# Is There A Diversification "Cost" of Shari'ah Compliance? Empirical Evidence from Malaysian Equities

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# Is There A Diversification "Cost" of Shari'ah Compliance? Empirical Evidence from Malaysian Equities

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**Abstract**

Islamic equity portfolios work with a smaller investment universe given the filtering of non-*Shari'ah* compliant stocks. It has been theoretically argued that this culminates in suboptimal portfolio diversification which in turn adversely affects risk-adjusted returns. We employ a number of methods, namely construction of efficient frontiers, time-varying maximum Sharpe ratios, MGARCH-DCC and analysis of covariance (ANCOVA), to offer empirical evidence that such a conceived portfolio diversification "penalty" is far from a foregone conclusion, at least empirically. Our results show that Islamic portfolios are not invariably handicapped in terms of portfolio diversification. We also explored dimensions which may account for differences in relative investment performance between Islamic and conventional portfolios such as portfolio constraints, length of investment horizon and market conditions. We believe this paper is among the first to apply substantial empirical analysis of the portfolio diversification perspective on Islamic equity investments.

*Keywords*: Islamic equity portfolio, portfolio diversification, efficient frontier, maximum Sharpe ratio, MGARCH-DCC, analysis of covariance (ANCOVA)

*JEL Classification*: C20, C61, G11

## 1. INTRODUCTION

Diversification in financial assets has been subjected to academic rigour for decades now. Since the advent of Modern Portfolio Theory championed by Markowitz, there is arguably little apparent dearth in research addressing various diversification perspectives. One aspect that has received some attention is the effect that constraints applied on portfolios would have in terms of diversification. Rudd (1981) argues theoretically that when a given portfolio is constrained, its performance will be affected. Using the case of stock portfolios avoiding firms that had dealings with the then-Apartheid South Africa, it was hypothesized that portfolios subjected to ethical screening would report inferior performance, primarily due to size and other biases introduced into the said portfolios. Grossman and Sharpe (1986) found some empirical support for Rudd's argument. The basic concept here is that having a smaller pool of potential stocks to choose from is detrimental to diversification which in turn affects risk-adjusted returns.

Hence, the conceptual framework of our research is not novel. It does, however, validate the research enquiry we are making as well as the approach we are taking. Shari'ah compliant stocks or simply Islamic equities represent a growing investment category paralleling socially responsible investing. Islamic principles and tenets are employed to screen stocks deemed unacceptable for investment by Muslim investors. Typically firms involved in sectors like interest-based finance, gambling and gaming, tobacco and alcohol are excluded from an Islamic stock portfolio. In a rising number of Shari'ah jurisdictions, financial ratios are also applied to limit reported quantum of interest income, interest-based debt and receivables. Investor portfolios and funds adhering to rules of Shari'ah compliance are unmistakeably a form of a constrained portfolio. Just as much research has been devoted to comparing socially responsible

funds with mainstream ones, and in particular, examining diversification differences and their impact on performance, it makes sense to do the same for Islamic equities.

The crux of the issue is somewhat straightforward. Paraphrasing Markowitz, in a diversified portfolio, how much a particular security contributes to the overall risk of the portfolio depends on the covariance of that security with other securities in the portfolio. Risks attributable to individual securities are diversified away. Given that assertions of CAPM, equity returns only reflect systematic (undiversifiable) risk. When a portfolio is constrained, as is the case with a Shari'ah compliant portfolio, it is arguably less diversified and in turn, its risk-return performance may be sub-optimal[1].

It is not uncommon to read commentaries on Islamic equity markets remarking as follows. Shari'ah compliant investors have a smaller investment universe to choose from. By excluding "sin" stocks from the pool of Shari'ah compliant investable equity investments, such investors obtain less benefit from portfolio diversification. However, to the best of our knowledge, such claims have thus far been appealing to simple logic at best and purely rhetorical at worst. This endeavour represents among the first attempts at providing substantial empirical evidence to shed light on this matter.

We feel the question of diversification and its impact on investment performance of Islamic portfolios relative to conventional portfolios is worthy of academic enquiry. Relating to our earlier mentioned case of ethical funds in South Africa, it can be argued that while a morally screened portfolio may be less diversified, the resulting small-stock bias may actually work to its advantage. There is ample empirical evidence that small stocks have historically outperformed larger stocks (the so-called small stock risk-return anomaly in CAPM literature). It follows that a number of recent empirical investigations find no statistically discerning evidence that the performance of socially responsible mutual funds is different from that of conventional ones. More pertinently, if it is true that Islamic portfolios have less diversification, why have ***some*** empirical results indicated that they have outperformed or are at par with conventional portfolios? It may be the case that the idea that less portfolio diversification implies suboptimal risk-adjusted returns is only valid theoretically. In reality, this intuition may not be observed empirically. We believe that tackling this from an empirical perspective can contribute towards demystifying the issue.

We contend that this study is not a purely academic investigation. Its results have the potential to develop the Islamic equity investment sector. If it can be empirically proven that Islamic equity portfolios are not necessarily disadvantaged in terms of diversification, it would aid in the promotion of Islamic equities, particularly to non-Muslim investors.

The proposition for Muslim investors is somewhat slightly different. Pious investors are likely to remain with their faith-based convictions regardless of our empirical findings. Such investors, steadfast in their beliefs, would avoid investing in non-Shari'ah compliant stocks even if evidence shows that these stocks offer additional diversification benefits. On the other hand, if the so-called diversification handicap is empirically established as unsubstantiated, our results would provide these investors with some psychological comfort albeit of little consequence. For

[1] It is important to note a key underlying assumption here – that the market does not ***completely*** price unsystematic risk. While we do not assume a perfect market which totally ignores unsystematic (diversifiable) risk, for the purposes of this endeavour at least, we assume that the market will, to some degree, penalize lack of portfolio diversification. If it was instead assumed that returns ***fully*** account for total risk (including any undiversified firm-specific risk), our proposed empirical investigation would be a somewhat futile exercise. In other words, diversification only matters (read: affects risk-adjusted returns) if returns reflect only or ***primarily*** systematic (undiversifiable) risk. Of course, if it was found that there is lack of empirical evidence of such a diversification disadvantage to Islamic portfolios, the aforementioned point could be a plausible explanation (i.e., our assumption is inappropriate).

this reason, we intend to widen the scope of our analysis to include investigation of factors that may have bearing on the extent that diversification levels impact investment performance. Stated differently, we seek an answer to the question – under what circumstances, if any, does the differences in diversification levels between Islamic and conventional portfolios result in differing quantum of investment performance? With this, Muslim and non-Muslim investors alike would potentially find practical use of our findings, in making informed investment decisions as well as in managing their equity portfolios.

The rest of this paper is organized as follows. In the next section we formalize our research objectives. Section 3 reviews some related literature, section 4 describes the various quantitative techniques that will be put to use and section 5 discusses the empirical findings while offering some intuitive interpretations. We conclude the paper with section 6 by summarizing our findings, identifying some key implications of our results and highlighting limitations of our research.

## 2. RESEARCH OBJECTIVES

This research endeavour will have two primary objectives:

i. To ascertain if there is substantial empirical evidence to reject the premise that Islamic portfolios are inferior in terms of risk-adjusted returns (relative to conventional portfolios) by virtue of the former's lesser diversification.
ii. To answer the question: Are there factors which impact comparative risk/return profiles of Islamic and conventional portfolios attributable to differences in level of portfolio diversification? In other words, we investigate if there are circumstances which also contribute to differing levels of investment performance between Islamic and conventional portfolios in addition to the hypothesized differing levels of portfolio diversification. In particular, we look at the following dimensions:
    a. The impact, if any, of allowing short selling.
    b. The use of portfolio constraints such as setting of minimum and/or maximum weights for a given portfolio constituent.
    c. Are there investment performance differences by portfolio risk profile?
    d. Does length of the investment period matter?
    e. Sub-period analysis – segregated by events of financial/market crisis.
    f. Variability in observed results owing to choice of investment performance yardstick and market benchmark employed.

## 3. LITERATURE REVIEW

Parallels can be drawn between Islamic portfolios and socially responsible investing (SRI) funds or ethically-screened funds. After all, they share at least one thing in common – they are both forms of constrained portfolios. Hence we deem it appropriate to begin our review of literature by looking at some previous work done pertaining to SRI funds. The question of whether investing in a socially responsible way comes at a financial cost has been subjected to much empirical analysis. Renneboog, Horst and Zhang (2008a) found a sample of SRI funds in the UK, US, Europe and Asia Pacific underperforming when benchmarked against their respective domestic benchmarks. Similarly, Renneboog, Horst and Zhang (2008b) argued that the pursuit of ethical objectives comes at a price in the form of suboptimal financial performance. However, this does not necessarily imply that mainstream funds performed any better. Blanchett (2010) found that although SRI funds underperformed relative to non-SRI peers when measured on pure return basis, the reverse was true after adjustments for risk.

Bauer, Koedijk and Otten (2005) found "no evidence of significant differences in risk-adjusted returns between ethical and conventional funds". They also found that in the earlier periods of

their analysis, ethical mutual funds played "catch up" before eventually registering returns comparable to mainstream funds. For the most part, reported empirical investigations find no statistically discerning evidence that the performance of socially responsible mutual funds is different from that of conventional ones (see Diltz, 1995; Sauer, 1997; Goldreyer, Ahmed and Diltz, 1999; Statman, 2000; Bello, 2005). It was suggested by Galema, Plantinga and Scholtens (2008) that this is not due to simply aggregation of analysis (individual constituents of a sample of SRI funds having opposite effects that cancel each other out when combined). Instead, Galema *et al.* (2008) attributes it to the use of the Fama and French risk factors (especially the HML factor). They argue that SRI funds have lower book-to-market ratios, and hence impact stock returns, but this is not captured in computed alphas as the Fama and French regressions have controlled for it. Hong and Kacperczyk (2009) provide empirical evidence of the cost of capital of "sin stocks" – firms involved in alcohol, tobacco and gaming which are typically excluded from a SRI portfolio – being statistically significantly affected by what they conceive as "effects of social norms". Among other things, the so-called sin stocks receive less attention from analysts, are ignored by norm-constrained investors and face higher risks of legal liabilities. All these contribute to the said stocks' higher expected returns than otherwise comparable stocks.

Comparisons are sometimes made between SRI funds and faith-based funds, such as the case of Islamic funds. Lyn and Zychowicz (2010) found that faith-based funds outperformed SRI funds. While SRI and faith-based investing have common grounds, it does not warrant the conclusion that one is a sub-category of another, much less equating the two. Characteristic differences can be found in terms of asset allocation and econometric profile between Islamic funds and SRI ones (Forte and Miglietta, 2007).

