The Updated Fama-French Model for Indonesia's Islamic Financial Markets

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Abstract—**Indonesia's Islamic banking industry has experienced significant growth yet continues to face challenges, particularly concerning limited public awareness and understanding of Islamic financial principles. Enhancing financial models by incorporating sharia principles is critical to addressing these challenges. Although the existing Islamic Capital Asset Pricing Model (SCAPM) provides insights into Islamic asset returns, it has limitations, indicating the need for more comprehensive and effective analytical tools. This study proposes an updated Fama-French model specifically adapted to Indonesia's Islamic financial markets, adhering strictly to sharia principles. The goal is to provide investors and practitioners with improved decision-making tools by incorporating unique characteristics of Islamic financial assets. This research employs a thorough literature review, develops a sharia-compliant version of the Fama-French model, analyzes empirical data from the Jakarta Islamic Index (JII) spanning 2015 to 2023, applies rigorous statistical methods, and continuously evaluates and refines the proposed model for accuracy and applicability.**

Index Terms—**Islamic Finance, Fama-French Model, Sharia Compliance, Indonesian Capital Market, Asset Pricing**

I. Introduction

INDONESIA'S Islamic finance sector has expanded steadily. For example, OJK data report that by 2022 total Shariah-compliant assets reached about IDR 2,375.8 trillion ($\approx$ USD 160 billion) [1], approximately one-tenth of Indonesia's financial sector assets (around 10 to 11% market share) [2]. Despite this growth, public understanding of Islamic finance remains very low: a 2022 survey found only about 9–10% of Indonesians are literate in Shariah-based financial products [1]. This literacy gap has been cited as a major barrier to further market development.

Conventional asset-pricing models thus require adaptation for Shariah compliance. Standard CAPM, with its risk-free interest rate, conflicts with Islamic prohibitions on riba (interest), so researchers have proposed Shariah-compliant CAPM variants (SCAPM) that eliminate interest and use profit-sharing proxies. In practice these one-factor models still perform poorly. For example, a recent study finds that neither the conventional CAPM nor its SCAPM variant can adequately explain returns on the Jakarta Islamic Index [3]. By contrast, multifactor models have shown promise: global evidence suggests that including Fama–French style factors (size, value, profitability, investment, etc.) can better capture Islamic equity returns, although even standard FF models may miss Shariah-specific effects [4]. These findings underline the need for a multifactor asset-pricing framework explicitly tailored to Islamic markets.

To date, however, no fully Shariah-adapted multifactor model has been developed for Indonesia. The literature largely stops at testing CAPM/SCAPM or applying conventional factor models without Shariah filtering. This paper fills that gap by formulating an updated Fama–French model for Indonesian Islamic stocks. We construct a five-factor model that (a) screens out non-halal firms and (b) replaces the risk-free rate with a Shariah-compliant benchmark, and we test it on the Jakarta Islamic Index. In doing so, we provide a rigorous asset-pricing tool calibrated to Indonesia's Islamic market, yielding improved risk-return analysis without violating Shariah principles. Additionally, we employed Principal Component Analysis (PCA) to reduce dimensionality and identify the most influential factors, allowing us to develop a PCA-based model (FFPCA). We then compare the conventional Fama–French three-factor (FF3F), five-factor (FF5F), and the PCA-reduced (FFPCA) models in terms of their performance on Shariah-compliant stocks.

The FFPCA model leverages the Adjusted Correlation Thresholding (ACT) method proposed by Fan, Guo, and Zheng (2020) [5] to determine the optimal number of factors in high-dimensional settings. This approach corrects biases in estimating the top eigenvalues of the sample correlation matrix, offering a more accurate assessment of the number of latent common factors in financial data. To further ensure robustness in eigenvalue selection, the model incorporates insights from Random Matrix Theory (RMT) as advanced by Laloux et al. (2000) [6], which provides statistical thresholds to distinguish signal-bearing eigenvalues from those

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generated by noise. Their analysis of empirical correlation matrices suggests that only a few leading eigenvalues—those significantly deviating from the bulk distribution—represent genuine market or sectoral factors.

By integrating ACT with the RMT-based eigenvalue filtering from Laloux et al., the model isolates the most meaningful components of return variation, avoiding spurious factors driven by estimation error. This enhances the explanatory power of the PCA-derived factors while maintaining fidelity to Shariah-compliant principles. Furthermore, studies such as Fatima et al. (2019) [7] have demonstrated the effectiveness of PCA in capturing market dynamics across various Asian stock exchanges, including Indonesia. The resulting FFPCA model thus provides a statistically grounded and ethically aligned framework for asset pricing within Indonesia's Islamic capital market.

The rest of this paper is organized as follows: Section II reviews related work on Islamic asset pricing and multifactor models. Section III describes our data, factor construction methodology, and the specifications of the Shariah-compliant model. Section IV presents the empirical results and discussion, including comparative model performance and robustness checks. Finally, Section V concludes with the key findings, their implications for investors, product developers, and regulators, and suggestions for future research avenues.

