

Revisit the Use of Index Returns as the Proxy of Market Return in CAPM

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Abstract

This study compares the performance of the capital asset pricing model (CAPM), which uses a mean-variance optimal portfolio, and the Jakarta Composite Index (JCI) as the market return proxy. The data samples are monthly stock returns of Kompas 100, LQ45, and IDX30 index from September 2012-August 2022. The expected returns of assets are calculated using the CAPM with rolling regression methodology based on each index's 2-5 years period. The mean-squared errors for each sample group are calculated to determine the CAPM performance. Although the market indexes have a sub-optimal risk and return profile according to their position on the efficient frontier diagram, this study finds that the JCI as the market proxy results in better CAPM performance than the optimal portfolio. However, the beta results from using JCI as the market proxy are also consistently higher than those using an optimal portfolio, leading to the overestimation bias of the asset risk. Since most studies in CAPM testing use the market index as the market return proxy, particularly JCI in Indonesia, this study provides new insight into the challenges of using the optimal portfolio as the market return proxy.

Keywords : *beta, CAPM, market index, optimization, optimal portfolio*

1. INTRODUCTION

CAPM determines the theoretically appropriate required rate of return on assets, particularly common shares (Lintner, 1965; Sharpe, 1964). The model explains the relationship between the expected returns and the systematic risk of an investment. CAPM assumes that investors require a premium for bearing the risk of holding an asset. The difference between the anticipated return on a risky investment and the risk-free rate determines this premium. Beta measures an asset's sensitivity to changes in the market return and explains its systematic risk. Since its introduction, CAPM has gained widespread acceptance from academics and professionals, leading to Sharpe's Nobel Prize

win in 1990. Due to its popularity, CAPM is the only asset pricing model taught in standard MBA courses (Fama & French, 2004)

CAPM builds on the Markowitz modern portfolio theory that assumes rational investors must hold a mean-variance efficient portfolio. Therefore, the market return proxy for the risk premium component of CAPM must be efficient. Nevertheless, most research nowadays uses the market index constructed by value-weighted methodology as the market proxy, which is fundamentally inefficient. Using an index as a proxy for market return in CAPM can have consequences on the estimation of betas and expected returns, including potential bias in the beta estimation, expected return estimation, and tracking error

problems. As an alternative, we evaluate the usage of the mean-variance optimal portfolio for the market proxy in CAPM as intended by the original derivation of the model. First, this study will investigate the validity of the market proxy commonly used in CAPM by examining the efficiency of its portfolio composition using the efficient frontier diagram. Since most studies in the CAPM test assume that the market index used as the market proxy is already efficient (Levy & Roll, 2010) hence implying that no further testing is needed, this study can fill the gap in the current works of literature for checking those assumptions. Second, the mean-squared errors of the expected return will be calculated to examine the performance of CAPM prediction using the market index and the optimal portfolio as the market proxy.

This study uses quantitative research methodology with secondary data. The data collection for this study is limited to the monthly returns of Kompas 100, LQ45, and IDX30 components in the Indonesian stock market for September 2012-August 2022. The basic procedures of this research are as the following. Initially, the data are grouped with periodicity and market index as the controlled variables. Portfolio optimization is then applied to each group to find the mean-variance optimal portfolio's weight, risk, and return. After that, the CAPM rolling regression across each periodicity uses the optimal portfolio and market index as the market proxy to find the optimal beta and market beta. Finally, the optimal beta and market beta is substituted to the CAPM to calculate the expected return for each stock using the respective market proxy. The mean-squared errors are computed for each group after comparing the model prediction to the actual returns.

Key assumptions for this research are the following. Assumptions for the mean-variance model are all investors are rational, risk-averse, and utility maximizers. Furthermore, assumptions for Sharpe-Linter CAPM are free borrowing and lending at a risk-free rate and homogenous expectations. These assumptions might not work in practice but are necessary to construct the framework that builds the model. In addition, it assumes that CAPM thoroughly explains returns. No other risk premiums besides market risk

premiums are needed, so the intercept (alpha) value is zero.

This study finds that the market index returns and risks used in this study are inefficient as their position is below the efficient frontier. On the other hand, portfolio optimization consistently produces the mean-variance optimal portfolio that lies on the efficient frontier and is linked to the risk-free rate, as the Markowitz theory suggests. The optimal portfolio is a more suitable option to be used as the market proxy in CAPM, as indicated by its theoretical construction. The market beta produced by JCI as the market proxy is also systematically higher than the optimal beta produced by the mean-variance optimal portfolio, suggesting an overestimation bias of risk from the value-weighted methodology used for index construction. Surprisingly, this study also finds that the mean-squared errors produced by return estimation from the market index proxy are consistently lower than those from the optimal market proxy. This contradiction is the challenge of using the optimal portfolio as the market proxy in CAPM since they produce a less accurate estimation of the expected return despite its efficient portfolio composition.