Closer to the subject matter of our study, a growing number of research works compare Islamic funds and portfolios with their conventional counterparts, at least in terms of risk-adjusted returns. Hayat and Kraeussl (2011) offer empirical evidence of conventional funds outperforming Islamic ones. Similarly, Al-Shakfa and Lypny(2011) argued that the expected costs of observance (to Shari'ah rulings) was positive. They note that in an out-of-sample basis, secular portfolios performed proportionately better. It was argued that given that Islamic portfolios begin with a smaller investment universe, they "cannot wash away as much idiosyncratic risk as they otherwise could". This diversification perspective however, was not explored in greater detail empirically. On the other hand, Alam and Rajjaque (2010) found Islamic funds to have outperformed mainstream funds.

To add to this already mixed results, we have many studies that find that the risk-adjusted returns of Islamic funds are not different from conventional funds to a statistically significant extent (see Hussein, 2004; Hakim and Rashidian, 2004; Elfakhani, Hassan and Sidani, 2005; Hassan, Antoniou and Paudyal, 2005; Girard and Hassan, 2008; Merdad, Hassan and Alhenawi, 2010). In addition to finding that adherence to religious norms is not costly in terms of investment performance; many of these papers observe that mainstream funds fare better during bullish markets while Islamic funds outperform their conventional counterparts when there is market downtrend. Thus the popular claim that Islamic funds offer good hedging opportunities when times are bad. Even this investment heuristic has not gone empirically unchallenged. Al-Shakfa and Lypny (2011) noted that "despite the subprime loan crisis being much harsher on non-compliant stocks, secular portfolios identified as dominant in-sample were more than likely than their Islamic counterparts to outperform during the downturn". Likewise, findings in Hussein and Omran (2005) suggest that over a bear market period, Islamic funds underperformed relative to mainstream funds. They attribute this to firms in the alcoholic beverage sector which were among the best performers during this bear market period. There was also suggestion that the September 11 attacks could have produced a negative environment for Islamic investors and depressed demand for Shari'ah compliant assets which in turn impacted performance.

In comparing Islamic and conventional portfolios, analysis is not limited to just risk-adjusted returns. For instance, Hoepner, Rammal and Rezec (2011) also explored differences in investment style and found Islamic funds favouring growth and small cap firms. Hussein and Omran (2005) reported similar findings that Islamic portfolios have a preference for smaller firms. Afza and Rauf (2009) investigated fund attributes that significantly influenced performance of Pakistani mutual funds. Derigs and Marzban (2009) delved into an arguably novel dimension of analysis in comparing Islamic portfolios with their conventional counterparts. They propose a new paradigm in determining Shari'ah compliance in equity investments. Instead of applying financial ratios individually for each stock under consideration, this aspect of Shari'ah screening can be done at the portfolio level. When done at this aggregated level, the authors show quantitatively that portfolio performance is significantly better, even to the extent of matching the performance of conventional portfolios. Further, the paper addressed an outstanding issue of differing standards in Shari'ah screening adopted by different index providers and institutions (Dow Jones, S&P, MSCI, FTSE, HSBC, to name a few). Portfolios optimized by varying screening methodology strategies (defined as "best of", consensus/*ijma'*, liberal and majority) are shown to yield differing performance. Market capitalization based financial ratios produced superior results compared to total assets based ratios.

As we will be using Malaysia as our market sample for empirical analysis, we accord some attention to previous empirical work based on Malaysian data. Most of the papers rely on commonly-used fund performance measures such as Sharpe, Treynor, Jensen's alpha and the information ratio. Abdullah, Hassan and Mohamad (2007) observed, as many other papers have, that Islamic funds did better when markets were bearish and conventional funds outperformed Islamic portfolios in bullish markets. The same paper also found evidence that both Islamic and conventional funds were poorly diversified and that their asset managers were bad at stock-picking and timing the market. Annuar, Shamsher and Ngu (1997) had reported similar findings albeit offering some evidence of positive selectivity performance. Working with actively and passively managed Malaysian funds, Shamsher, Annuar and Taufiq (2000) found both categories of funds underperformed the market benchmark. Interestingly, Mansor and Bhatti (2011) reported their sample of Islamic and conventional Malaysian mutual funds as outdoing the market portfolio. It was also found that the Islamic portfolio was riskier and slightly underperformed, relative to the conventional portfolio. The aforementioned trend of mixed empirical results is evident in the case of Malaysian funds, with Hassan, Khan and Ngow (2010) finding no convincing performance differences between Islamic and non-Islamic funds. Hassan *et al.* (2010) also found that Islamic funds tended to be small-capitalization oriented and non-Islamic mutual funds more value-focused. They also added that portfolio diversification opportunities within the local mutual fund market were limited, suggesting that international diversification was the way to go. Saad, Majid, Kassim, Hamid and Yusof (2010) went with a different approach, analyzing Malaysian mutual funds from an efficiency perspective and found Islamic funds to have performed better in this respect.

Our work here can be considered as part of the literature segment that compares and contrasts Islamic and conventional portfolios. However, we take a more specific approach by focusing on the diversification dimension. Empirical and theoretical papers that discuss diversification perspectives related to equity portfolios are arguably not in short supply. Nonetheless, many of these papers, especially in more recent times, tend to focus on international portfolio diversification. For example, De Santis and Gerard (1997) found, among other things, that long-term gains from international diversification remain economically attractive, at least for U.S. investors. This is despite increasing integration of international markets and contagion during market declines. International diversification benefits remain substantial even when U.S. investors' portfolios are constrained, such as prohibited from short selling activities (Li, Sarkar and Wang, 2003). Driessen and Laeven (2007) found that cross-border investing is most beneficial for investors in developing countries particularly countries with high country risk. Fifield, Power and Sinclair (2002) question the efficacy of the ex-post analytical framework,

arguing that it tends to overstate the extent of gains from international diversification. They show empirically that reliance on historical data to identify optimal portfolios on the more realistic ex-ante basis produces dismal results.

Our very brief account of some literature on international portfolio diversification is not meant to be exhaustive, but rather to illustrate that research work that deals in depth with the diversification perspective in articulating the comparison between constrained portfolios (such as SRI funds) and mainstream portfolios are few and far between. In this regard, work more specifically on Islamic portfolios is even scarcer. We highlight such works, which are most closely related to our present study, in what follows.

Hoepner (2010) argues that it is wrong to make an inescapable conclusion that constrained portfolios such as SRI-based ones will always have worsened levels of portfolio diversification. A simple theoretical model was developed with three primary drivers of portfolio diversification – (i) number of stocks, (ii) correlation of stocks, and (iii) average specific risk of stocks. While ethically screened portfolios will nearly always lose out in terms of the first two drivers, it may not necessarily be the case for the third. In fact, it was argued that many SRI funds would typically have lower average idiosyncratic risks, even to the point of offsetting any disadvantage they would have in terms of the first two drivers. This is especially the case when positive screening takes place (actively looking for best-in-class investments) as opposed to merely negative exclusionary screening (just avoiding irresponsible firms). Borrowing the author's "eggs in baskets" analogy, the argument is that socially-responsible investing may end up with fewer baskets to work with, but the quality of the selected baskets could be higher.

A more quantitative approach was taken by Galema, Plantinga and Scholtens (2009) to analyze the diversification consequences of socially responsible investing. Their work improved upon that of Schroder (2006) and found that when short selling was restricted, SRI funds are not worse off. With short selling allowed, there is evidence of socially responsible investors losing out in terms of foregone risk reduction opportunities. Another empirical investigation into the effects of socially responsible investing on portfolio diversification was conducted by Bello (2005). The paper's primary findings were that SRI funds and conventional funds did not differ in terms of characteristics of assets held, level of portfolio diversification and effects of diversification on investment performance. Chong, Her and Phillips (2006) approached the issue at hand somewhat antithetically by examining the risk and performance of the Vice Fund, which invests primarily in defence, alcohol, tobacco and gambling. The fund was found to be highly correlated with the S&P500 which suggests that its benefit in terms of portfolio diversification was limited. However, based on a robust measure of the Sharpe ratio, it was shown that the fund could enhance a portfolio's risk-reward characteristics. Basically, the results indicate that there is benefit in investing in "sin" although not in terms of improving portfolio diversification.

To the best of our knowledge, focused deliberation of the diversification perspective with empirical substantiation applied to Islamic portfolios is thus far limited to the work by Kamil, Bacha and Masih (2012). The authors argue that while there is some evidence that Islamic portfolios are at a disadvantage diversification-wise when analysis is conducted at sector level, the results also show that such a generalization cannot be made at the stock-specific level. Hence there is room for investors to manage their portfolios to mitigate any foregone diversification opportunities. It was demonstrated that conditional correlations are indeed time-varying and varies from stock to stock. Informed and perceptive portfolio management can thus add value. A portfolio allocation switching strategy should consider, among other things, market sentiment (bull/bear trends) and commodity prices. This empirical effort however has the limitation of addressing only the risk dimension of equity investment performance, which our present endeavour intends to improve upon.

Finally, we briefly review the previous use of the empirical methods that we will be employing in our paper. The construction of efficient frontiers to analytically compare portfolios is certainly not a novel approach. Sazali, Ariff, Annuar and Shamsher (2004) used them to investigate international equity portfolio diversification gains from a Malaysian perspective. Previously mentioned Al-Shakfa and Lypny (2011) opted to rely on efficient frontiers to compare secular and Islamic portfolios. It was argued that the method effectively sidesteps the potentially confounding effects of differing levels of fund manager competence as well as dependence on asset pricing assumptions. Derigs and Marzban (2009)'s approach in constructing Shari'ah-compliant efficient frontiers is akin to ours – first computing two extreme efficient portfolios (maximal return and minimal risk) and subsequently approximating the frontier via equidistant return values between these two extremes. They also applied arbitrary limits to asset weights to make the models practical, as we do. Their model also specifies a limit to number of assets in the portfolio, not necessary in our case as we work with a small number of sector "assets" instead of individual stocks.

Chiou (2009) used maximum Sharpe ratios within the context of international portfolio diversification to evidence some gains to U.S. investors' cross-border equity investments even after accounting for various portfolio constraints. Martellini (2008) constructed portfolios on the basis of maximum Sharpe ratios to make a case for an alternative design of an equity market index or benchmark. This is in response to growing scrutiny of the inadequacies of the currently popular market-capitalization weighting schemes for index construction.