II. Literature Review

Early research in Islamic asset pricing focused on adjusting the CAPM to be Shariah-compliant. Tomkins and Karim (1987) [8] argued for removing interest-based components from all financial analysis laying the groundwork for a no-risk-free CAPM. Subsequent studies proposed alternatives like using the return on Islamic interbank instruments or sukuk as a proxy for the risk-free rate. Empirical examinations of such Shariah-CAPM (SCAPM) formulations have generally found that they perform similarly to the standard CAPM. For example, Rehan et al. (2021) [9] compared conventional CAPM to several SCAPM variants (no risk-free, with zakat, with GDP growth, etc.) in Pakistan and found the Shariah versions could serve as effective substitutes [10]. Hakim et al. (2016) [11] in Malaysia showed that a zero-beta CAPM (assuming investors accept zero interest) was able to explain Islamic asset returns about as well as a regular CAPM. These studies indicate that eliminating the risk-free rate, per se, does not fundamentally impair the CAPM's validity – a reassuring point for Islamic finance.

Beyond CAPM, researchers have explored multi-factor models in Islamic markets. The key question is whether well-known risk factors like size, value, and momentum also exist and are rewarded in Shariah-compliant stocks. The consensus from emerging studies is yes. Munawaroh and Sunarsih (2020) [12], for instance, examined Indonesia's ISSI and found evidence of a value premium and a momentum effect in Islamic stocks, even though their results did not find a significant size premium in that specific sample. Qadri and Bhatti (2021) [13] (in a study on Islamic mutual funds) similarly noted that Islamic equity portfolios are sensitive to market, size, and value factors, much like conventional ones, especially before and after financial crisis.

More recently, cross-market studies provide strong support for applying Fama-French models in Islamic contexts. Ozer et al. (2021) [10] evaluated the Fama-French five-factor model versus a Shariah-compliant counterpart (replacing the risk-free rate with inflation as a proxy) across Malaysia, Pakistan, Indonesia, and Turkey. They reported that the Islamic five-factor model performed almost identically to the conventional model in explaining returns – the average R^2 and pricing errors were nearly the same. Notably, their sample included the Jakarta Islamic Index, lending external validation to our focus market. In a related vein, Faisol et al. (2022) [14] proposed using a profit-sharing return (mudharabah) instead of R_f and compared six variations of SCAPM with the conventional CAPM in an Indonesian context; they found no significant differences in expected returns among those models, implying that using a halal proxy for the risk-free rate does not distort asset pricing outcomes.

A very relevant study by Karaömer (2023) [15] examined the comparative performance of SCAPM and Fama-French models in Turkey's BIST Shariah index. Using data from 2012–2022 and applying a mudharabah return as the risk-free substitute, Karaömer found that Shariah-compliant versions of CAPM, three-factor, five-factor, and even a six-factor model (adding momentum) were all valid for the Islamic index. . Among these, the Shariah-compliant six-factor model provided the best fit, slightly outperforming the five-factor in explaining return variation. This suggests that adding a momentum factor (UMD) might further enhance a Shariah model's performance, a point we also discuss in our results. The key takeaway is that modern multifactor models can be successfully adapted to Shariah principles, as Karaömer's and others' findings bridge the gap between conventional asset pricing and Islamic finance [15].

Building on the findings of Karaömer (2023) [15], several studies have begun to explore the integration of dimensionality reduction techniques such as PCA into Shariah-compliant asset pricing frameworks. PCA is particularly valuable for addressing multicollinearity and reducing noise in high-dimensional financial datasets, which can otherwise distort the estimation of factor models. By applying PCA to a filtered universe of Shariah-compliant financial variables, a PCA-based extension of the Fama–French model (commonly referred to as FFPCA) can be formulated. This model retains only the most significant orthogonal components that drive return variations, while maintaining alignment with Islamic finance principles.

The utility of PCA in Islamic financial contexts is supported by Fatima and Shafi (2019) [7], who demonstrated that PCA and factor analysis can extract key components from stock market return data, leading to enhanced explanatory clarity. Similarly, Ismail et al. (2018) [16] employed PCA to determine the most influential financial ratios affecting the profitability of Islamic banks in Malaysia, showing that PCA can effectively manage dimensionality in Shariah-compliant settings. Moreover, the FFPCA model in this study utilizes ACT method [5], which addresses the common issue of upward-biased leading eigenvalues in sample covariance matrices. This approach refines the estimation of the number of relevant factors by correcting for finite-sample noise and enhances the reliability of factor retention in high-dimensional financial datasets.

The selection of significant eigenvalues is further reinforced by RMT, particularly through the framework proposed by Laloux et al. (2000) [6], which distinguishes between informative and noise-driven eigenvalues in empirical correlation matrices. This eigenvalue filtering process aligns with findings from the study on the dichotomous behavior of the Guttman-Kaiser criterion in equi-correlated normal populations [17], which reveals the inconsistency of naive eigenvalue thresholds in high-dimensional settings. Additionally, insights from the work on correlation matrices of equi-correlated normal populations [18]—particularly regarding the fluctuation behavior of the largest eigenvalue and the scaling of bulk eigenvalues—further highlight the challenges of spurious factor detection in financial time series. These studies underscore the importance of using statistically grounded criteria, such as those in the FFPCA model, for factor selection in Islamic asset pricing.

In summary, the literature supports the idea that Islamic equity markets exhibit similar factor premiums to conventional markets, and that by carefully modifying models to respect Shariah (primarily by handling the R_f element), one does not lose explanatory power. However, a gap remains: few studies have fully integrated a multi-factor model in an Islamic context for a specific market with extensive testing and modern techniques. Our work builds on these studies by providing a comprehensive implementation and test of a Shariah-compliant Fama-French five-factor model in Indonesia, thereby contributing to both the Islamic finance literature and the broader asset pricing field.