2. LITERATURE STUDY AND HYPOTHESIS DEVELOPMENT

CAPM describes a simple mathematical relationship between the risk of an asset and its expected return. As one of the efficient market hypothesis's core components, academic research has rigorously tested CAPM. Although CAPM gained strong support in early research, some researchers document insufficient empirical evidence that led to the investigation of its failure (Blume & Friend, 1973; Fama & French, 1992; Fama & MacBeth, 1973). The model's simplicity depends on the risk component to describe an asset return thoroughly, and many researchers attempt to find other variables suspected to influence the asset return. Those variables are "common risk factors", later added to the original CAPM equation to expand the CAPM into the multifactor model. Much research in this field has been inspired by the research on systematic bias which exists in the stock market that hinders the market from being perfectly efficient. In this reasoning, beta

alone is insufficient to describe the asset return.

Many studies confirm the existence of factors besides beta that has explanatory power on the expected return of assets. Starting with evidence that tests the CAPM regression on common stocks sorted on earnings-price (E/P) ratios, it finds that the high E/P shares deliver returns that exceed the model's projected values (Basu, 1977). Additionally, other research shows that the common stocks' returns have an inverse relationship with the size of their market capitalization (Banz, 1981). Another study shows that a higher debt-equity ratio (DER) correlates with higher stock returns (Bhandari, 1988). Moreover, a "value premium" is identified in the Japanese stock market, where the returns of high book-to-market (B/M) equity stocks exceed what attributes to beta alone (Chan et al., 1991). Recently, Novy-Marx finds that companies' expected gross profitability strongly relates to their stock returns (Novy-Marx, 2013). Finally, the anticipated investment by companies has a statistically reliable relation to their average stock returns (Aharoni et al., 2012).

Those findings lead to modifying the original CAPM by adding more variables deemed to explain returns that beta misses. For example, Fama and French introduce a three-factor model that includes market risk, size, and value premium (Fama & French, 1992), which subsequently extends to a five-factor model that provides profitability and investment premium to the three-factor model (Fama & French, 2015). The documentation of seasonal factors such as momentum (Jegadeesh & Titman, 1993) also leads to the test of the "four-factor" model (market risk, size, value, and momentum premium) on a large sample of mutual funds which concludes that the returns are explainable by factors alone, not the skill of fund managers (Carhart, 1997).

Although research on the multifactor model dominates nowadays, empirical evidence presenting the validity of additional risk factor premiums is mixed. For example, Odean finds that the momentum strategy does not realize excess return after adjusting for transaction costs (Odean, 1999). In addition, many additional risk factor premiums found to be significant in earlier studies tend to

disappear over time. McLean and Pontiff document the post-publication decline of return predictability after the publication of characteristics reflecting mispricing identified in published academic studies (McLean & Pontiff, 2016). Another piece of evidence (Alquist et al., 2018) suggests that the performance of small stocks peaked a decade after Banz's first publication about the "size effect" in 1981 (Banz, 1981), only to diminish afterward gradually. Hwang and Rubesam also document the disappearance of cross-sectional momentum profit starting in the late 1990s (Hwang & Rubesam, 2013), shortly after the publication of the momentum effect (Jegadeesh & Titman, 1993). Recently, Fama and French found that expected value premiums are lower in the period 1991-2019 in the US stock market (Fama & French, 2021). Due to this inconsistency, academics realize that CAPM is the only fundamental model that abides by efficient market assumptions.

Another explanation of the model's failure to describe an asset return is the model misspecification used in the empirical research, particularly by the incorrect choice of market return proxy. In CAPM testing, it is typical for empirical research to presume that the market proxy employed is on the mean-variance frontier. Roll even went as far as to argue that the market proxy used in CAPM must include all marketable assets, such as bonds, commodities, collectibles, and real estate (Roll, 1977). If the values of all those assets can be observed and measured, then theoretically, we can create the "true market portfolio" formed on the diversification of those assets. Nevertheless, Fama and French oppose the argument because the assumptions render CAPM untestable since data for all assets are likely beyond reach, and the choice of investments in the portfolio is unclear (Fama & French, 2004). Stambaugh provides evidence to support this assertion by demonstrating that a portfolio of common stocks serves as an adequate approximation, as the results of CAPM remain unaffected by the inclusion of other assets in the market proxy (Stambaugh, 1982). A recent study (Chaudhary & Bakhshi, 2021) proposes a better market proxy by adding macroeconomic variables in a time series equation to extrapolate a more appropriate

market index value representing macroeconomic conditions.

The research mentioned above does not address the issue of the inefficiency inherent in the value-weighted market index. Complying with its theoretical construction, the mean-variance efficient portfolio must be used as the market proxy in CAPM for beta estimation as required by the model's original development (Sharpe, 1964). The recent asset pricing research seems to ignore the issue of the market proxy, despite evidence from early cross-section regression tests of CAPM (Fama & MacBeth, 1973) and early time series regression tests (Stambaugh, 1982) which suggest that the value-weighted index used as the market proxy in standard CAPM tests is on the mean-variance efficient frontier. In opposition to those findings, we find evidence that the value-weighted index's risk and return are consistently below the efficient frontier. Therefore, the value-weighted index must fail to qualify as a mean-variance efficient portfolio.