MGARCH-DCC was the method employed in the paper that is most closely related to this present endeavour, Kamil *et al.* (2012). MGARCH-DCC allows us to relax the improbable assumption of constant correlations and observe the time-varying nature of correlations. The earlier discussed Chong *et al.* (2006) also used a similar GARCH model. Tularam, Roca and Wong (2010) used dynamic conditional correlations to establish their findings pertaining to gains of international portfolio diversification for Australian investors. While analysis of covariance (ANCOVA) is widely used in many disciplines including finance, its specific use to discern comparative diversification effects between portfolios is somewhat uncommon. One instance of its use however is in Bello (2005).

In summary, while there is no obvious dearth in literature comparing ethically-screened funds with mainstream funds, and to a lesser extent, research comparing Islamic portfolios with non-Islamic ones, enquiries into the specific aspect of diversification in making these comparisons are still in short supply. This is particularly the case for Islamic equities. The idea that Islamic portfolios may be less diversified than a non-constrained portfolio is often mentioned in published works, but empirical substantiation of such a contention in current available literature leaves much to be desired. This is the research gap that we seek to address. In terms of methodology, our chosen techniques have been used by others in similar contexts in the past. In this endeavour however we apply multiple methods to improve robustness.

## 4. METHODOLOGY

We employ four distinct but interrelated quantitative methods to produce empirical evidence to address our two research objectives, namely construction of efficient frontiers, analysis of time-varying maximum Sharpe ratio, dynamic correlation coefficients (DCC) in a multivariate generalized autoregressive conditional heteroscedastic (MGARCH) framework, and computing residual variances and subsequent analysis of covariance (ANCOVA).

### 4.1 Efficient Frontiers

We begin our empirical analysis by making an Islamic versus conventional comparison of efficient frontiers. From collected returns and volatility data, we construct a number of efficient

frontier portfolios, as per the Markowitz mean-variance model. In many cases, we expect that a graphical representation of the constructed efficient frontiers would indicate revealing findings. Specifically, if one efficient frontier is clearly more "north-west" than another, it would be simple to conclude that the former is superior. The efficient frontier is plotted with expected return on the y-axis and standard deviation (volatility) on the x-axis. Thus, if a frontier is "north-west" in relation to another, this indicates that the former has higher returns for a given level of volatility or lower volatility for a given level of return.

Relating this empirical approach to our research objective, if it is evident that conventional efficient frontiers are "north-west" of Islamic frontiers, this can be taken as ***tentative*** evidence of the relative superiority of conventional portfolios, and ***possibly*** attributable to the fact that Islamic portfolios are less diversified. At this juncture, it is important to note that here we are working with **hypothetical** risk-return outcomes. Efficient frontiers represent the best-possible result an investor could achieve given a particular investment universe. Notation 1 in the Appendices briefly describes our portfolio optimization method.

To introduce some robustness into our empirical investigation, as well as to expand the dimensions of analysis, we constructed a set of efficient portfolios by varying the following parameters – source of returns and volatility data, data frequency, period of estimation, and differing portfolio assumptions/scenarios.

**Source of data**

In constructing the efficient frontiers, to make computational loads more manageable, we work with "sectors" instead of individual stocks. It is substantially more cumbersome to compute an efficient portfolio from a potential investable set of over 800 stocks compared to a set of 20-odd sectors. We opted for two sources of asset returns and volatility data to construct the efficient frontiers – Dow Jones indices and a self-constructed set of indices.

From the Dow Jones stable of indices, 23 sector indices were selected of which 16 are deemed as Shari'ah-compliant and 7 are designated as non-Shari'ah compliant (see Table A1 in the Appendices). Dow Jones indices were chosen primarily because of convenience and their objectivity (data are readily and publicly available). However, the manner in which these indices were constructed (that is, operative criteria for inclusion of a particular stock into a given sector) may not be completely in congruence with the purposes of our study. Our objective here is to have a set of asset returns and volatility; some to represent Shari'ah-compliant stocks and some to represent non-Shari'ah compliant firms. Islamic efficient portfolios are constructed by including only the former while conventional efficient portfolios will feature both categories. The issue is that with these Dow Jones indices, the sectors do not fit perfectly into our required dichotomy of Shari'ah-compliant and non-Shari'ah compliant. It is not difficult to see why. While there are some clear-cut cases such as the brewery, gambling and tobacco sectors, which are unconditionally non-Shari'ah compliant, there are other sectors that are less categorical. There are some sectors which we have assumed to be non-Shari'ah compliant but include Shari'ah compliant companies[2]. Similarly, some firms included in the designated Shari'ah compliant sectors may not be Shari'ah compliant[3]. In addition, relying on Dow Jones' indices in this manner disregards the financial ratio criteria aspect of Shari'ah stock screening.

While we do not believe that these aforementioned "exceptions" are substantial in numbers and effect so as to render the selected Dow Jones indices inappropriate for our analysis, we do consider it as grounds to opt for an alternative source of data. To get more precise categorization of Shari'ah and non-Shari'ah compliant sectors, we constructed our own set of

[2] For instance, there is at least one bank and one "insurance" firm that are in fact Shari'ah-compliant firms (BIMB and Syarikat Takaful Malaysia, respectively).

[3] For example, there are a number of real estate companies that have not been given Shari'ah compliant status.

indices. We obtained returns data for 814 Main Board stocks on Bursa Malaysia. Using Industry Classification Benchmark (ICB) industry and sector classifications, and cross-referencing against Shari'ah compliance status as issued by the Shari'ah Advisory Council of Securities Commission of Malaysia, we computed our own set of indices, listed in Table A2 of the Appendices. A total of 18 indices are computed, 10 of which are Shari'ah compliant with the remaining non-Shari'ah compliant. Attention was given to ensure each sector is substantial both in terms of number of composition stocks as well as total market capitalization. The indices were constructed on a market capitalization weighted basis with rebalancing done each period.

For both the Dow Jones indices and the self-constructed indices, total returns are used (hence accounting for dividends, bonus issues, share splits, etc.). Efficient frontiers are constructed based on returns from January 1992 to April 2013.

**Data frequency**
Efficient frontiers are initially constructed using monthly returns. Additional frontiers are then constructed using weekly returns for comparison, and to enhance the robustness of findings.

**Period of estimation**
In addition to the constructing of efficient frontiers representing the whole period of analysis (January 1992 to May 2013), we also construct efficient frontiers by sub-periods, isolating two periods of financial crises – the Asian Financial Crisis of 1998 and the more recent (Subprime Mortgage) Global Financial Crisis. Table A3 (in the Appendices) shows the start and end dates for the defined sub-periods.

**Portfolio assumptions/scenarios**
We construct efficient portfolios allowing for short selling as well as when the "no short sales" constraint is applied. This is despite the fact that short selling is limited in availability and practice and rather heavily regulated in Malaysia (at least in recent times). This allows us to analyze the effect that short selling has or would have, in comparing Islamic and conventional portfolios.

In addition, we constructed efficient frontiers wherein we impose minimum weights for each of the non-Shari'ah compliant sectors. The rationale for this is as follows. Strictly-speaking, it is inconceivable that an Islamic efficient frontier can be superior to that of a conventional one. This is because the Islamic portfolio is a subset of the conventional investment universe. Any hypothetical Islamic portfolio can always be labelled as "conventional" even if it does not contain any non-Shari'ah compliant stocks. Put differently, suppose a given Islamic optimal portfolio is located at a superior north-west position, that exact portfolio can also be on the conventional efficient frontier, as by definition, we need not necessarily impose the condition that conventional portfolios must have non-Shari'ah compliant stocks (that is, the result of our portfolio optimization procedure may result in zero weightings for non-Shari'ah compliant sectors). Hence, the Islamic efficient frontier can be equal to the conventional efficient frontier, at best, and never superior. Of course, the Islamic frontier can always be inferior, and this can be taken as evidencing potential deficiencies in diversification of Islamic portfolios.

In an attempt to make the study more insightful, we will construct additional conventional efficient frontiers where we impose minimum weightings for non-Shari'ah compliant sectors. Not only will this not preclude the possibility of the Islamic efficient frontier showing to be superior to that of the conventional frontier, but we also feel that it makes for a more realistic comparison. It is highly unlikely that a conventional portfolio does not contain any non-Shari'ah compliant stocks, especially from the finance sector. Additionally, we believe it makes the analysis more characteristic and purposeful. After all, what makes a portfolio "conventional" as opposed to "Islamic" is the presence of non-Shari'ah compliant sectors.

### 4.2 Time-varying Maximum Sharpe Ratio

One plausible disadvantage of the previous method (of constructing efficient frontiers) is that it is based on aggregated or averaged historical data spanning quite a number of years. It makes the assumption that long-term historical averages are the best predictors of means, variance and co-variances. Some have questioned the efficacy of such a supposition. To address this, we indulge in another method which is similar to the previous one. Inspired by Chiou (2009) and using sector returns and volatility data, we compute optimal portfolios. However, instead of constructing a frontier of portfolios with the highest expected return for a given standard deviation, we identify the optimal portfolio yielding the highest Sharpe ratio. We do this for quarterly intervals spanning our sample period. The objective is to analyze and compare the time-varying characteristics of our chosen measure of return-per-unit-of-volatility applied to an Islamic and a conventional portfolio. Stated simply, we track for each quarter, what is the maximum Sharpe ratio attainable for a hypothetical Islamic portfolio and compare with its conventional counterpart.

The data source is our self-constructed indices obtained from weekly returns of stocks (essentially the same as those used in constructing efficient frontiers with our previous method). We begin with weekly returns by sector (self-constructed). Each quarter, we obtain the average weekly return for each sector. Standard deviation of returns is also computed. A separate variance-covariance matrix is constructed for each quarter (based on weekly returns belonging to that quarter). An average risk-free rate proxy is calculated using weekly data on the Malaysian T-bill Band 4 Mid-rate. Once we have the average quarterly return for each sector, its standard deviations, the variance-covariance matrix and the risk-free rate, we use our optimization tool (Microsoft Excel's Solver) to determine the portfolio allocation weights (percentage by sector) that results in the highest Sharpe ratio. We do this for a total of 85 quarters (Quarter 1, 1992 to Quarter 1, 2013). This enables us to plot a chart that tracks the maximum Sharpe ratio as it varies throughout our sample period. Two sets of maximum Sharpe ratios are computed per chart for comparison – Conventional, where portfolio optimization is based on all available sectors, and Islamic, where our optimization tool only works with Shari'ah compliant sectors.