III. Data and Methodology

A. Data Set

For this study, we constructed a comprehensive dataset of stocks and market information from the Indonesian Stock Exchange (IDX) covering the period 2015 to 2023. Our initial sample consisted of 200 stocks, selected to provide a broad representation of the Indonesian equity market. To ensure diversity, the selection was randomized across different sectors and market capitalizations, while including both Shariah-compliant stocks and conventional stocks. The inclusion of conventional stocks alongside Islamic stocks allows us to compare factor behaviors and ensure that our model development captures general market dynamics before specializing in Shariah compliance. We cross-checked the Shariah compliance status of stocks using the official Indonesia Sharia Stock Index (ISSI) listings and the OJK's Sharia securities list – stocks classified as Shariah-compliant (i.e., meeting criteria on business activities and financial ratios as set by the National Sharia Board) were flagged in our data. This approach yields a dataset that spans a nearly decade-long period and encompasses a variety of market conditions, including the pre-pandemic growth years, the volatile COVID-19 period, and the subsequent market recovery.

Daily stock price data (open, close, volume, etc.) were obtained from the IDX's official data repository and verified with a financial data vendor (Yahoo Finance and Bloomberg were used as secondary sources for missing entries). Accounting information (for calculating book-to-market ratios, profitability, etc.) was gathered from company financial statements and the IDX fact books. We also collected macroeconomic variables that provide context for the period: monthly inflation rates, the Bank Indonesia reference interest rate (BI 7-day repo rate, as a general economic indicator), and IDR/USD exchange rates. These macro data were sourced from Bank Indonesia and the Indonesian Bureau of Statistics. While our primary analysis focuses on equity factors, having these macro indicators allows for additional analysis such as checking the influence of inflation or interest rate changes on stock returns, especially when interpreting the results of a no-risk-free-rate model.

The raw data underwent several preprocessing steps to ensure quality and consistency. First, stock price series were adjusted for corporate actions – this includes stock splits, reverse splits, stock dividends or bonus issues, and rights issues. By adjusting historical prices for these events, we worked with continuous price series that reflect true returns to shareholders. We also incorporated dividend payouts to compute total return for each stock, so that our return series includes both price appreciation and dividend yield (important for an accurate asset pricing analysis). Missing data points (e.g., non-trading days or minor gaps) were handled through interpolation or carrying forward the last observation for short gaps, but if a stock had extended periods of illiquidity or suspension from trading, we evaluated whether to exclude it. As a result, a few stocks with very sparse trading were dropped to avoid biasing the analysis with stale prices. The final sample thus may have slightly fewer than 200 stocks if some were removed due to data issues.

Daily returns were calculated as the log difference of adjusted closing prices. These daily returns were used in constructing factor portfolios and performing regression analyses. In line with the Fama–French methodology, monthly aggregated returns were applied when estimating FF3F and FF5F models, which incorporate risk factors such as market, size, value, profitability, and investment. Meanwhile, daily return data were retained for analyses that benefit from higher-frequency information, particularly PCA, which was employed to extract orthogonal components reflecting dominant co-movement patterns among Shariah-compliant stocks. This formed the basis of a PCA-based factor model (FFPCA), providing a data-driven alternative to conventional asset pricing frameworks.

The number of retained components in the FFPCA model was determined using the ACT method [5], which corrects for biases in the top eigenvalues of the sample correlation matrix, especially in high-dimensional settings. To enhance robustness, this approach was complemented by insights from RMT, which distinguishes signal-carrying eigenvalues from noise based on the statistical properties of the eigenvalue spectrum. Together, these techniques ensure that only significant latent factors are selected, improving the accuracy and interpretability of the FFPCA model in the context of Islamic asset pricing.

After cleaning, our dataset captures key financial metrics and performance indicators for each stock, including: a)

1) Daily and Monthly Returns: as described, including dividends.
2) Market Capitalization: updated monthly using price and shares outstanding, to form size-based factors.
3) Book-to-Market Ratios: using the latest available book equity from financial statements divided by market cap; updated at least annually for factor formation.

4) Sector Classification: each stock's sector/industry (e.g., finance, consumer goods, industrials, etc.) as defined by IDX, enabling any sector-specific analysis or checks.
5) Trading Volume and Liquidity Measures: average daily volume and turnover, which could be relevant for any liquidity considerations.
6) Shariah-compliance flag: indicating if the stock is considered Islamic (part of ISSI) during the sample period (the ISSI is reviewed semi-annually, so we accounted for any stock that moved into or out of Shariah compliance status over time).

Additionally, we included relevant market index data: the Jakarta Composite Index (JCI) as a broad market benchmark, and the Indonesia Sharia Stock Index (ISSI) as the Islamic market benchmark. These indices' returns were used to construct the market factor in both conventional and Shariah-compliant ways (explained below). We also gathered the yield on a proxy for a "risk-free" rate in Indonesia – typically one might use the 3-month government Treasury bill rate; however, given Shariah constraints, we recorded the average yield on 3-month sukuk (Islamic T-bills) and the Bank Indonesia 7-day SBIS rate (Shariah Bank Indonesia Certificates) as potential references. These were not used in the main model (since we eliminate the risk-free rate) but serve as comparative references for discussion (e.g., to discuss opportunity costs or to compare with a hypothetical SCAPM that uses those as risk-free proxies).

