tibiletti, L. (2018), "The Macaulay duration: a key indicator for the risk-adjustment in fair value", *International Journal of Business and Management*, Vol. 13 No No. 12, pp. 105-128.

Beck, K.L., Goldreyer, E.F. and D'Antonio, L.J. (2000), "Duration gap in the context of a banks strategic planning process", *Journal of Financial and Strategic Decisions*, Vol. 13 No. 2, pp. 57-71.

Belkhir, M., Grira, J., Hassan, M.K. and Soumaré, I. (2018), "Islamic banks and political risk: international evidence", *The Quarterly Review of Economics and Finance*, available at: https://doi.org/10.1016/j.qref.2018.04.006

Beltrame, F., Previtali, D. and Sclip, A. (2016), "Does earnings management affect banks' cost of funding? An empirical investigation across a European sample", *Bank Funding, Financial Instruments and Decision-Making in the Banking Industry*, Palgrave Macmillan, Cham, pp. 7-30.

Bhuiyan, S.Y.H. (2017), "Customer attitude toward Islami banking services and performance of Al-ArafahIslami bank limited", Doctoral dissertation, *Daffodil International University*.

Bierwag, G.O. (1977), "Immunization, duration, and the term structure of interest rates", *The Journal of Financial and Quantitative Analysis*, Vol. 12 No. 5, pp. 725-742.

Bierwag, G.O., Kaufman, G.G. and Khang, C. (1978), "Duration and bond portfolio analysis: an overview", *The Journal of Financial and Quantitative Analysis*, Vol. 13 No. 4, pp. 671-681.

Bierwag, G.O., Kaufman, G.G. and Toevs, A.L. (1982), "Single factor duration models in a discrete general equilibrium framework", *The Journal of Finance*, Vol. 37 No. 2, pp. 325-338.

Blocher, E. and Stickney, C. (1979), "Duration and risk assessments in capital budgeting", *Accounting Review*, Vol. 54 No. 1, pp. 180-188.

Boquist, J.A., Racette, G.A. and Schlarbaum, G.G. (1975), "Duration and risk assessment for bonds and common stocks", *The Journal of Finance*, Vol. 30 No. 5, pp. 1360-1365.

Bowden, R.J. (1997), "Generalising interest rate duration with directional derivatives: direction X and applications", *Management Science*, Vol. 43 No. 5, pp. 586-595.

Chattha, J.A. (2013), "Significance and key challenges in conducting stress testing for Islamic commercial banks", *Global Review of Islamic Economics and Business*, Vol. 1 No. 2, pp. 85-98.

Chattha, J.A. and Alhabshi, S.M.S.J. (2017), "Risk management in changing benchmark rates regime: prudential implications for Islamic banks and supervisors", *Journal of Islamic Finance*, Vol. 6 No. Special Issue, pp. 205-230.

Chattha, J.A. and Alhabshi, S.M.S.J. (2018), "Benchmark rate risk, duration gap and stress testing in dual banking systems", *Pacific-Basin Finance Journal*, available at: https://doi.org/10.1016-/j.pacfin.2018.08.017

Chattha, J.A. and Bacha, O.I. (2010), "Duration gaps and net worth risk for Islamic and conventional banks: a comparative cross-country analysis", *Review of Islamic Economics*, Vol. 13 No. 2, pp. 5-33.

Cooper, I.A. (1977), "Asset values, interest-rate changes, and duration", *The Journal of Financial and Quantitative Analysis*, Vol. 12 No. 5, pp. 701-723.

Cox, J.C., Ingersoll, J.E. Jr,. and Ross, S.A. (1979), "Duration and the measurement of basis risk", *The Journal of Business*, Vol. 52 No. 1, pp. 51-61.

Cox, J.C., Ingersoll, J.E., Jr and Ross, S.A. (1985), "A theory of the term structure of interest rates", *Econometrica*, Vol. 53 No. 2, pp. 385-408.