A total of five portfolio scenarios are produced (and hence five charts showing comparisons of time-varying maximum Sharpe ratio).We begin with two basic scenarios – with short selling allowed and when short selling is not permitted. A third scenario applies a minimum weight of 3% on all sectors (both conventional and Islamic). Apart from the reasons already discussed above, there is another rationale for imposing such a constraint on the portfolios. The framework of Markowitz's mean-variance optimization does not take into account portfolio liquidity. In fashioning realistic diversified portfolios, most if not all fund managers and investors would want a reasonably liquid portfolio. Hence, and more so in the case of the conventional portfolio, it is likely that portfolios would feature large-cap stocks that are arguably more liquid. In a recent count, 14 out of the top 30 stocks by market capitalization are not Shari'ah compliant. The point here is that a conventional portfolio should contain non-Shari'ah compliant stocks/sectors. Imposing minimum weights on all sectors also reduces heavy concentration on single sectors which can make the results biased and atypical of the average investor.

Optimal portfolio construction, while elegant and powerful, has received its share of criticisms, especially when viewed in a practical context. Apart from the additional computational burden, optimal portfolios have a tendency to result in excessive concentration in a limited subset of the full set of securities. Also, it is said that the mean-variance solution is overly sensitive to input parameters. In the marketplace, practitioners prefer simpler, more heuristic solutions. For these reasons, two techniques have grown in popularity and have been labelled as robust alternatives to portfolio optimization. They are the global minimum variance portfolio and the equally-

weighted portfolio (or sometimes called the "1/n" portfolio). Recognizing the place that these two methods have in the minds of the common fund manager and investors, we also compute the minimum variance portfolio and the 1/n portfolio for Islamic and conventional portfolios on a time-varying basis, for subsequent comparative analytics. These two are our fourth and fifth scenarios.

### 4.3 MGARCH-DCC

Our third method focuses on volatility. We seek to examine the nature of correlations between sectors. In particular, if we can establish low correlations between non-Shari'ah compliant sectors and Shari'ah compliant sectors, a case can be made that exclusion of non-Shari'ah compliant stocks from an Islamic portfolio may be depriving it from some additional benefits of diversification. Admittedly, this approach only considers the volatility dimension of the risk-return framework of stock performance analysis. It makes the potentially erroneous assumption that stock returns strictly reflect systematic risk only. To the extent that prices are not efficient in this manner (and there is voluminous empirical literature attesting to violations of the Efficient Market Hypothesis) our observations stemming from this approach may need revisiting and/or refinement.

Notwithstanding this, we feel it is a useful approach towards understanding the characteristics of the Malaysian equity market, in particular how the interplay or correlations between among sectors may have bearing on diversification idiosyncrasies arising when non-Shari'ah compliant sectors are excluded. An advantage of this method is that it allows articulation of correlation behaviour dynamically. Analyzing temporal characteristics of correlations among sectors can provide useful insights in an attempt to minimize loss of diversification benefit borne by Islamic portfolios, should it exist.

For the empirical work here, data that will be used is our self-constructed indices based on weekly returns (the same data set as used before in the previous two methods). We rely on the Multivariate Generalized Autoregressive Conditional Heteroscedastic (MGARCH) model in Pesaran and Pesaran (2009) to compute conditional cross-asset correlations, computed by Microfit as

$$\tilde{\rho}_{ij,t-1}(\phi) = \frac{q_{ij,t-1}}{\sqrt{q_{ii,t-1}q_{jj,t-1}}}$$

Where $q_{ij,t-1}$ are given by

$$q_{ij,t-1} = \bar{\rho}_{ij}(1 - \phi_1 - \phi_2) + \phi_1 q_{ij,t-2} + \phi_2 \tilde{r}_{i,t-1}\tilde{r}_{j,t-1}$$

In the above, $\bar{\rho}_{ij}$ is the $(i,j)$th unconditional correlation, $\phi_1$ and $\phi_2$ are parameters such that $\phi_1 + \phi_2 < 1$, and $\tilde{r}_{i,t-1}$ are the standardized asset returns. For brevity, we omit further details of this model, which can be found in Pesaran and Pesaran (2009).

### 4.4 Residual Variances and ANCOVA

Our three previous methods while useful and capable of producing important insights have two major limitations. Firstly, it makes the assumption that returns strictly incorporate systematic risk only. Despite the fact that the validity of this notion has been questioned by many, it enables us to make risk-return profile comparisons between conventional and Islamic portfolios and some theoretical inferences regarding levels of diversification. The existence of many empirical results attesting supposed violation of the aforementioned assumption makes for a key caveat of the previous three methods. Secondly, in constructing efficient frontiers, calculating maximum Sharpe ratios and examining time-varying correlations, we essentially work with

"theoretical" Islamic and conventional portfolios. It would certainly be a value-add to extend the analysis to "real-life" data of actual Islamic and conventional portfolios. Our last method seeks to address these two shortcomings.

We will be comparing two samples of Malaysian equity mutual funds – one Islamic and the other conventional. We limit these samples to strictly Malaysian equity funds (including small and midcap funds) as defined by Lipper Malaysia. Hence, funds investing substantially outside of Malaysia, bond funds, money market funds, balanced funds (combination of bond and equity), capital protected/guaranteed funds, and funds investing in other asset classes such as commodities and real estate, including mixed asset funds, are all excluded from our samples. After taking into account availability of data, we are left with 50 Islamic funds and 78 conventional funds. We work with weekly total returns to increase the number of data points in our already relatively small sample. In order to gauge investment performance, we construct our own broad-based market index which will serve as proxy for market return. The index covers all stocks (with available data) listed in the Main Board of Bursa Malaysia, is weighted by market capitalization, and is recomputed every period (weekly). We resort to our own index construction (at least for the case of Islamic funds) because the FTSE Bursa Malaysia Shari'ah Index was only introduced in December 2006 and to the best of our knowledge, there is no other publicly-available index with earlier historical data to represent Shari'ah compliant stocks. We felt that a longer estimation period was necessary. We did the same for conventional stocks for the sake of consistency. As an alternative market benchmark for conventional funds, we use the Kuala Lumpur Composite Index (KLCI), the bellwether index for the Malaysian stock market. The proxy for the risk-free rate will be the Malaysian T-bill Band 4 mid-rate.

From Jensen's alpha, portfolio return can be given as:

$$r_p = \alpha_p + \beta_p . r_m + \varepsilon_p$$

Hence the total variance of a portfolio comprises two components – a market-related component and a fund-specific one:

$$\sigma_p^2 = \beta_p^2 . \sigma_m^2 + \frac{1}{n} \sigma_{\varepsilon_p}^2$$

We can then normalize total variance to arrive at a measure of residual variance:

$$RV = 1 - \frac{\beta_p^2 . \sigma_m^2}{\sigma_p^2}$$

This measure of residual variance can be said to represent unsystematic risk. By comparing Z-scores for the Islamic and conventional samples in a Wilcoxon two-sample rank-sum test, we can identify if the residual variances between the two are statistically different. In other words, we obtain statistical evidence to answer the question – do Islamic funds have higher unsystematic risk compared to conventional funds (and hence are presumably less diversified)?

Even if evidence is found that Islamic funds are less diversified, a central question remains unanswered – how does this (difference in residual variance) affect overall risk-adjusted performance? Some yardsticks for investment performance are required. Apart from Jensen's alpha, we will rely on four additional measures: the standard Sharpe and Treynor ratios, Sharpe's information ratio (Reilly and Norton, 2003) and a third measure suggested by Statman (2000) called eSDAR.

Sharpe information ratio: $S_p = \frac{\bar{D}}{\sigma_D}$

$D_t$ is the difference in return between the portfolio and the benchmark in period $t$, $\overline{D}$ is the average value of monthly differences in return between the benchmark and portfolio, and $\sigma_D$ is the standard deviation of that differential return.

eSDAR: $$eSDAR = r_f + \left(\frac{r_p - r_f}{S_p}\right) . S_m - r_m$$

$r_f$ is risk-free rate proxy, $r_p$ is portfolio return, $r_m$ is benchmark return, $S_p$ is standard deviation of portfolio return and $S_m$ is standard deviation of benchmark portfolio return. Basically eSDAR represents the excess return of a portfolio over a given benchmark with the portfolio being adjusted to have that benchmark's standard deviation.

We then adopt the model in Bello (2005) to test whether differences in investment performance (as measured by our five measures above) are attributable to differences in residual variance. Through analysis of covariance, we investigate the differential impact of residual variance on investment performance with the following model:

$$y = \omega_0 + \omega_1 x_1 + \omega_2 x_2 + \omega_3 x_1 x_2 + \varepsilon$$

$y$ is the investment performance of portfolio, $x_1$ is the residual variance (the covariate in our model) and $x_2$ represents the "group" with assigned value of 0 for Islamic funds and 1 for conventional funds. Applying the assigned values for group gives up expected values for investment performance as follows:

[For Conventional funds] $$E(y) = (\omega_0 + \omega_2) + (\omega_1 + \omega_3) x_1$$
[For Islamic funds] $$E(y) = \omega_0 + \omega_1 x_1$$

Differences in investment performance between Islamic and conventional funds can come from potentially two sources:

i. The fact that the two funds have (potentially) different residual variances (that is, levels of diversification), and/or,
ii. Actual differences in investment performance not related to quantum of diversification.

By testing the hypothesis $H_0 : \omega_3 = 0$, we can ascertain if there is a statistically significant difference in slopes between Islamic and conventional funds. The difference in slope can be interpreted as the difference in the effect that residual variance has on investment performance as a function of group (whether Islamic or conventional). Seen in another way, the interaction term $x_1x_2$ indicates the difference in the relation between residual variance and investment performance as a function of group. We envisage that the above statistical procedures can provide some evidence as to extent that differences in levels of diversification (if it exists) have impacted investment performance.

After accounting for the effects of residual variance on investment performance, we can test the hypothesis $H_0 : \omega_2 = 0$, to see if differences in investment performance originate from the second source, although this would only be an auxiliary finding. We can also test the hypothesis $H_0 : \omega_1 = 0$ to discover whether investment performance is related to levels of diversification (as measured by residual variance) in the case of Islamic funds.

To be clear, with analysis of covariance what we essentially will be doing is computing the five investment performance measures and the residual variances for each of the fund in our two sets of samples. Once the fund averages are obtained we perform a cross-section regression where the given investment performance measure is the dependent variable, and residual variance as well as a binary variable (to denote whether it is an Islamic or conventional fund) are the explanatory variables.