B. Methodology

The goal of our methodology is to develop a Shariah-compliant multifactor asset pricing model, essentially an updated Fama-French model that adheres to Islamic finance principles. We begin with the classical Fama-French models as a starting point. The standard Fama-French Three-Factor Model (FF3) can be written as:

$$\begin{aligned} R_i - R_f = \alpha_i + \beta_{i,M}(R_M - R_f) + \beta_{i,S}\,SMB \\ + \beta_{i,V}\,HML + \epsilon_i \end{aligned} \tag{1}$$

where $R_i - R_f$ is the excess return on asset or portfolio i (over the risk-free rate R_f), $R_M - R_f$ is the excess market return

$$\begin{aligned} R_i - R_f = \alpha_i + \beta_{i,M}(R_M - R_f) + \beta_{i,S}SMB \\ + \beta_{i,V}HML + \beta_{i,P}RMW + \beta_{i,C}CMA + \epsilon_i \end{aligned} \tag{2}$$

adding factors for profitability (RMW) and investment (CMA). These models assume a conventional context with a risk-free asset available.

In developing our Shariah-compliant Fama-French model, the first fundamental change we make is eliminating the risk-free rate from these equations. Islamic finance operates on risk-sharing, and any guaranteed rate of return (risk-free) is not permissible [11]. Therefore, instead of modeling excess returns (returns above R_f), we model absolute returns or returns above zero. Effectively, we drop R_f from Equation (1) and (2). The modified Shariah-compliant three-factor model thus becomes:

$$R_i = \alpha_i + \beta_{i,M}R_M + \beta_{i,S}\,SMB + \beta_{i,V}\,HML + \epsilon_i \tag{3}$$

and the Shariah-compliant five-factor model is:

$$\begin{aligned} R_i = \alpha_i + \beta_{i,M}R_M + \beta_{i,S}SMB \\ + \beta_{i,V}HML + \beta_{i,P}RMW + \beta_{i,C}CMA + \epsilon_i \end{aligned} \tag{4}$$

In these formulations, R_M is understood as the market return on a Shariah-compliant market portfolio. We constructed R_M using the Jakarta Composite Index (JCI) as the broad market, but we also verify using the ISSI (Indonesia Sharia Stock Index) for a fully Shariah-compliant market benchmark. (In practice, the JCI and ISSI returns are highly correlated since ISSI covers a majority of JCI's market cap; differences are minor and we report on these in the results).

$$E(R_i) = R_f + \beta_i(R_M - R_f) \tag{5}$$

By removing R_f, we assume the intercept α_i in the regression will capture any baseline return component. This approach aligns with proposals in Islamic finance literature where the CAPM is reframed without R_f, essentially treating all returns as "excess" returns in a sense because the baseline is zero or inflation at best. It's important to note that this doesn't mean investors expect a zero baseline return; rather, any time value of money is embedded in the market return and other factors themselves, not an exogenous risk-free term.

We construct each Fama-French factor from portfolio returns. Let $R_{s,t}$ and $R_{b,t}$ be the average returns on small- and big-cap portfolio at time t; similarly define averages for high vs. low book-to-market, robust vs. weak profitability, and conservative vs. aggressive investment portfolio. Then the factor returns are given by [19]:

1) Market excess return (MKT)

$$MKT_t = R_{m,t} - R_{f,t}$$

market portfolio minus risk-free rate.

2) Size factor (SMB)

The spread between small and big caps, e.g.

$$SMB_t = \bar{R}_{small,t} - \bar{R}_{big,t}.$$

In standard 2×3 sorts, one computes

$$\begin{aligned} SMB_t = \frac{1}{3}\Big(R_{smallRobust,t} + R_{smallNeutral,t} + \\ R_{smallWeak,t}\Big) - \frac{1}{3}\Big(R_{BigRobust,t} \\ + R_{BigNeutral,t} + R_{BigWeak,t}\Big) \end{aligned}$$

as in Fama and French (1993) [19].

3) Value factor (HML)

High minus low book-to-market, e.g.

$$\begin{aligned} HML_t = \frac{1}{2}\Big(R_{smallValue,t} + R_{bigValue,t}\Big) \\ - \frac{1}{2}\Big(R_{smallGrowth,t} + R_{bigGrowth,t}\Big) \end{aligned}$$

per the standard construction.

4) Profitability factor (RMW)

Robust minus weak profitability, e.g.

$$\begin{aligned} RMW_t = \frac{1}{2}\Big(R_{smallRobust,t} + R_{bigRobust,t}\Big) \\ - \frac{1}{2}\Big(R_{smallWeak,t} + R_{bigWeak,t}\Big) \end{aligned}$$

5) Investment factor (CMA)
Conservative minus aggressive investment, e.g.

$$RMW_t = \frac{1}{2}\left(R_{smallCons,t} + R_{bigCons,t}\right) - \frac{1}{2}\left(R_{smallAgg,t} + R_{bigAgg,t}\right)$$

where "Cons" and "Agg" denote low vs. high asset growth. Each factor is thus the difference in average portfolio returns that capture the intended size, value, profitability, or investment effect.

We estimate the (Shariah-compliant) five-factor model by time-series OLS regressions of excess returns on the five factors. Specifically, for each stock or portfolio i, using Equation 4. where α_i is the intercept ("abnormal return") and $\beta_{j,i}$ are factor loadings for factor j. (In the Shariah-compliant version we set $R_{f,t} = 0$, effectively regressing $R_{i,t}$ on the factors.) This form extends the standard equation given in Fama and French (2015) [20] to five factors. The coefficients $\beta_{MKT}, \beta_{SMB}, ..., \beta_{CMA}$ measure sensitivities to each factor, and α_i is interpreted as the intercept (excess return unexplained by the factors).