Craig, B.R. and Dinger, V. (2014), "The duration of bank retail interest rates", *International Journal of the Economics of Business*, Vol. 21 No. 2, pp. 191-207.

Daher, H., Masih, M. and Ibrahim, M. (2015), "The unique risk exposures of Islamic banks' capital buffers: a dynamic panel data analysis", *Journal of International Financial Markets, Institutions and Money*, Vol. 36, pp. 36-52.

Duan, J., Sealey, C.W. and Yan, Y. (1999), "Managing banks' duration gaps when interest rates are stochastic and equity has limited liability", *International Review of Economics and Finance*, Vol. 8 No. 3, pp. 253-265.

Entrop, O., Wilkens, M. and Zeisler, A. (2009), "Quantifying the interest rate risk of banks: assumptions do matter", *European Financial Management*, Vol. 15 No. 5, pp. 1001-1018.

Fakhfekh, M., Hachicha, N., Jawadi, F., Selmi, N. and Cheffou, A.I. (2016), "Measuring volatility persistence for conventional and Islamic banks: an FI-EGARCH approach", *Emerging Markets Review*, Vol. 27, pp. 84-99.

Farooq, O. and Alahkam, A. (2016), "Performance of shariah-compliant firms and non-Shariah-compliant firms in the MENA region: which is better?", *Journal of Islamic Accounting and Business Research*, Vol. 7 No. 4, pp. 268-281.

Fisher, L. and Weil, R.L. (1971), "Coping with the risk of interest rate fluctuations: returns to bondholders from naive and optimal strategies", *The Journal of Business*, Vol. 44 No. 4, pp. 408-431.

Ghenimi, A., Chaibi, H. and Omri, M.A.B. (2017), "The effects of liquidity risk and credit risk on bank stability: evidence from the MENA region", *Borsa Istanbul Review*, Vol. 17 No. 4, pp. 238-248.

Hamza, H. and Saadaoui, Z. (2018), "Monetary transmission through the debt financing channel of Islamic banks: does PSIA play a role?", *Research in International Business and Finance*, Vol. 45, pp. 557-570.

Hassan, M.K., Aliyu, S. and Brodmann, J. (2017), "An introduction to Islamic banking and finance", *The Most Important Concepts in Finance*, Edward Elgar Publishing.

Hicks, J.R. (1939), *Value and Capital, Clarendon Press, Oxford*.

Hicks, J.R. (1946), *Value and Capital*, 2nd ed., *Clarendon Press, Oxford*.

Ho, C.S.F., Abd-Rahman, N.A., Yusuf, N.H.M. and Zamzamin, Z. (2011), "Comparison of quantitative shariah-compliant screening methods", *International Journal of Islamic Finance*, Vol. 3 No. 2, pp. 91-109.

Ho, C.S.F., Masood, O., Abdul-Rehman, A. and Bellalah, M. (2012), "Syariah accounting and compliant practices", *Qualitative Research in Financial Markets*, Vol. 4 No. 2, pp. 24-254.

Ho, C.S.F., Rahman, N.A.A., Yusuf, N.H.M. and Zamzamin, Z. (2014), "Performance of global islamic versus conventional share indices: international evidence", *Pacific-Basin Finance Journal*, Vol. 28, pp. 110-121.

Hopewell, M.H. and Kaufman, G.G. (1973), "Bond price volatility and term to maturity: a generalized respecification", *American Economic Review*, Vol. 63 No. 4, pp. 749-753.

Huseynov, A. (2018), "Interest rate risk stemming from liquidity risk, gap and duration analysis in banks", *Journal of Contemporary Applied Mathematics*, Vol. 8 No. 1, pp.8, pp. 1-96.

IFSB-13 (2012), *March. IFSB-13: Guiding Principles on Stress Testing for Institutions Offering Islamic Financial Services [Excluding Islamic Insurance (Takaful) Institutions and Islamic Collective Investment Schemes]*, Kuala Lumpur, Malaysia.