# 5. EMPIRICAL RESULTS AND INTERPRETATIONS

## 5.1 Efficient Frontiers

### 5.1.1 Base Case – Dow Jones Indices – Monthly – Entire Period

We start off with the base case of relying on monthly returns of selected Dow Jones indices spanning the entire sample period. Figure 1 shows the resulting efficient frontiers. When short selling is permitted, conventional portfolios are clearly superior. Upon imposing the no short selling rule, this advantage diminishes, with the two efficient frontiers overlapping for the most part (see Panel B of Figure 1). However, the conventional efficient frontier appears to offer additional lower volatility efficient portfolio options to the investor. Upon closer analysis of sector weights (not reported here), this lower range of volatility comes primarily from the broadcast and entertainment, tobacco and brewery sectors.

Our results suggest that short selling ***amplifies*** risk-return profile differences between conventional and Islamic portfolios. Alcohol and tobacco are often seen as recession-proof businesses evidenced by low volatility and correlations with other sectors. Investors seeking the extreme end of low volatility can overweight on these sectors and go short on higher-volatility sectors.

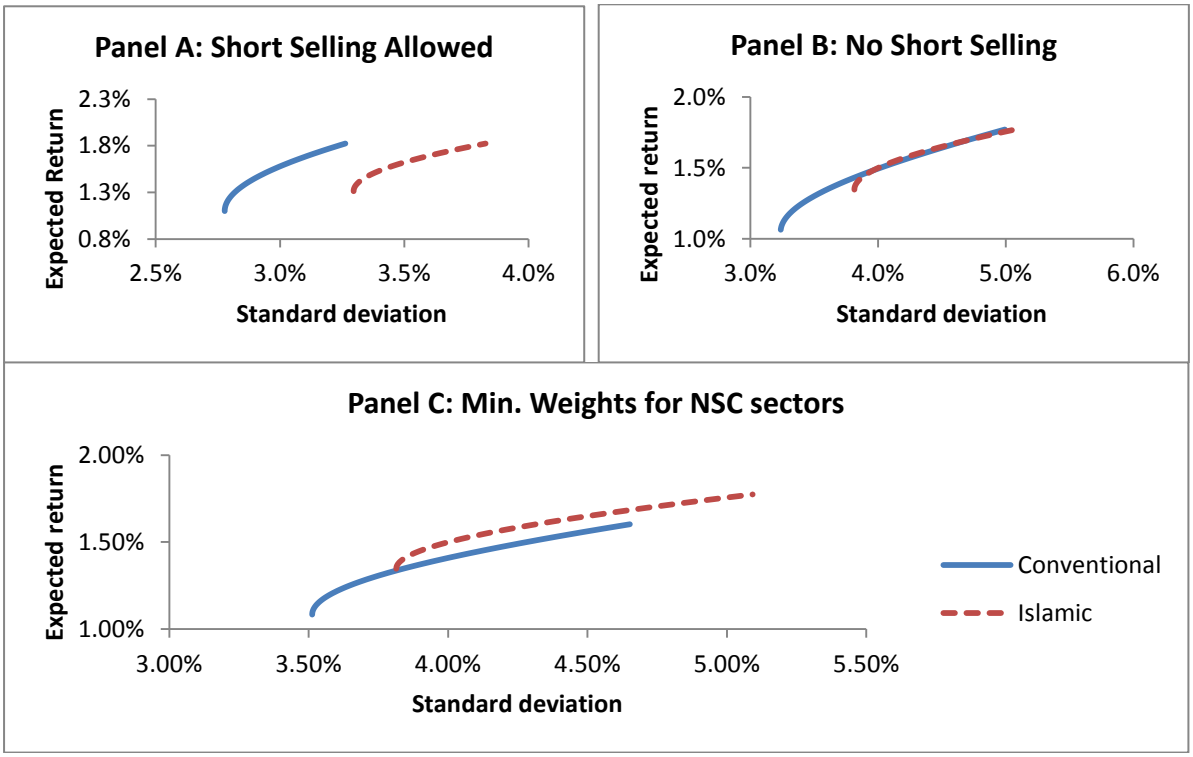
In Panel C of Figure 1, we illustrate the resulting efficient frontiers when we impose the constraint that each of the non-Shari'ah compliant sectors must have a minimum weight of 3%[4]. The choice of the 3% weight is arbitrary. We do not see this as an issue as the intent here is to arrive at some general exploratory observations rather than conclusive assertions. As alluded to earlier, the purpose of constructing this scenario is to discover how the efficient frontiers would look like if we require the conventional portfolio to make mandatory minimum allocations in all of its (non-Shari'ah compliant) component sectors. That is, we seek to construct an efficient frontier that is more characteristically "conventional". Of course, there are numerous ways we can achieve this and the one used here (minimum 3% weight on all non-Shari'ah compliant sectors) is only one out of a possible many. We acknowledge that the efficacy of observations stemming from this approach depends on the appropriateness of our stipulated portfolio constraint. Thus, our interpretations are exploratory at best.

Interestingly, when this additional constraint is applied, we observe that the Islamic portfolio sits north-west of the conventional portfolio, albeit the conventional portfolio (again) offering lower volatility efficient portfolio options not available to the Islamic portfolio. From this we can assume that some non-Shari'ah compliant sectors are "less efficient" in terms of returns per unit of volatility. Forcing a portfolio to allocate some weight to these sectors will understandably produce an inferior efficient frontier.

At this juncture, we can make some initial observations. If efficient frontiers can be taken to indicate the extent to which Islamic portfolios are at a diversification disadvantage compared to conventional portfolios, there is only very limited evidence of that, so far. Such a handicap certainly does not seem evident when conventional portfolios are made to invest in all non-Shari'ah compliant sectors available. Nonetheless, we see that when short selling is permitted, Islamic portfolios are at the short-end of the diversification stick.

[4] Note that axis starting values for many of the charts are varied (does not begin at zero) to make the figures more compact and space-saving.

**Figure 1**
**Efficient Frontiers – Dow Jones Indices – Monthly – Entire Period**




### 5.1.2 Efficient Frontiers by Sub-Periods

Next we construct efficient frontiers by defined sub-periods, in particular to isolate two periods of financial crises – the Asian Financial Crisis (AFC) of 1998/99 and the recent Global Financial Crisis (GFC). For brevity, we illustrate the resulting efficient frontiers in the Appendices (see Figures A1 through A5). We observe that under the allowed short selling scenario, in all sub-periods, the conventional efficient frontier is superior to that of the Islamic one. Moreover, this appears to be more pronounced during both crisis periods. This is consistent with our earlier observation. Short selling exacerbates risk-return differences between the two portfolios, and more so the case during period of market crisis when asset volatilities are heightened.

Next, under the no short selling scenario, during the Asian Financial Crisis, the conventional efficient frontier appears clearly north-west of the Islamic frontier. During a time when all Islamic efficient portfolios are in negative expected return territory, we find a significant portion of conventional efficient portfolios still registering positive returns. Upon closer analysis, we attribute this primarily to the tobacco sector, which appeared to be particularly resilient in that otherwise turbulent time. Due to the nature of the construction of our efficient portfolios, asset allocation can be heavily concentrated to a single sector. So, one clear "winning" sector (in this case the tobacco sector) can prop up the results for the entire portfolio. This becomes obvious when we look at the scenario wherein we force minimum weights for non-Shari'ah compliant sectors (Panel C of Figure A2). The advantage that the conventional portfolio had was constrained and this resulted in the frontier dropping to negative return territory in its entirety. Nonetheless, the conventional efficient portfolio is still superior to that of the Islamic one.

At a quick glance, this finding appears to be at odds with some of the available studies comparing the performance of Islamic portfolios with conventional ones. Empirical evidences have been offered to suggest that Islamic portfolios tend to fare better when markets are down

while the opposite is true during market bullish trends. We reconcile such findings with our above observation (that during the Asian Financial Crisis, conventional efficient frontiers are superior to Islamic ones) with the following reasoning. With efficient frontiers, we construct a set of **hypothetical** portfolios. That is, with the benefit of hindsight (exact asset returns, volatilities and correlations), we specifically determine the best possible set of portfolios (highest return for a given measure of volatility or lowest volatility for a given level of return). In reality, it is plausible to assume that most investors' portfolios would fall short of such "ideal" portfolios. In contrast, many empirical studies rely on **actual** portfolios (for example, real-world mutual funds). Hence, although conventional portfolios have the ***potential*** to outperform Islamic portfolios during times of crisis, it turned out (as the aforementioned empirical studies have found) that ***real*** conventional portfolios have failed to do this. In the case of the Asian Financial Crisis, our efficient frontiers prescribed heavy weightings on the tobacco sector, which many conventional mutual funds may not have done at the time; choosing instead to focus on more "exciting" sectors like finance and real estate. We believe this perspective helps to make sense of our results in light of existing related empirical literature.

During the Global Financial Crisis, the resulting efficient frontiers are somewhat similar to the Asian Financial Crisis. In all three scenarios, conventional frontiers dominate Islamic ones, for the most part. Closer scrutiny reveals that again this is due to the tobacco sector. Just as the case with the AFC, when short selling is disallowed, the gap between frontiers narrows and narrows further when we require the conventional portfolio to have minimum weights in all non-Shari'ah compliant sectors. Comparing these two crisis periods, the difference between conventional and Islamic is less pronounced in the latter. We attribute this to the belief that the Asian Financial Crisis of 1997/98 had a relatively more substantial impact on the Malaysian equity market than the more recent Global Financial Crisis. In the case of the former, Malaysia was very much at the epicentre of the financial turmoil while mostly a victim of contagion in financial markets in the case of the latter.

Looking at the two periods before our defined crisis periods (see Figures A1 and A3), we find the resulting efficient frontiers to be similar to those constructed for the entire analysis period. This should not come as a surprise as the entire-period frontiers represent accumulation of returns and volatility data, and in terms of relative length of time, these two pre-crisis periods are the longest (and hence contribute the most in terms of number of data points). Interestingly, under the no short selling scenario, the conventional and Islamic efficient frontiers are identical. This implies that the Islamic efficient frontier ***is*** the conventional efficient frontier. Put differently, the conventional efficient frontier is made up of only Shari'ah compliant sectors. The tobacco sector, which was the "saviour" for conventional portfolios during crisis periods, did not outdo Shari'ah compliant sectors during non-crisis times, in terms of returns relative to volatility. When conventional portfolios are forced to have minimum weights on all non-Shari'ah compliant sectors, Islamic frontiers emerge more north-west.