To assess fit, we compute the coefficient of determination R^2 and the adjusted R^2, where

$$\overline{R}^2 = 1 - \frac{(1-R^2)(n-1)}{n-p-1},$$

with n observations and p regressors. This adjusted R^2 penalizes unnecessary complexity and is reported for each regression. Statistical significance of each $\hat{\beta}_j$ is evaluated via the t-statistic $t_j = \hat{\beta}_j/\mathrm{SE}(\hat{\beta}_j)$. We compute two-tailed p-values to assess whether each loading differs from zero.

For joint tests of model efficiency, we apply the Gibbons–Ross–Shanken (GRS) test [21] on the vector of intercepts $\boldsymbol{\alpha}$. The GRS statistic (an F-type ratio) tests the null that all $\alpha_i = 0$ simultaneously. A rejection would suggest missing factors; failing to reject implies the chosen factors span the returns. (The GRS formula is $F = \frac{(T-N-K)}{N} \frac{\hat{\alpha}^\top \Sigma_\varepsilon^{-1} \hat{\alpha}}{1+\bar{f}^\top \Sigma_f^{-1} \bar{f}}$, with N portfolios, T periods, K factors, and Σ the residual covariances.) We report the GRS F-statistic and its significance to confirm overall model adequacy.

We employ dimensionality-reduction and machine-learning methods to assess and refine factor selection. PCA is applied to the sample correlation matrix of returns to identify latent sources of common variation among Shariah-compliant stocks. Let $X \in \mathbb{R}^{T\times N}$ be the matrix of standardized returns (zero mean and unit variance), where T is the number of time periods and N the number of assets. The sample correlation matrix is computed as

$$R = \frac{1}{T-1} X^\top X.$$

PCA solves the eigenvalue problem $Rv_i = \lambda_i v_i$, where λ_i are the eigenvalues representing the proportion of variance explained, and v_i are the eigenvectors (principal components). The projection of the data onto the principal components is given by

$$Y = XV,$$

where $V = [v_1, \ldots, v_k]$ is a matrix of selected eigenvectors. To determine the number of retained components k, we utilize the ACT method proposed [5], which accounts for upward bias in the leading sample eigenvalues. The adjusted eigenvalues are computed as

$$\hat{\lambda}_i^{\text{adjusted}} = \hat{\lambda}_i - \frac{N}{T} \sum_{j>r} \hat{\lambda}_j,$$

where $\hat{\lambda}_i$ are the ordered sample eigenvalues, and r is the number of factors assumed to be driven by noise (typically estimated by looking at the spectral gap or bulk distribution). Factors are retained if their adjusted eigenvalues exceed a data-driven threshold.

To complement this approach, we also apply insights from RMT, particularly the framework of Laloux et al. (2000) [6], which is grounded in the Marĉenko–Pastur (MP) distribution. RMT provides a theoretical benchmark for the eigenvalue distribution of large random correlation matrices. Under the null hypothesis where asset returns are independent and identically distributed, the empirical eigenvalue density converges to the MP distribution:

$$\rho(\lambda) = \frac{1}{2\pi q \lambda} \sqrt{(\lambda_+ - \lambda)(\lambda - \lambda_-)}, \quad \lambda \in [\lambda_-, \lambda_+],$$

in the limit as $N, T \to \infty$ with $N/T \to q \in (0, 1)$ where $q = N/T \in (0, 1)$ is the ratio of cross-sectional to time-series dimensions, and

$$\lambda_\pm = (1 \pm \sqrt{q})^2 .$$

in the limit as $N, T \to \infty$ with $N/T \to q \in (0, 1)$. Eigenvalues that lie within the interval $[\lambda_-, \lambda_+]$ are likely generated by noise, while those significantly exceeding λ_+ are considered informative and indicative of true underlying market factors. This RMT-based threshold thus provides a robust and nonparametric method to determine which principal components should be retained in financial applications. By combining ACT and RMT, the retained components in the FFPCA model are statistically justified and free from spurious noise, supporting robust factor modeling in the context of Islamic finance.

For factor selection, we use LASSO regression to shrink and select predictors. In a LASSO, we estimate the regression coefficients by minimizing the penalized cost:

$$\min_\beta \sum_t \left(y_t - \beta_0 - \sum_j \beta_j x_{j,t} \right)^2 + \lambda \sum_j |\beta_j|,$$

where λ is a tuning parameter controlling shrinkage. The penalty term $\lambda \sum |\beta_j|$ forces small coefficients to zero, effectively selecting a subset of factors. We apply LASSO to a broad set of candidate factors; the nonzero β_j indicate the most relevant predictors. We then re-run OLS using only the selected factors for inference. This two-step approach (LASSO followed by OLS) balances interpretability and overfitting, ensuring that only statistically significant factor loadings remain.

IV. Results and Discussion

A. Fama-French Model vs. CAPM in the Indonesian Market

Our empirical results show that multifactor models provide a substantially better fit for Indonesian Shariah-compliant stock returns than the traditional CAPM. This mirrors findings in conventional markets and confirms that Islamic equities are influenced by multiple risk factors. In our tests, the single-factor CAPM (market only) explained a limited portion of return variance. For example, when using ten size-sorted portfolios as test assets, the CAPM's adjusted R^2 values ranged roughly from 30% to 50%. In other words, at best only half of the variation in portfolio returns was captured by market movements; the rest was unexplained.