IFSB-16 (2014), *March. IFSB-16: Revised Guidance on Key Elements in the Supervisory Review Process for IIFS*, Kuala Lumpur, Malaysia.

IFSB-I (2015), *April.IFSB-17: Core Principles for Islamic Finance Regulation (Banking Segment)*, Kuala Lumpur, Malaysia.

Ingersoll, J.E., Skelton, J. and Weil, R.L. (1978), "Duration forty years later", *The Journal of Financial and Quantitative Analysis*, Vol. 13 No. 4, pp. 627-650.

Islam, S. and Sultana, T. (2019), "Practice of Islamic financial management in Bangladesh: evidence from Islamic banks", *International, Journal of Islamic Banking and Finance Research*, Vol. 3 No. 1, pp. 1-12.

Jawadi, F., Jawadi, N. and Cheffou, A.I. (2018), "A statistical analysis of uncertainty for conventional and ethical stock indexes", *The Quarterly Review of Economics and Finance*, available at: https://doi.org/10.1016/j.qref.2018.03.002

Jiang, H. and and Sun, Z. (2015), "Equity duration: a puzzle on high dividend stocks", *Michigan State University* working paper.

Khammasi, I. and Jedidia, K.B. (2018), "Do islamic banking standards convey more financial transparency than conventional banking ones?", *Turkish Journal of Islamic Economics*, Vol. 5 No. 1, pp. 109-125.

Khang, C. (1979), "Bond immunization when short-term interest rates fluctuate more than long-term rates", *The Journal of Financial and Quantitative Analysis*, Vol. 14 No. 5, pp. 1085-1090.

Koch, T.W. and MacDonald, S.S. (2009), *Bank Management*, 7th ed., Cengage Learning.

Livingston, M. and Caks, J. (1977), "A 'duration' fallacy", *The Journal of Finance*, Vol. 32 No. 1, pp. 185-187.

Lusyana, D. and Sherif, M. (2017), "Shariah-compliant investments and stock returns: evidence from the Indonesian stock market", *Journal of Islamic Accounting and Business Research*, Vol. 8 No. 2, pp. 143-160.

Macaulay, F.R. (1938), *Some Theoretical Problems Suggested by the Movements of Interest Rates, Bond Yields, and Stock Prices in the US Since 1856*, National Bureau of Economic Research, New York, NY.

Mohammad, N. and Ashraf, D. (2015), "The market timing ability and return performance of Islamic equities: an empirical study", *Pacific-Basin Finance Journal*, Vol. 34, pp. 169-183.

Mohrschladt, H. and Nolte, S. (2018), "A new risk factor based on equity duration", *Journal of Banking and Finance*, Vol. 96, pp. 126-135.

Narmeen, S., Saba, I., Kouser, R. and Khurram, H. (2018), "Why banks need adequate capital adequacy ratio? A study of lending and deposit behaviors of banking sector of Pakistan", *Journal of Accounting and Finance in Emerging Economies*, Vol. 4 No. 1, pp. 11-26.

Navarro, E. and Nave, J.M. (1997), "A two-factor duration model for interest rate risk management", *Investigacioneseconómicas*, Vol. 21 No. 1, pp. 55-74.

Nawaz, M.A. and Farzana, U. (2018), "Investment related risk management practice by Islamic banks in Bangladesh", *International Journal of Economics, Finance and Management Sciences*, Vol. 6 No. 4, pp. 153-164.

Neifar, S. and Jarboui, A. (2018), "Corporate governance and operational risk voluntary disclosure: evidence from Islamic banks", *Research in International Business and Finance*, Vol. 46, pp. 43-54.

Rashid, A. and Jabeen, S. (2016), "Analyzing performance determinants: conventional versus Islamic banks in Pakistan", *Borsa Istanbul Review*, Vol. 16 No. 2, pp. 92-107.

Redington, F.M. (1952), "Review of the principle of life office valuations", *Journal of the Institute of Actuaries*, Vol. 18, pp. 286-340.