This study uses optimal portfolios resulting from mean-variance portfolio optimization as the market proxy in CAPM, replacing value-weighted indexes commonly used. We believe the value-weighted index methodology will create an inefficient market portfolio since it favors larger capitalization stocks (Chaudhary & Bakhshi, 2021). The price floor policy (capping the minimum price of 50 for the main index) that is uniquely enforced in the Indonesian stock market also exacerbates the problem of inefficiency.

We argue that CAPM is impeccable from the academic viewpoint since it complies with the assumption that states only higher risk can compensate for higher returns in an efficient market environment. Therefore, we focus on fixing the issue of the market proxy problem in CAPM, as academic research rarely addresses the issue.

The specification for CAPM is the original model as proposed by Sharpe and Lintner, written as:

$$E[r_i] = r_f + \beta_i \times (E[R_m] - r_f) \quad (1)$$

Where:

$E[r_i]$ = the anticipated return of stock i

r_f = the return of a riskless asset

β_i = systematic risk of stock i

$E[R_m]$ = the anticipated return of the market proxy

Depending on the choice of the return of market proxy, if the proxy used is the market index, the result is the market index beta, β_m . Similarly, if the market proxy is the optimal portfolio, the result is the optimal beta β_{opt} . The common assumption holds that the beta produced by the market index proxy does not have a higher value than the beta produced by the optimal portfolio proxy, implying the market beta is riskier than the optimal beta. Therefore, the market beta is equal to or lower than the optimal beta. Hypothesis Testing 1 for this study is as the following:

$$H_0: \beta_m \leq \beta_{opt}$$

$$H_1: \beta_m > \beta_{opt}$$

Where:

H_0 = null hypothesis

H_1 = alternative hypothesis

After obtaining the beta, it is inserted back into the CAPM equation to estimate the anticipated asset return, utilizing the corresponding market proxy. The anticipated return is then compared to the actual return to find the error of prediction:

$$\varepsilon = E(r_i) - r_i \quad (2)$$

Where:

ε = the error of prediction

Finally, compute the mean-squared errors as:

$$MSE = \frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2 \quad (3)$$

Where:

Y_i = actual value of component i

The null hypothesis states that the mean-squared errors for the optimal portfolio proxy are equal to or lower than the mean-squared errors for the market index proxy, implying that the performance of the optimal portfolio proxy is better than those of the market index proxy. Hypothesis Testing 2 for this study is as the following:

$$H_0: MSE_{opt} \leq MSE_m$$

$$H_1: MSE_{opt} > MSE_m$$

3. RESEARCH METHODOLOGY

The secondary data used in this study are the monthly adjusted close price of Kompas 100, LQ45, and IDX30 index components

extracted from Yahoo Finance for September 2012-August 2022. This study's risk-free rate proxy is the 10-year Indonesian government bond yield. The number of stocks included in Kompas 100, LQ45, and IDX30 is 78, 43, and 28, respectively, since incomplete data during the observation omit some data. The samples are formed into 12 groups with periodicity (2, 3, 4, and 5 years) and market index (Kompas 100, LQ45, and IDX30) as the controlled variables. The risk-free rate proxy is the yield of a 10-year Indonesian government bond. According to the Markowitz model, portfolio optimization is applied to each group to find the weight, risk, and return of the mean-variance optimal portfolio. After that, the CAPM rolling regression across each periodicity uses the optimal portfolio and market index as the market proxy to find the optimal beta and market beta. Finally, the optimal beta and market beta is substituted into the CAPM equation to determine the anticipated return for each stock using the respective market proxy. Finally, each group's mean-squared errors are computed after comparing the model prediction to the actual returns.

This study uses portfolio optimization and CAPM rolling regression, carried out in Matlab 2021, to analyze the data. The portfolio optimization process employs the Markowitz framework, which calculates a group of mean-variance efficient portfolios situated on the efficient frontier. The problem can be formulated as risk minimization, expressed as a set of equations in the matrix form:

$$\min_{\omega} \frac{1}{2} \omega' \Sigma \omega \quad (4)$$

$$\text{s. t. } \omega' \mu = r_p \quad (5)$$

$$\omega' 1 = 1 \quad (6)$$

Where:

ω = the weight of a stock

μ = the mean of return

r_p = portfolio return

By solving a set of Equations 4-6, a group of portfolios with minimum variance for various levels of portfolio return can be calculated by quadratic programming and plotted as the portfolio points along the efficient frontier.