Finally, in the period after the Global Financial Crisis, we observe conventional frontiers appearing superior in all scenarios. This can be accounted for by exceptional performance in non-Shari'ah compliant sectors like breweries and insurance. This is probably due to the fact that these sectors were the hardest hit during the crisis and their pricing corrections when markets returned to exuberance made the biggest impact.

### 5.1.3 Different Data Frequency

In an attempt to improve the rigour of our analysis, we investigated if the efficient frontiers would be different if we changed the frequency of our data. Working with weekly returns, we show that the results are substantially similar (compare Figure 1 above with Figure A6 in the Appendices).

### 5.1.4 Self-constructed Indices

In the final set of efficient frontiers, we investigate the comparison between conventional and Islamic portfolios using our own self-constructed indices[5]. See Figure A7 in the Appendices. The results do not differ much from previous constructed frontiers. With short selling, the conventional efficient frontier dominates but when short sales are disallowed, the gap disappears and both Islamic and conventional efficient frontiers are almost identical.

As for requiring conventional portfolios to have minimum weights, we added two additional scenarios to give a total of three:

i. Minimum 3% weight on all non-Shari'ah compliant sectors
ii. Minimum 40% weight for total of all non-Shari'ah compliant sectors
iii. Minimum 3% weight on ***all*** sectors (Shari'ah compliant sectors as well)

Resulting efficient frontiers for the above three scenarios are similar. Conventional and Islamic frontiers criss-cross and intersect at some point. Below that point of intersection, that is, at the lower end of volatility, the conventional frontier is superior while the reverse is true for risk/return combinations above the point of intersection (higher volatilities). Such a finding is again consistent with previous observations. Owing to sectors like tobacco and gambling which exhibit relatively lower volatility and correlations, at the lower spectrum of standard deviation of returns, the conventional frontier dominates. At higher levels of volatility, the Islamic frontier gets the upper hand due to sectors like oil and gas coupled with the fact that the conventional portfolio is constrained to have minimum weights.

### 5.1.5 Summary of Observations for Efficient Frontiers and Some Caveats

The following are some key takeaways from our analysis of efficient frontiers:

i. Short selling magnifies the risk-return differences between conventional and Islamic portfolios, culminating in conventional efficient frontiers clearly dominating Islamic ones.
ii. With the possibility of short selling removed, in most cases, Islamic and conventional efficient frontiers are substantially similar, implying that Islamic portfolios may not have a diversification disadvantage compared to conventional portfolios.
iii. When conventional portfolios are constrained to have minimum weights in all non-Shari'ah compliant sectors, Islamic efficient frontiers, for the most part, are positioned north-west of conventional frontiers.
iv. Periods of crisis seem to favour conventional portfolios, at least hypothetically and in part due to heavy concentration on single low-volatility, low correlations sectors (in particular, the tobacco sector).

We believe our analysis of efficient frontiers is robust to a certain extent, as we have varied portfolio assumptions, data frequency and data source, and conducted analysis by sub-periods. Nonetheless, we recognize some limitations and briefly discuss them here. Firstly, we reiterate the point that efficient frontiers represent hypothetical portfolios. It is unlikely that real-world investment portfolios are able to replicate fully optimal portfolios. However, it does not imply that our findings are purely academic. The idea here is not to find conclusive statistical evidence of the superiority of one category of portfolio over another. Rather, we seek to demonstrate that in the final analysis, there is inadequate evidence to lay claim that Islamic portfolios will ***necessarily*** be at a disadvantage in terms of portfolio diversification. Investors of Shari'ah compliant equities can take some comfort that the investment playing field is still somewhat level. In addition, we attempt to introduce some realism in our analysis by incorporating the scenario wherein conventional portfolios are required to have minimum weights assigned to

[5] See Section 4.1 above for a description of how the indices are constructed and the rationale for their construction.

non-Shari'ah compliant sectors. This would, to some extent, reduce disproportionately high concentration of allocation to a particular sector, which is arguably uncommon for the common investor. Also, it makes the constructed conventional portfolio more characteristically "conventional".

Secondly, in order to associate the relative position of efficient frontiers with the extent of portfolio diversification, we have to make the strong assumption that returns are efficiently priced by systematic risks only. There is argument (and some backed by empirical results) that markets do price-in unsystematic risks. Hence the conclusions of our analysis here are appropriate only to the extent that the market does not compensate idiosyncratic risks to a statistically significant degree.

Thirdly, close inspection of our constructed efficient frontiers reveals that some of them are not as curvilinear as theory would suggest. Having an efficient frontier that is closer to a straight line than a curve could infer lack of prevailing risk aversion. The established theory is that market players are generally risk averse. Thus, as volatility of returns increases, the required expected return also increases but not in a linear fashion. The risk-avoiding investor would rationally demand a higher expected return (than a strictly linear relationship would dictate) to compensate for increasing uncertainty. This would produce a curvilinear relationship between expected return and standard deviation of returns, and graphically represented by the well-known hyperbola of the theoretical Markowitz efficient frontier. A more linear efficient frontier would suggest that investors were more risk-neutral.

We do not challenge this established assumption of risk aversion. Instead, we attribute the observed "linearity" of some of our efficient frontiers to shortcomings of our employed optimization tool/model (discussed further below). Also, the idea of a nicely curved efficient frontier emanates from the Markowitz theorem which comes with a set of assumptions. Some of these assumptions may not apply to our dataset. Over the years, assumptions of the Modern Portfolio Theory framework have been subjected to criticism. To maintain brevity and focus, we avoid detailed deliberation of these; suffice to make mention of but a few – normality of asset return distribution, information symmetry, price-taking investors and constant asset correlations.

Finally, our optimization model is only one out of a possible few. There are other techniques available (quadratic programming, meta-heuristic methods, to name a few) and may produce different results. Our measure of risk, standard deviation, is probably not as robust as other available measures. Also, our approach to portfolio optimization is relatively simplistic. We refrained from more sophisticated methods like optimization by individual stocks (instead of sectors) and two-step procedures (optimize by sector and then by individual stocks) to make the study more manageable. We do not account for specific market regulations, tax and transaction costs.

### 5.2 Time-varying Maximum Sharpe Ratio

Figure 2 illustrates the time-varying nature of the computed maximum Sharpe ratios for both conventional and Islamic portfolios spanning our analysis period[6]. It is clear that short selling ***consistently*** favours the conventional portfolio. In almost all quarters, the conventional

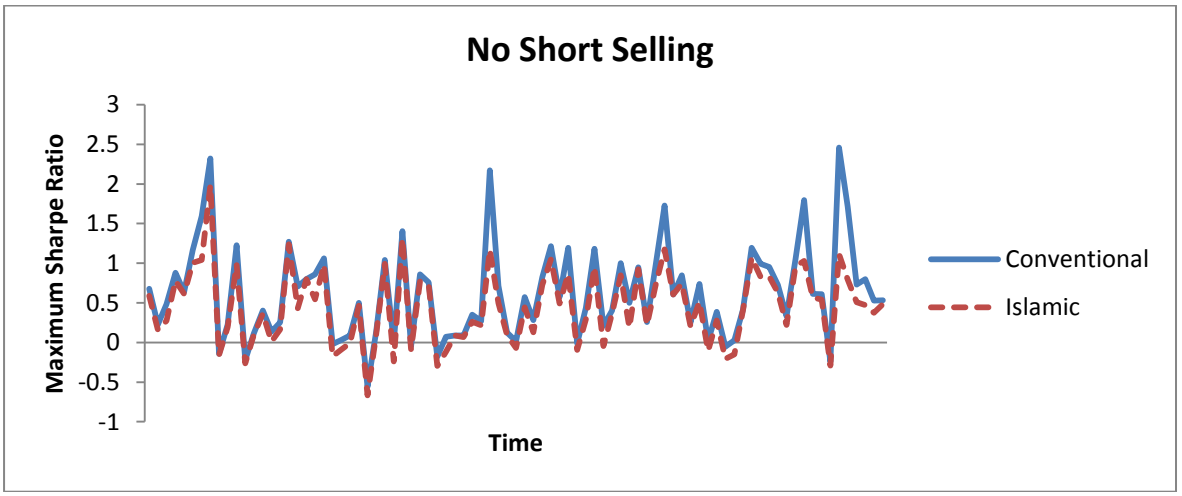
[6] In computing maximum Sharpe ratios, it is necessary for us to set limits for weights per sector. This is especially for the case where we allow for short selling. Else, our optimization tool will not be able to determine a solution. The optimization program will continue to sell short on lesser performing sectors while overweighting on better ones. This will continue indefinitely and hence no final solution would be found. We arbitrarily fix the bounds of sector weights to +/- 30%.

maximum Sharpe ratio is higher than the Islamic one. This finding reinforces our earlier empirical results with efficient frontiers.

**Figure 2**
**Time-varying maximum Sharpe ratio – with short selling**


In the no short selling scenario, we limit (maximum) sector weights to 30%. This would moderate resulting Sharpe ratios and make them more realistic. Just as with efficient frontiers, when short selling is disallowed, the gap of maximum Sharpe ratio (MSR) between conventional and Islamic tightens noticeably (see Figure 3). Still, there are periods when the conventional maximum Sharpe ratio is higher than the Islamic one. Islamic MSRs never exceed conventional ones[7]. This is to be expected as any Islamic portfolio composition, by definition, can always be labelled as a conventional portfolio as well.