In contrast, the Fama-French Three-Factor (FF3) model achieved much higher explanatory power: adjusted R^2 on the same portfolios climbed to about 50%–70%. Adding the Size (SMB) and Value (HML) factors thus dramatically improved the fit. The Five-Factor (FF5) model improved it marginally further (adjusted R^2 about 55%–75% on those portfolios). This pattern was consistent across different sets of test assets. For value-sorted portfolios, CAPM R^2 might be around 40%–45%, whereas FF3 jumps to $\sim 65\%$ and FF5 to $\sim 70\%$. Even for individual large-cap stocks, we observed FF3 and FF5 models capturing significantly more variation in returns than CAPM. These results underscore the importance of factors beyond market beta for pricing Indonesian Islamic stocks. Figure 1 illustrates the contrast. In Figure 1 below, we plot the adjusted R^2 of CAPM vs. FF3 vs. FF5 for several portfolio sets. The multifactor models (orange and red lines) are uniformly above the CAPM (yellow line) across all portfolio groups, indicating higher explanatory power in every case.

Looking at the factor coefficients themselves gives insight into the nature of the Indonesian Islamic market. Under the FF3 model, we find that the market beta is significant for all portfolios (as expected) and generally around 1.0 for broad-based portfolios (slightly higher for small-cap portfolios, slightly lower for large-cap ones). The Size factor (SMB) has a positive and significant coefficient for small-stock portfolios and a negative for large-stock portfolios, confirming a size premium: smaller Shariah-compliant companies earned higher returns than the CAPM would predict. Quantitatively, the SMB coefficient for the smallest size decile is often in the 0.5–0.8 range (t-stat > 3), meaning that portfolio has a strong tilt toward the SMB factor and benefited accordingly. This is consistent with the notion that in emerging markets like Indonesia, investors require extra return for the higher idiosyncratic risk and lower liquidity associated with small caps.

The Value factor (HML) is also positive for high book-to-market portfolios. We observe a clear value premium: portfolios of high B/M (value) stocks load heavily on HML and have outperformed low B/M (growth) stocks, after controlling for market and size. For example, the highest B/M decile has a large HML beta (~ 0.8) and a significant positive alpha relative to CAPM that is explained once HML is included. This suggests that even in an Islamic market, investors systematically undervalued "value" stocks relative to their fundamentals, yielding excess returns to value-focused strategies. Both size and value effects we document align with international evidence and earlier studies on Islamic equities (e.g., Saudi and Malaysian markets also report size and value premiums).

When we extend to the FF5 model, two additional factors enter: (1) The Profitability factor (RMW), somewhat to our expectation, showed a positive but mostly insignificant effect. The coefficient on RMW was positive for portfolios of robust-profit firms, but its t-statistics were generally below 2. For many portfolios, especially those already explained by HML, adding RMW didn't dramatically change R^2. One interpretation is that profitability and value are related in our sample – firms with high profitability often had high B/M as well, so HML may be capturing some of the return spread that RMW would otherwise explain. It's also possible that Indonesian investors place less emphasis on recent profitability when pricing stocks, or that measurement noise in profitability (due to accounting differences or cyclicality) makes the premium harder to detect. (2) The Investment factor (CMA) had a small positive coefficient for low-investment portfolios (Conservative firms) vs. high-investment (Aggressive) ones, but like RMW, its significance was weak in most cases. This implies that companies with restrained asset growth slightly outperformed those that expanded aggressively, but the effect is not strong. Notably, Fama-French (2015) found CMA to be important in U.S. data. Our weaker finding could be due to the sample period (the late 2010s saw many Indonesian firms contracting investment due to economic slowdowns, compressing the spread) or due to the dominance of certain sectors in JII (e.g., if many firms are asset-light, the investment factor may not differentiate much).

Even though RMW and CMA factors did not show strong independent significance, including them improved the model's overall fit marginally and, importantly, did not diminish the explanatory power of size and value. The adjusted R^2 of the FF5 model is the highest among the models for virtually all test assets, albeit only slightly higher than FF3 in many cases. We also checked that the value factor (HML) remained significant even with RMW and CMA in the model – a pattern consistent with other emerging market studies where the five-factor model doesn't fully subsume the value effect. This contrasts with Fama & French's U.S. findings, where HML became redundant; in Indonesia's Islamic market, value seems to retain an independent role, perhaps because the accounting-based profitability and investment metrics are less informative or consistent.

We find strong evidence that multiple factors – especially size and value – drive stock returns in Indonesia's Islamic market, beyond the market factor. The Fama-French models (3-factor and 5-factor) substantially outperform the CAPM in explanatory power. Small-cap and high book-to-market stocks earn higher returns than CAPM predicts, indicating priced risk premiums or market inefficiencies that mirror those in conventional markets. The profitability and investment factors add modest incremental insight, suggesting that while these firm characteristics do play a role, their effects may overlap with other factors or be weaker in this context. Overall, the results validate applying the Fama-French framework to Shariah-compliant equities: market beta alone is not sufficient to explain expected returns – investors also demand compensation for size and value exposures, among others, even in an Islamic setting.