Portfolio optimization aims to find the portfolio weight, risk, and return of the optimal mean-variance portfolio. The optimal

portfolio has a global optimum Sharpe ratio among the efficient portfolios and connects with a line to the risk-free rate point in the vertical axis (Fabozzi, 2015). The optimal portfolio is calculated directly by solving the problem of maximization in the form of a matrix:

$$\max_{\omega} \frac{\mu' \omega - r_f}{\sqrt{\omega' \Sigma \omega}} \quad (7)$$

$$\text{s. t. } \omega' 1 = 1 \quad (8)$$

4. RESULTS AND DISCUSSION

Table 1 summarizes the statistical description of the monthly return of the Kompas 100, LQ45, and IDX30 components and the monthly return of the index for the observation period. The mean of return is positive, indicating the price appreciation at the end of the observation period. IDX30 components have the lowest standard deviation, which is logical since the index contains mostly larger capitalization stocks. Interestingly, the distribution pattern of the components and index returns is different since component returns have positive skewness, meaning there are a small number of high positive returns at the end of the tail. In contrast, the skewness of the index return distribution is negative, which means the index is subject to infrequent but significant negative returns. On the other hand, the return distribution tends to peak at the centre, as indicated by high kurtosis.

Table 1 *Descriptive statistics of monthly returns*

	K100	LQ45	IDX30
Min	-0,575	-0,555	-0,506
Max	1,743	1,000	1,000
Mean	0,011	0,011	0,012
Median	-0,004	0,000	0,000
Stdev	0,145	0,129	0,123
Skewness	1,718	0,906	1,176
Kurtosis	11,685	4,622	5,971
N	4680	2580	1680

Figure 1-3 shows the efficient frontier diagram for Kompas 100, LQ45, and IDX30 at each periodicity. The optimal portfolio is at the efficient frontier (red line) and connected to the risk-free rate. The Kompas 100, LQ45, IDX30, and JCI index returns are below the

efficient frontier, indicating their portfolio inefficiency. The return of individual stock components is also located below the efficient frontier, meaning that individual returns are not efficient.

Figure 1: Kompas 100 Efficient Frontier for 2-5 Years Period

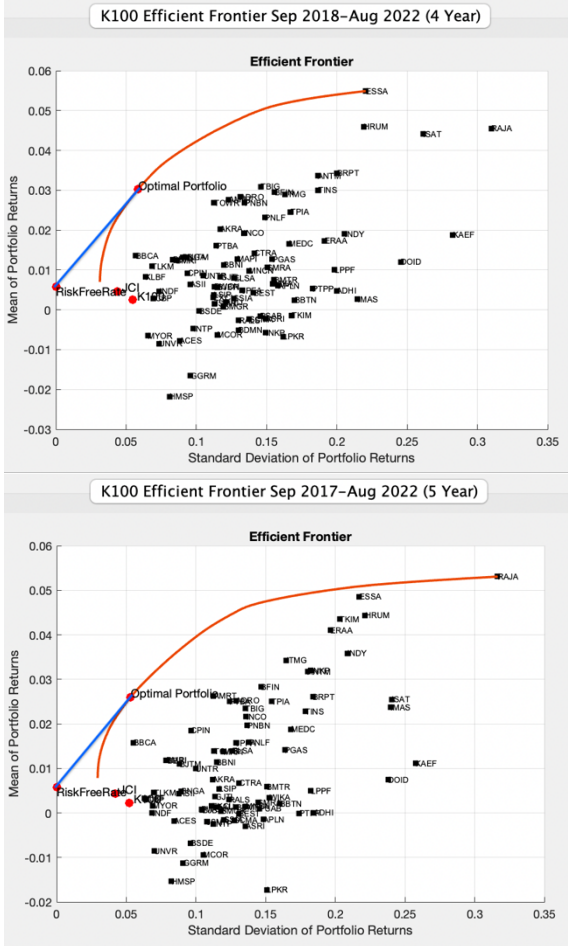
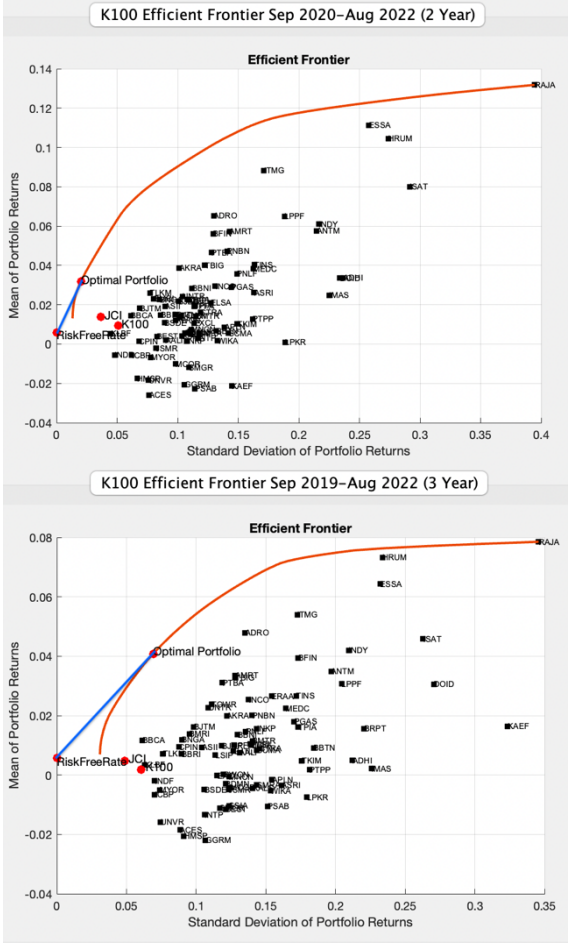
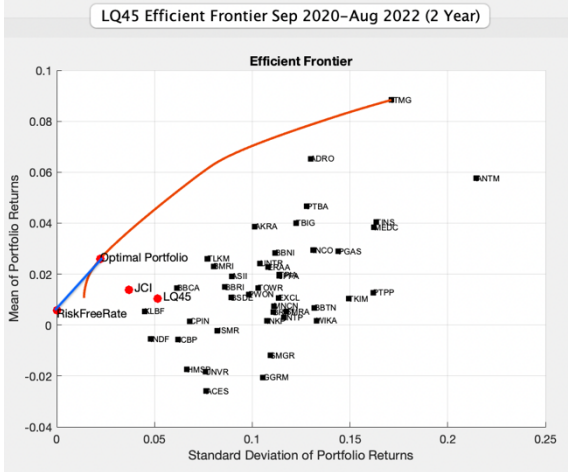