Reitando, R.R. (1991), "Multivariate duration analysis", *Transaction of the Society of Actuaries*, Vol. 43, pp. 335-376.

Rizvi, S.A.R., Arshad, S. and Alam, N. (2015), "Crises and contagion in Asia pacific – Islamic v/s conventional markets", *Pacific-Basin Finance Journal*, Vol. 34, pp. 315-326.

Sadiq, R., Arshed, N. and Ahmad, H.K. (2017), "Determinants of cost efficiency of Islamic Banks of Pakistan", *The Journal of Muamalat and Islamic Finance Research*, Vol. 14 No. 2, pp. 111-128.

Saeed, Y. and Ayub, H. (2017), "Impact of credit risk transfer techniques on lending behavior of conventional and Islamic Banks in Pakistan", *Sukkur IBA Journal of Management and Business*, Vol. 4 No. 2, pp. 12-25.

Safiullah, M. and Shamsuddin, A. (2018), "Risk in Islamic banking and corporate governance", *Pacific-Basin Finance Journal*, Vol. 47, pp. 129-149.

Samuelson, P.A. (1945), "The effect of interest rate increases on the banking system", *American Economic Review*, Vol. 35 No. 1, pp. 16-27.

Saunders, A. and Cornett, M.M. (2007), *Financial Markets and Institutions: An Introduction to the Risk Management Approach*, McGraw-Hill, New York, NY.

Shah, S.A.A. and Masood, O. (2017), "Input efficiency of financial services sector: a non- parametric analysis of banking and insurance sectors of Pakistan", *European Journal of Islamic Finance*, Vol. 6, pp. 1-11.

Trad, N., Trabelsi, M.A. and Goux, J.F. (2017), "Risk and profitability of islamic banks: a religious deception or an alternative solution?", *European Research on Management and Business Economics*, Vol. 23 No. 1, pp. 40-45.

Uizani, M. (2017), "Free cash flow, agency cost and dividend policy of Sharia-compliant and non-Sharia-compliant firms", *International Journal of Economics and Management*, Vol. 11 No. 2, pp. 355-370.

Wallas, G.E. (1959), "Immunization", *Journal of the Staple Inn Actuarial Society*, Vol. 15, pp. 345-357.

Wan Ismail, W.A., Kamarudin, K.A. and Sarman, S.R. (2015), "The quality of earnings in shariah-compliant companies: evidence from Malaysia", *Journal of Islamic Accounting and Business Research*, Vol. 6 No. 1, pp. 19-41.

Wu, X. (2000), "A new stochastic duration based on the vasicekand CIR term structure theories", *Journal of Business Finance and Accounting*, Vol. 27 Nos 7/8, pp. 911-932.

Zaheer, S., Ongena, S. and and Wijnbergen, S. (2013), "The transmission of monetary policy through conventional and Islamic Banks", Tinbergen Institute Discussion Paper, No. 12- 048/2, Tinbergen Institute, Amsterdam and Rotterdam.

Zainol, Z. and Hj. Kassim, S. (2012), "A critical review of the literature on the rate of return risk in islamic banks", *Journal of Islamic Accounting and Business Research*, Vol. 3 No. 2, pp. 121-137.

Zaremba, L. (2017), "Does macaulay duration provide the most cost-effective immunization method – a theoretical approach", *Foundations of Management*, Vol. 9 No. 1, pp. 99-110.

Zheng, H., Thomas, L.C. and Allen, D.E. (2003), "The duration derby: a comparison of duration based strategies in asset liability management", *Journal of Bond Trading and Management*, Vol. 1 No. 4, pp. 371-380.

Further reading

Cox, J.C., Ingersoll, J. and and Ross, S. (1978), "A theory of the term structure of interest rates", Working Paper *J. Ingersoll, University of Chicago*.

Domanski, D., Shin, H.S. and Sushko, V. (2017), "The hunt for duration: not waving but drowning?", *IMF Economic Review*, Vol. 65 No. 1, pp. 113-153.

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