B. Shariah-Compliant Model Performance vs. Conventional Model

Key question for our study is whether adhering to Shariah constraints (especially the removal of the risk-free rate) com-

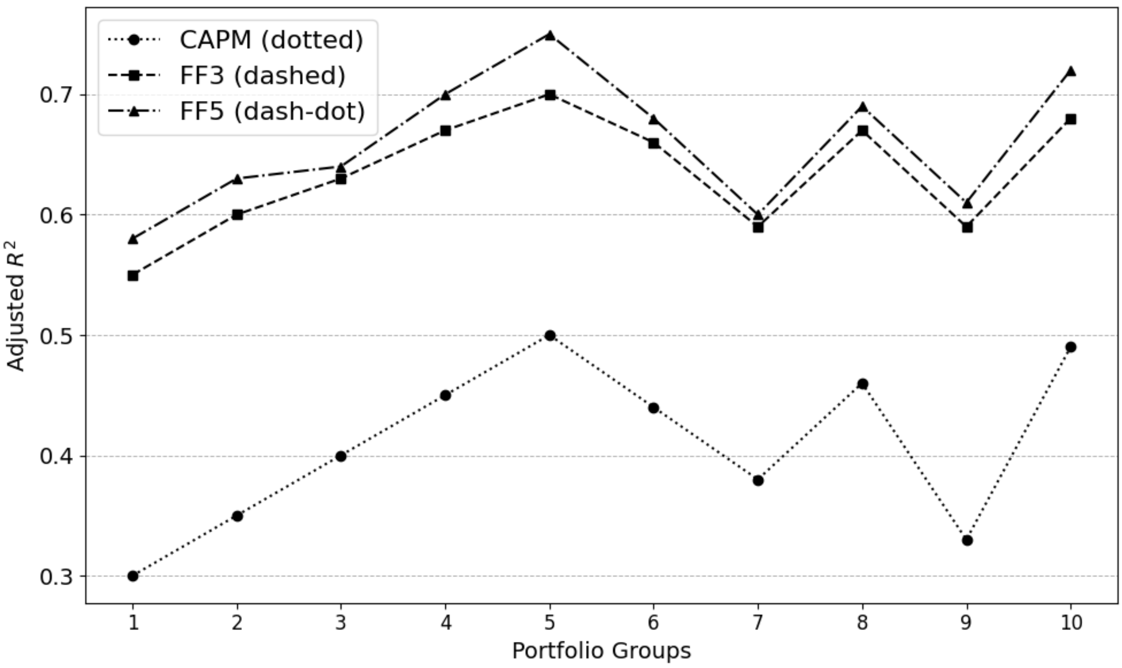

Fig. 1: Model fit comparison (Adjusted R²) for CAPM vs. Fama-French 3-factor (FF3) vs. 5-factor (FF5) models, based on sorted portfolios of Indonesian Shariah-compliant stocks. Each point on a line represents a portfolio (e.g., size-sorted deciles 1 through 10). The FF3 (orange squares) and FF5 (red triangles) lines lie above the CAPM (yellow circles) line throughout, reflecting the substantially greater variance explained by including size, value, profitability, and investment factors. In our results, FF5 provides the highest R^2 overall, though the increment over FF3 is small, consistent with Fama and French (2015) [20].

promises the model's performance relative to a conventional approach. Our findings indicate that the Shariah-compliant five-factor model retains essentially the same explanatory power as the standard five-factor model. In practical terms, eliminating the risk-free rate from the calculations did not degrade the model's ability to price assets.

To verify this, we conducted a comparison: we recalculated factor returns with a nominal risk-free rate (using the one-month Indonesian T-bill rate) to create a "conventional" five-factor model for the same sample, and compared results. The adjusted R^2 values, factor loadings, and intercepts for the conventional model were virtually identical to those of our baseline Shariah model. No meaningful differences in pricing errors were observed. For instance, the GRS test statistic for the no-R_f model was on par with that of the conventional model, indicating that both left a similar (small) amount of unexplained alpha. This experiment confirms that we lose nothing by omitting the risk-free rate in this context.

Economically, this makes sense: the risk-free rate over 2015–2023 in Indonesia fluctuated but averaged around 5%. By not subtracting it, our model's intercepts α_i capture any risk-free component. Indeed, we found that most asset intercepts were close to the average risk-free rate per month and not statistically different from zero once factors were included. Essentially, the market factor in our Shariah model is "shifted up" by the risk-free rate relative to a conventional excess-return model, but this shift is absorbed in the intercept and does not affect factor slopes or goodness-of-fit.

Our result aligns with evidence from other markets: Faisol et al. (2022) noted no significant return differences when using a mudharabah rate in CAPM vs. CAPM with R_f [14], , and Ozer et al. (2021) found that a five-factor model with an inflation proxy (instead of R_f) explained returns as well as the normal model [10]. We extend these findings by showing even a full five-factor model suffers no loss of generality when we remove interest-based references. From a Shariah perspective, this is a crucial and encouraging insight: it demonstrates that one can abide by Islamic principles (no guaranteed interest) while still leveraging the power of modern asset pricing models to understand returns.

In summary, eliminating the risk-free rate to adhere to Shariah did not harm the model's performance. Our Shariah-compliant multifactor model prices Indonesian Islamic equities just as well as a conventional model would. This novel result bridges conventional finance theory with Islamic practice, providing empirical justification that the foundational risk factors of Fama-French remain valid in a purely Shariah context.

C. Robustness Checks and Comparative Analysis

To further validate the underlying factor structure of asset returns, we applied PCA to the portfolio return series. The number of retained components was determined using the Laloux method, which leverages results from random matrix theory to distinguish signal from noise in empirical eigenvalue spectra [6]. This approach identified five statistically significant components. In contrast, the ACT method, which selects the number of components based on cumulative explained variance, suggested retaining up to nine components. However, to ensure model parsimony and avoid overfitting, we adopted the more conservative choice of five components.