Figure 2: LQ45 Efficient Frontier for 2-5 Years Period



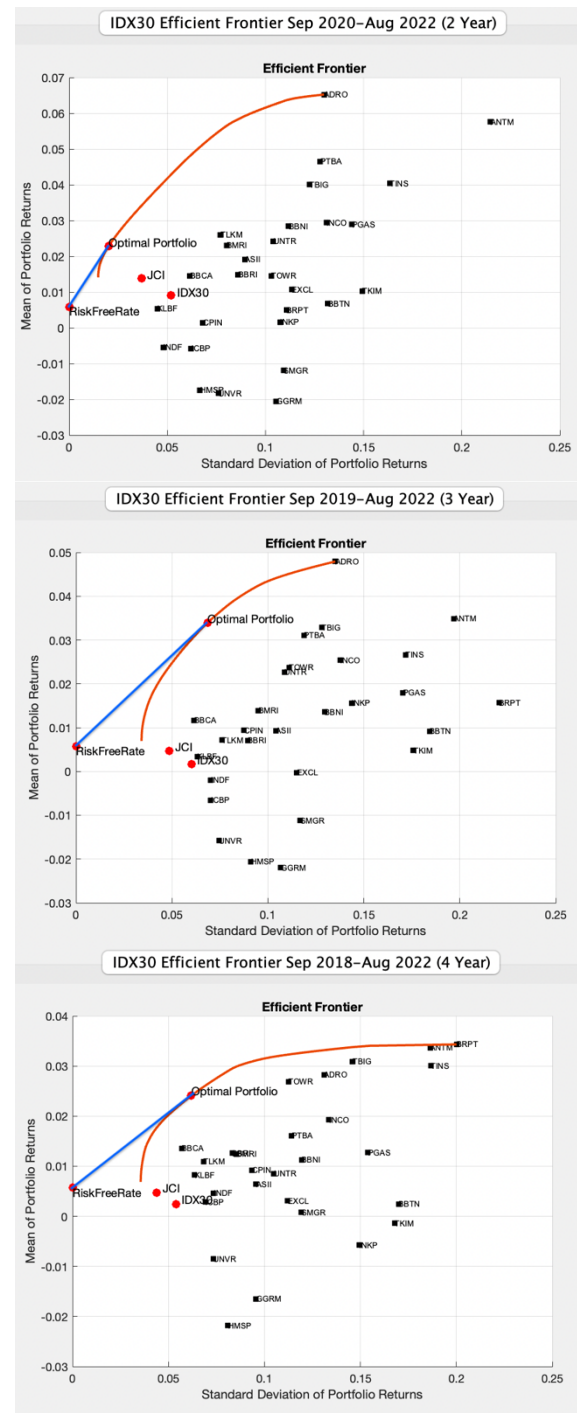
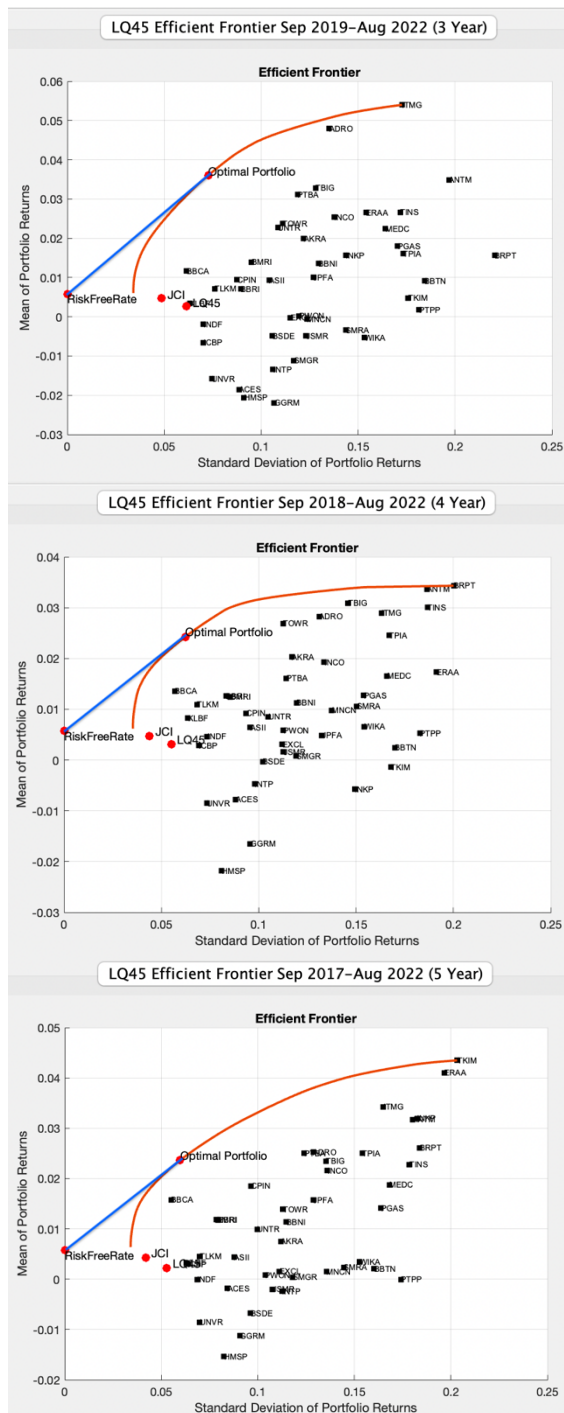