**Figure 3**
**Time-varying maximum Sharpe ratio – no short selling**



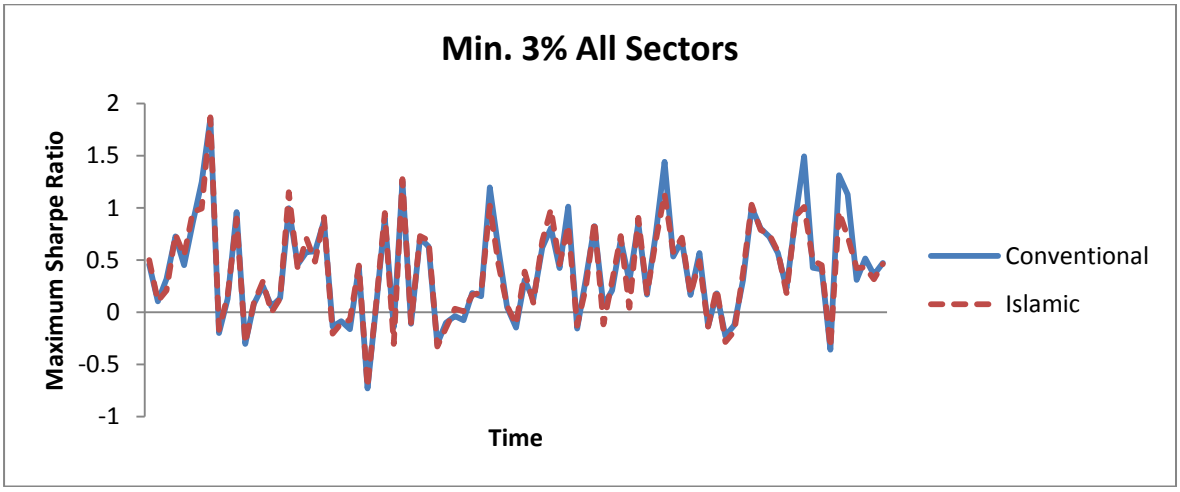

Our results get more insightful when we look at the scenario where we impose the constraint that there should be a minimum of 3% weight on all sectors across the board[8]. As can be seen in Figure 4, the plots of the two sets of MSRs closely track one another, for the most part. In most

[7] To be clear, the Sharpe ratio measures return (more specifically excess return or risk premium) per unit of risk (defined as standard deviation of observations). Hence MSR represents the highest attainable (albeit hypothetical) reward-to-volatility ratio.
[8] We also impose a maximum weight of 30% per sector.

instances, the maximum Sharpe ratios for conventional and Islamic are similar if not identical. There are quarters when conventional MSRs exceed Islamic ones but there are also times when the opposite occurs (Islamic MSRs are higher).

We posit that this scenario is typical for the common investor. A diversified portfolio is likely to make investments across the breadth of available broad sectors. Thus, we find some tentative evidence to dispel the notion that Islamic portfolios will always have to tolerate a diversification disadvantage. It may happen at certain points in time but our results show that it does not necessarily occur all the time. In fact, there are times when Islamic portfolios fare better.

**Figure 4**
**Time-varying maximum Sharpe ratio – minimum 3% weight on all sectors**




The chart in Figure 5 tracks the MSRs for an investor whose investment approach is to hold the global minimum variance portfolio[9]. Although only a hypothetical portfolio, many investors and mutual funds adopt such an investment stance in practice. More risk-averse investors and funds seeking capital preservation may opt for less volatile or "safer" equity investments. In this regard, we find some degree of divergence in maximum Sharpe ratios between conventional and Islamic portfolios. We note a number of occasions when conventional MSRs exceed Islamic MSRs, although there are limited instances when the reverse is also true.

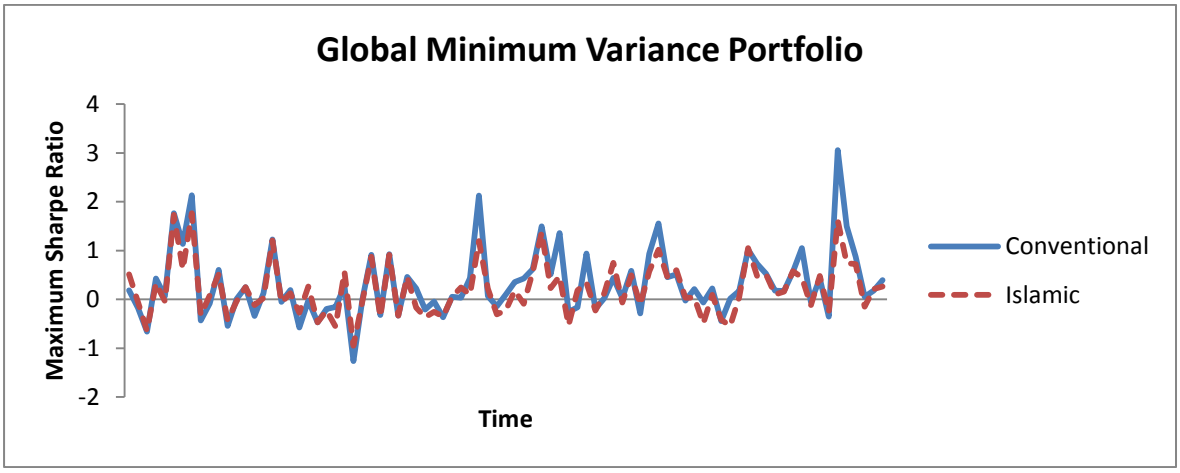
Since we are dealing with portfolios comprising low volatility constituents, it is appropriate to bring in the idea of a "low-volatility anomaly", reported in some published empirical works. Some research has shown that portfolios made up of low-volatility stocks produce higher risk-adjusted returns compared to portfolios invested in high-volatility stocks. This observation is considered anomalous because it contradicts risk-return prescriptions of the Capital Asset Pricing Model (CAPM). Examples of research dwelling on this apparent anomaly include Haugen and Baker (1991), Clarke, de Silva and Thorley (2006) and Baker, Bradley and Wurgler (2011).

In our earlier discussion of efficient frontiers we found some non-Shari'ah compliant sectors (most notably the tobacco sector) showing low volatility and superior risk-adjusted returns. We believe this to be, to some extent, the aforementioned low-volatility anomaly which helps to explain higher conventional MSRs in our global minimum variance portfolio. In other words, investors seeking a low-variability option in their equity investments ***may*** find it advantageous

[9] Short selling is disallowed here and we do not impose any other minimum or maximum weight constraints.

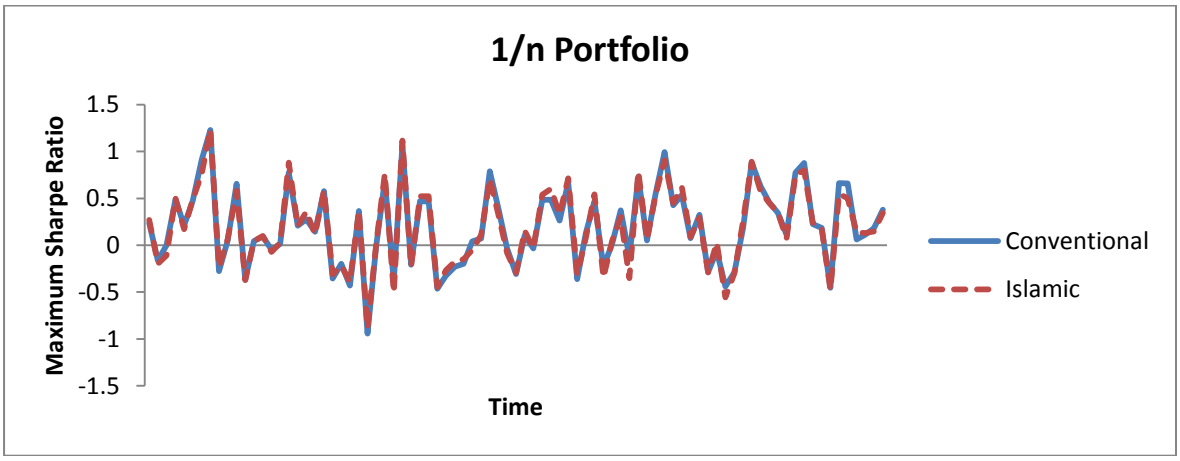
to invest in conventional stocks, as opposed to sticking with Shari'ah compliant equities only[10]. Incidentally, this contended anomaly also explains why conventional efficient frontiers at the lower spectrum of volatility tend to outperform Islamic efficient frontiers.

**Figure 5**
**Time-varying maximum Sharpe ratio – global minimum variance portfolio**




Finally, we examine the scenario for the equally-weighted or "1/n" portfolio. Figure 6 illustrates that conventional and Islamic portfolios are almost indistinguishable. Very little separates the MSRs of these two portfolios when sector weights are made equal. Any anomalies (such as the low-volatility anomaly) will have minimal effect as we spread portfolio allocation evenly across sectors. More importantly, our finding here offers further evidence that Islamic investors are not necessarily disadvantaged, particularly if they adopt an equally-weighted portfolio strategy.

**Figure 6**
**Time-varying maximum Sharpe ratio – 1/n portfolio**




Another observation worth noting is the fact that, for all our scenarios except the short selling one, during periods of crisis (especially the Asian Financial Crisis period of 1997/98) the maximum Sharpe ratios of both conventional and Islamic portfolios were very similar. During a market crisis, correlations in stock price movements are expected to increase significantly and this diminishes benefits of diversification. Hence, when a crisis occurs, neither conventional nor

[10] However, we caution here that the outcome of such a strategy may stem primarily from investment in a few (tobacco) stocks with particularly low levels of volatility. To the extent that investors may be reluctant to overweight on these stocks, for whatever reasons, such an outcome may not materialize.

Islamic investors can argue they are better off, in terms of diversification, at least from a maximum Sharpe ratio perspective.

As a final note here, we reiterate a caveat mentioned earlier. Computation of maximum Sharpe ratios is similar to construction of efficient frontiers in that we perform portfolio optimization and determine hypothetical best-case results. Previously discussed issues with this approach are similarly applicable here. Further, equity investment is a forward looking activity, and thus expected return, risk levels and correlations are unobservable and must be forecasted. While historical data can provide insights, they are no guarantees of future prospects. The portfolio optimization framework incorporates this to a certain extent by assuming that the investor has some degree of risk aversion. The investor requires additional compensation to factor in the possibility that stock prices may exhibit significant differences between their historical or forecast values and what is experienced.

### 5.3 MGARCH-DCC

We now look at the empirical results under our third method[11]. Table A4 in the Appendices shows the descriptive statistics of conditional **volatilities**. To be clear, we are dealing with time-varying volatilities here and the summary statistics show the average results and distribution of those time-varying volatilities[12]. In this regard, looking at means alone may not tell the whole story. Observing standard deviations, minimum and maximum values of volatilities as well as the range (defined as maximum minus minimum) can provide additional insights. Similarly, we compute skewness and kurtosis. Based on these parameters, we can argue that banks and financial firms are the most volatile. While their means and standard deviations are not noticeably higher than other sectors, their range of values are tellingly high, stemming from markedly higher maximum values. Such numbers confirm the observed scenario in Malaysian equities. During brief periods of heightened market exuberance, finance-related stocks tend to receive more than their "fair share" of overzealous market activity. These periods typically are short-lived and when markets return to "normal", their volatilities may not stand out from the other sectors, hence probably why their volatility averages and standard deviation are not substantially dissimilar to the rest.