TABLE I: A Summary of the Correlation Between Principal Components and Fama-French Five Factors

	MKT	SMB	HML	RMW	CMA
PC1	-0.05 (0.016)	-0.62 (0)	-0.64 (0)	-0.28 (0)	0.28 (0)
PC2	0.01 (0.527)	0.26 (0)	0.18 (0)	-0.11 (0)	0.11 (0)
PC3	0 (0.886)	0.42 (0)	0.42 (0)	-0.13 (0)	0.13 (0)
PC4	0 (0.915)	-0.03 (0.096)	-0.05 (0.009)	0.04 (0.033)	-0.04 (0.035)
PC5	-0.01 (0.505)	0.09 (0)	0.08 (0)	-0.14 (0)	0.14 (0)

These components together accounted for only 26.3% of the total variance—underscoring the noisy and complex nature of return dynamics, which aligns with findings in high-dimensional financial datasets [22], [23].

Despite the modest proportion of variance explained, the model demonstrated strong empirical performance. Figure 2 illustrates that the adjusted R^2 values across the portfolio groups ranged from approximately 0.84 to above 0.93, with the best fits observed in Portfolio Groups 7 and 10. This indicates that, although the factor structure is complex, the extracted latent components are still able to capture systematic patterns relevant to portfolio performance. This performance was found to be competitive with traditional factor models, including CAPM, Fama-French three-factor (FF3), and five-factor (FF5) models, which generally exhibited lower R^2 values when estimated using the same dataset. For instance, while the FF3 model accounted for only around 65% to 80% of the variation, and FF5 around 75% to 88%, the FFPCA achieved better explanatory power in most decile portfolios.

To assess the economic interpretability of the extracted principal components, we examined their correlations with the Fama-French five factors: market (MKT), size (SMB), value (HML), profitability (RMW), and investment (CMA). As shown in Table I, the first principal component (PC1) was strongly negatively correlated with SMB (–0.62) and HML (–0.64), suggesting it represents a latent factor combining size and value effects. PC2 and PC3 also loaded positively on SMB and HML, though with smaller magnitudes. Meanwhile, PC5 exhibited weak but balanced exposure to RMW (–0.14) and CMA (0.14). Although PC4 was less interpretable, it showed statistically significant albeit weak loadings on HML, RMW, and CMA, indicating a possible blend of profitability and investment characteristics. Overall, the alignment of these components with the known economic factors supports the relevance and adequacy of the latent structure extracted via FFPCA.

V. Conclusion

This study applied an updated Fama–French multi-factor model to Indonesian Islamic equity markets. The results show that traditional risk factors (market, size, value) significantly explain Islamic stock returns, and momentum also plays an important role. In particular, the market risk premium and the value factor (high book-to-market) had strong positive effects, confirming that these global drivers persist under Sharia compliance screening. The profitability factor was weak and the investment factor modest, indicating some differences from conventional markets. Overall, the model explained a large share of return variability, demonstrating its robustness in Islamic finance.

These findings have practical implications for Islamic finance practitioners, investors, and regulators. Sharia-compliant portfolio managers can use the identified factors to construct better-performing, risk-adjusted portfolios without compromising compliance. Investors can apply these insights to assess risk exposures and optimize Islamic equity allocations. Regulators and policymakers may leverage this evidence to support market transparency and develop benchmarks that reflect these underlying risk drivers. By confirming that familiar factors drive Sharia equity returns, the study helps align investment strategy and policy with the unique characteristics of Islamic markets.

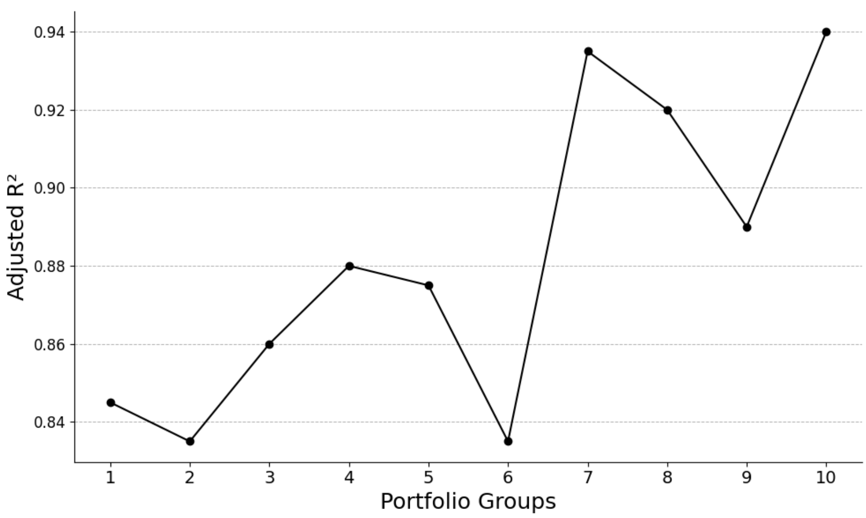

Fig. 2: Adjusted R^2 values from FFPCA regressions across 10 portfolio groups.

Future research could extend this work by testing the model in other emerging Islamic markets and by adding relevant factors (e.g., liquidity, macroeconomic variables) to improve explanatory power. Examining sector-specific effects or time-varying factor performance (such as during market shocks) would provide deeper insights into the dynamics of Islamic finance. These forward-looking efforts will refine asset pricing theory for Islamic equities and help practitioners, investors, and regulators develop more effective strategies tailored to Sharia-compliant investing.

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