Figure 3: IDX30 Efficient Frontier for 2-5 Years Period

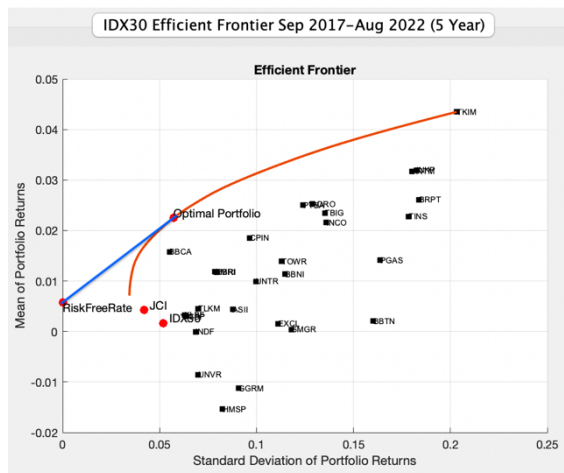


Table 2 explains each sample group's average risk and return of the optimal portfolio and market index. The return of the Kompas 100, LQ45, and IDX30 optimal portfolio is consistently higher than the market index. Since the optimal portfolio lies on the mean-variance efficient frontier line, as suggested in Figure 1-3, the return divided by risk must be higher than those of the market index.

Table 2 *Mean of return and risk*

Kompas 100 Components				
Period (years)	K100 Optimal Portfolio		JCI	
	Return	Risk	Return	Risk
2	0,036	0,043	0,001	0,068
3	0,034	0,049	-0,002	0,058
4	0,031	0,047	-0,002	0,054
5	0,030	0,048	0,002	0,050
Mean	0,033	0,047	0,000	0,057
LQ45 Components				
Period (years)	LQ45 Optimal Portfolio		JCI	
	Return	Risk	Return	Risk
2	0,040	0,058	0,001	0,069
3	0,039	0,064	-0,001	0,059
4	0,035	0,061	-0,002	0,055

5	0,033	0,061	0,002	0,051
Mean	0,037	0,061	0,000	0,059
IDX30 Components				
Period (years)	IDX30 Optimal Portfolio		JCI	
	Return	Risk	Return	Risk
2	0,039	0,059	0,000	0,067
3	0,039	0,067	-0,002	0,057
4	0,034	0,062	-0,002	0,054
5	0,032	0,061	0,002	0,050
Mean	0,036	0,062	0,000	0,057

Table 3 describes the average beta of stock components of Kompas 100, LQ45, and IDX30. The lefthand side of the table is the beta obtained from the optimal portfolio proxy. Similarly, the table's righthand side is the beta obtained from the JCI proxy. The market beta that uses the JCI proxy show systematically higher values for all sample groups.

Table 3 *Stocks Beta*

Kompas 100 Components				
Period (years)	K100 Optimal Portfolio		JCI	
	Mean	t-stat	Mean	t-stat
2	0,72	1,77	1,51	3,02
3	0,73	2,11	1,49	3,51
4	0,7	2,42	1,48	3,8
5	0,74	2,76	1,45	4,08
Total	0,72	2,26	1,48	3,6
LQ45 Components				
Period (years)	LQ45 Optimal Portfolio		JCI	
	Mean	t-stat	Mean	t-stat
2	0,65	1,9	1,48	3,21
3	0,64	2,26	1,48	3,8

4	0,67	2,66	1,46	4,18
5	0,65	3,05	1,41	4,51
Total	0,65	2,47	1,46	3,93
IDX30 Components				
Period (years)	IDX30 Optimal Portfolio		JCI	
	Mea n	t- stat	Mea n	t-stat
2	0,63	1,89	1,31	3,04
3	0,58	2,22	1,32	3,67
4	0,61	2,65	1,31	4,07
5	0,62	3,04	1,26	4,4
Total	0,61	2,45	1,3	3,79

Notes: Fisher's method calculates the p-values for combined stock components' beta. All values are under 0,05 significance level

Table 4 describes the mean-squared errors for all stock components in Kompas 100, LQ45, and IDX30. This table compares the prediction performance between the optimal portfolio and the JCI proxy. The mean-squared errors for the optimal portfolio proxy are consistently higher than those for the JCI proxy for all sample groups, indicating that the prediction performance using JCI as the market proxy in CAPM is still more accurate than the optimal market proxy. To provide a more balanced comparison, Table 5 provides the results for only 28 similar components of Kompas 100, LQ45, and IDX30.

The results are identical. The mean-squared errors for the optimal portfolio proxy are still higher than those for the JCI proxy.

Table 4 *Mean-squared Errors For All Components in Kompas 100, LQ45 and IDX30*

Period (years)	Kompas 100	
	Optimal Portfolio	JCI
2	0,017181	0,015143
3	0,017153	0,015385
4	0,017235	0,015549
5	0,017656	0,015853
Average	0,017306	0,015483
LQ45		

Period (years)	Optimal Portfolio	JCI
2	0,013683	0,011451
3	0,013355	0,011638
4	0,013554	0,011764
5	0,013964	0,011973
Average	0,013639	0,011707
Period (years)	IDX30	
	Optimal Portfolio	JCI
2	0,012936	0,01079
3	0,012509	0,010991
4	0,012635	0,011119
5	0,012749	0,011254
Average	0,012707	0,011039

Table 5 *Mean-squared Errors For 30 Similiar Components in Kompas 100, LQ45 and IDX30*

Period (years)	Kompas 100	
	Optimal Portfolio	JCI
2	0,012297	0,01079
3	0,012448	0,010991
4	0,012427	0,011119
5	0,012624	0,011254
Average	0,012449	0,011039
Period (years)	LQ45	
	Optimal Portfolio	JCI
2	0,012786	0,01079
3	0,012471	0,010991
4	0,012679	0,011119
5	0,012869	0,011254
Average	0,012701	0,011039
Period (years)	IDX30	
	Optimal Portfolio	JCI
2	0,012936	0,01079
3	0,012509	0,010991
4	0,012635	0,011119
5	0,012749	0,011254

Average	0,012707	0,011039
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Table 6 describes the average and standard deviation of the expected monthly return for each sample group. Although the JCI proxy has larger beta values, the expected return is consistently lower than the optimal portfolio proxy because of the lower return of JCI when used as the market return proxy in CAPM than the return of the optimal portfolio. On the other hand, the standard deviation of the anticipated return for the optimal portfolio proxy is consistently higher for each sample group. For the robustness test, Table 7 presents the paired t-test results for the mean expected monthly return of the optimal portfolio proxy and the JCI proxy. The results imply the statistically significant difference between the average of the expected monthly return of the optimal portfolio proxy and the JCI proxy.

Table 6 *Expected Monthly Return of Each Optimal Portfolio*

Kompas 100 Components				
Period (years)	Optimal Portfolio		JCI	
	Mea n	Stde v	Mea n	Stde v
2	0,0198	0,0218	0,0029	0,0273
3	0,018	0,0206	0,0018	0,0236
4	0,0153	0,021	0,0028	0,0208
5	0,0154	0,0212	0,0034	0,0292
Total	0,0171	0,0211	0,0027	0,0227
LQ45 Components				
Period (years)	Optimal Portfolio		JCI	
	Mea n	Stde v	Mea n	Stde v
2	0,0203	0,0219	0,0028	0,0281
3	0,0189	0,0247	0,0019	0,0244
4	0,0166	0,025	0,0029	0,0214
5	0,0156	0,0258	0,0034	0,0293

Total	0,0179	0,0243	0,0027	0,0233
IDX30 Components				
Period (years)	Optimal Portfolio		JCI	
	Mea n	Stde v	Mea n	Stde v
2	0,0184	0,0235	0,0034	0,0275
3	0,0175	0,0275	0,0024	0,024
4	0,0159	0,0293	0,0032	0,021
5	0,0149	0,0291	0,0037	0,0286
Total	0,0167	0,0274	0,0032	0,0228

The theoretical consideration of the CAPM to be considered valid is the assumption that the market portfolio proxy is mean-variance efficient (Roll, 1977). The efficient frontier diagram in Figure 1-3 shows that value-weighted market indexes, such as Kompas 100, LQ45, IDX30, and JCI, are consistently inefficient regarding mean-variance conditions, as they are below the efficient frontier. The market proxy should use the optimal Sharpe ratio portfolio to satisfy the efficiency assumption. The inefficient mean-variance market proxy used in current research is sufficient to conclude that the CAPM testing is invalid (Levy & Roll, 2010).

Table 7 *A Paired t-test (p-value) Between Optimal Portfolio and JCI*

Period (years)	Kompas 100	LQ45	IDX30
2	87,49	70,43	51,84
3	113,34	87,24	66,75
4	112,78	90,08	70,07
5	131,74	97,45	75,22

Notes: All values are statistically significant under 0.05 level. The hypothesized mean difference sets to zero.

The beta values from the JCI proxy are consistently higher than those using the optimal portfolio of Kompas 100, LQ45, and

IDX30 components as the market proxy. For optimal portfolio proxy used in the Kompas 100, LQ45, and IDX30 components, the average beta is 0,72, 0,65, and 0,61, respectively. For the JCI proxy used in the Kompas 100, LQ45, and IDX30 components, the average beta is 1,48, 1,46, and 1,30. Therefore, the null hypothesis in Hypothesis Testing 1 is safely rejected as the values of the market beta are more than twice the values of the optimal beta. The consequence of using the market index proxy for beta estimation is there will be an overestimation of the risk of an asset.

The mean-squared errors for the expected returns of CAPM that uses the optimal portfolio proxy are higher than those that use the JCI proxy. The mean-squared errors for Kompas 100, LQ45, and IDX30 components that use the optimal portfolio proxy are 0,0173, 0,0136, and 0,0127, respectively. On the other hand, the mean-squared errors for Kompas 100, LQ45, and IDX30 components that use the JCI proxy are 0,0155, 0,0117, and 0,0110, respectively. A similar pattern persists if we compare only similar stocks among the Kompas 100, LQ45, and IDX30 components. The null hypothesis in Hypothesis Testing 2 is rejected as the values of the mean-squared errors for the optimal portfolio proxy are consistently higher than those for the JCI proxy, indicating that although the JCI is a class of value-weighted market index that is inherently inefficient based on its position on the efficient frontier diagram, the usage of JCI return as the market proxy may result in better prediction performance of CAPM.

This study shows that market indexes such as JCI, Kompas 100, LQ45, and IDX30, often used to proxy market return in CAPM, are inefficient. Those market indices' risk and return position is not on the mean-variance efficient frontier. Therefore, we must re-evaluate the theoretical validity of using the market index for the market proxy in CAPM. On the other hand, the market beta and the JCI return as the market proxy still result in the lower mean-squared error of CAPM prediction compared to the usage of the optimal beta and optimal portfolio proxy based on the five years of monthly return analysis in the Kompas 100, LQ45 and IDX30 components. Therefore, this study implies that using the JCI return as the market proxy in

CAPM, as commonly done in current practice, can be justified if the primary purpose is to give the most accurate prediction of the expected return. Lastly, since this study is limited to low-frequency monthly data of small sample populations, this study can expand by using higher frequency data such as daily return with a more extended period of data analysis.

As mentioned before, using JCI return as the market proxy in CAPM can affect the estimation of expected returns and betas. Some of them are:

Bias in expected return estimation. By relying on a market index as a replacement for the market return in CAPM, the biased estimates of expected returns may result due to the reliance on the index's historical average return, which may not reflect the actual expected return of the market or individual securities. Instead, a more accurate estimation of expected returns can be achieved through a comprehensive analysis of various factors, such as the company's financials, the broader macroeconomic environment, and other relevant factors.

Bias in beta estimation. Suppose an index is used for the proxy of the market return. In that case, the beta estimated for an individual security is calculated based on the regression line slope between the security's returns and index returns, which may result in biased estimates of the actual beta due to imperfections in the market index. A more precise beta estimation can be achieved by assessing the responsiveness of the security's returns to market factors that influence the risk.

Tracking error. Using an index for the market proxy can result in tracking errors since no index can perfectly capture the market's performance. This imperfection may lead to errors in estimating expected returns and betas, ultimately impacting the accuracy of the CAPM predictions.

5. CONCLUSION

This study concludes that the market indexes portfolio such as Kompas 100, LQ45, IDX30, and JCI are inefficient in the mean-variance framework because they are not on the efficient frontier. Overall, using an index for the proxy of market return in the CAPM can result in biased estimates of expected returns and betas, significantly impacting

investment decisions. Therefore, combining an index with other relevant information is crucial to estimate the expected returns and betas of individual securities more precisely.

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