[11] For the sake of focus, we only briefly discuss results of some diagnostic testing here. We test for both normal and $t$ distributions, to determine which would model our case more aptly. We compute the maximum likelihood estimates of $\lambda_{i1}$ and $\lambda_{i2}$ for the sector indices returns, and $\delta_1$ and $\delta_2$, comparing multivariate normal distribution with multivariate student $t$-distribution. We note that the asset-specific estimates of the volatility decay parameters are all highly significant. The maximized log-likelihood value for the case of $t$-distribution is larger than that obtained under the normality assumption. In addition, the estimated degree of freedom for the $t$-distribution [5.7291] is well below 30; and any other value one would expect for a multivariate normal distribution. This suggests that the $t$-distribution is more appropriate in capturing the fat-tailed nature of the distribution of index returns (Pesaran and Pesaran, 2009). Henceforth our analysis works with the $t$-distribution estimates. For the most part, the tests indicate validity of our $t$-DCC model. The Lagrange Multiplier (LM) statistic is less than the critical value thus the null hypothesis of correct specification of the $t$-DCC model cannot be rejected. In testing for VaR violations, $\hat{\pi}_N$ is very close to its expected value and the test statistic $z_\pi$ is not significant (p-value = 0.397), both supporting the validity of the $t$-DCC model. However, the Kolmogorov-Smirnov test statistic is larger than its 5% critical value, rejecting the null hypothesis that probability integral transforms are uniformly distributed.

[12] In addition, we tested the hypothesis that the index returns have non-mean reverting volatility. We found that in all sector indices, volatility was mean-reverting (detailed results available upon request). This implies that despite the fluctuations in volatility and correlation, in the long run, the volatility assumes an average value. However, note that the mean reverting process is generally a very slow one. Estimates of $(1 - \lambda_{i1} - \lambda_{i2})$ range from 0.006497 to 0.046830. Thus, while in the shorter term, the dynamics of conditional volatility and correlation can have significant impact, in the longer term, the effects tend to even out and are captured by unconditional volatilities and correlations. Given that it takes a very long time (a few years at least) for volatility to revert to a long-term average, there is value in portfolio sector switching that can optimize portfolio return by minimizing loss in diversification benefit. In other words, unless an investor is only concerned with very long term returns, it pays to monitor the dynamism (or temporal dimension) of correlations between sectors and manage their portfolios accordingly.

To a lesser extent, the real estate sector (both Shari'ah compliant and non-Shari'ah compliant) was also shown to be particularly volatile (based on mean and range of min/max values). Observers of the Malaysian stock market would attest to the fact that during market bull runs, these two sectors – finance and properties – would typically outshine other sectors. This was particularly evident during the period preceding the Asian Financial Crisis of 1997/98. Another observation worth noting is the high kurtosis of the oil and gas sector[13]. Stock prices of oil and gas firms are highly sensitive to oil prices, which can oscillate substantially, especially in more recent times.

Finally, we note that when we compare the average numbers between Shari'ah compliant and non-Shari'ah compliant sectors, in all cases with the exception of skewness and kurtosis, non-Shari'ah compliant sectors are, on the average, more volatile. Some caution should be exercised when analyzing computed skewness, as a smaller number may not necessarily indicate a more symmetric distribution. Asymmetry in distribution may balance each other out (such as the case of long but thin tail on one end, and fat but short tail on the other end) and our simple skewness measure cannot make corrective distinction.

While studying volatilities can provide some interesting insights, more pertinent to the objectives of our research are the correlations between sectors. If the assumptions of our research framework are correct, diversification benefit originates from correlation of returns among sectors. As our primary interest is to examine the diversification dimension of Islamic portfolios vis-à-vis conventional portfolios, correlation of returns between sectors is a key variable. Our challenge here is that since we have 18 sectors in total and correlations are measured pair-wise between any given two sets of returns (sectors), we will end up with 153 unique correlation numbers. To add to the complexity, we have taken the more realistic assumption that these correlations are not constant and vary across time. We may not be doing the analysis justice by simply looking at the average values of these time-varying correlations. However, detailed perusal of time-varying correlations between each and every possible combinations of sector would be overwhelmingly arduous, and would produce too much information to allow any relevant, focused and intuitive findings.

As a reasoned compromise, we go with the following approach. Firstly, we only look at correlation pairings between each of the 10 Shari'ah compliant sectors and all the other sectors (both Shari'ah compliant and non-Shari'ah compliant). That is, we exclude correlations between a non-Shari'ah compliant sector and another non-Shari'ah compliant sector. The rationale is that our main interest is to explore the nature of diversification pertaining to a Shari'ah compliant portfolio. The approach taken is to compare (i) correlation between Shari'ah compliant sectors and non-Shari'ah compliant sectors, with (ii) correlation among Shari'ah compliant sectors. If there is evidence that the former is substantially lower than the latter, a case can be made to claim that Islamic portfolios are at a diversification disadvantage. For this reason, strictly-speaking, we need not articulate correlations among non-Shari'ah compliant sectors.

Secondly, instead of just relying on mean values of the time-varying correlations, we will also consider dimensions of variability of the correlations, in particular, standard deviation, minimum and maximum values, the resulting range of values, skewness and kurtosis, as alternative measures of the extent and nature of correlation between sectors.

In Table A5 in the Appendices we rank the ***mean*** correlation between each of the 10 Shari'ah compliant sectors with all other sectors. The basic idea here is to see if the absence of non-Shari'ah compliant sectors in an Islamic portfolio would impact diversification (by looking at the quantum of correlations). The most obvious observation is the fact that the tobacco sector has

[13] High kurtosis implies that more of the observed variance came from infrequent extreme deviations, as compared to frequent modestly-sized divergences from mean (shorter peak, fatter tails).

the lowest correlation numbers (by far) in all cases. What this implies is that Islamic portfolios do lose some benefits of diversification by excluding tobacco stocks, at least on the basis of average correlation figures. The good news for Islamic investors is that in second, third and fourth places, in most cases, are Shari'ah compliant sectors. Beyond that, the rankings are spread out somewhat sporadically between Shari'ah compliant and non-Shari'ah compliant sectors, insufficiently systematic for us to make any reasonable conclusions. Thus, with the exception of the case of the tobacco sector, we find only limited evidence that Islamic portfolios have to accept lower levels of diversification.

We mentioned earlier that analyzing the correlations which we have reasonably assumed to be time-varying solely on the basis of their computed means can obscure some important perspectives. Thus we also conducted the same nature of ranking as per Table A5 but using instead variability dimensions of the distribution of correlations as the criteria for ranking. In other words, we rank the correlations among sectors by standard deviation, minimum and maximum values, range, skewness and kurtosis. To save space, we have not included these rankings here but they are available upon request.

We focus on the tobacco sector as it appears that this poses the greatest disadvantage to Islamic portfolios, in terms of lost diversification benefit. We notice that the tobacco sector is reported as having the lowest levels of standard deviation. Similarly, its range of values is also the lowest compared to other sectors. This suggests that the tobacco sector's correlation with other sectors is comparatively more stable than the rest, and as the aforementioned findings have shown, the lowest among all. However, this also means that the sector has less "spikes" or extreme values in correlation, which insofar as portfolio diversification is concerned, is a good thing. Compare the tobacco sector with say, the oil and gas sector. The latter has among the highest levels of standard deviation, and its minimum values are, in almost all cases, the lowest among all sectors, and are substantially lower than the tobacco sector. Hence while overall the tobacco sector offers superior benefits of diversification which Islamic portfolios cannot gain from, at particular instances when correlations are at their extremes (especially at the lower end of the correlation spectrum), sectors like oil and gas would arguably do better. This scenario, albeit infrequent, serves to mitigate to some extent the apparent diversification disadvantage borne by Islamic portfolios. Under regular circumstances, we cannot deny the superior low correlations observed for the tobacco sector but in the limited instances that correlations are "stretched", Shari'ah compliant sectors like oil and gas can be of some redeeming value. In many cases, the minimum value of correlation for the oil and gas sector even goes into negative territory.

The results in Table 1 reinforce our aforementioned point. Here we compute the descriptive statistics of correlations, separating between non-Shari'ah compliant and Shari'ah compliant sectors. Although going by mean values, the average for non-Shari'ah compliant sectors is lower than that for Shari'ah-compliant sectors, based on variability dimensions (standard deviation, minimum values, range, skewness and kurtosis) Shari'ah compliant sectors report higher ***potential*** for diversification benefit.

Finally, we briefly analyze correlation dynamics by sub-periods (see Table A6 in the Appendices). In all sub-periods except the one preceding the Asian Financial Crisis, mean correlations for non-Shari'ah compliant sectors are lower than for Shari'ah compliant. Interestingly, non-Shari'ah compliant sectors even show greater variability in the distribution of correlations in each of those four sub-periods, in particular having higher standard deviation and range of values. A possible implication of this finding is that conventional portfolios have higher potential to benefit from diversification when the investment horizon period is shorter. It follows that Islamic portfolios garner greater portfolio diversification opportunities when investment is longer termed.

**Table 1**
**Descriptive statistics of average conditional correlations (non-Shari'ah compliant sectors compared with Shari'ah compliant sectors)**

| | | Mean | SD | Min | Max | Range | Skew | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| NSC | BMATS | 0.6619 | 0.1046 | 0.0699 | 0.7999 | 0.7299 | -2.2615 | 8.5878 |
| | CONST | 0.6556 | 0.1102 | 0.0730 | 0.7979 | 0.7249 | -1.9949 | 6.2316 |
| | CGOOD | 0.6323 | 0.1057 | 0.0914 | 0.7750 | 0.6835 | -2.0205 | 6.8548 |
| | CSERV | 0.6625 | 0.1075 | 0.0569 | 0.7941 | 0.7372 | -2.5081 | 9.3330 |
| | INDUS | 0.5960 | 0.1094 | 0.0707 | 0.7465 | 0.6757 | -1.8345 | 5.1415 |
| | OILGS | 0.4739 | 0.1282 | -0.0228 | 0.6687 | 0.6916 | -1.5018 | 3.1429 |
| | SCRES | 0.6793 | 0.0975 | 0.0784 | 0.8080 | 0.7296 | -2.7413 | 12.1157 |
| | TELCO | 0.4880 | 0.1119 | -0.0092 | 0.6492 | 0.6584 | -1.7195 | 3.9589 |
| | TRANS | 0.5932 | 0.1069 | 0.1208 | 0.7541 | 0.6332 | -1.5216 | 3.5875 |
| | UTILS | 0.4975 | 0.1202 | 0.0186 | 0.6707 | 0.6521 | -1.4936 | 2.9898 |
| | **Average** | **0.5940** | **0.1102** | **0.0548** | **0.7464** | **0.6916** | **-1.9597** | **6.1944** |
| SC | BMATS | 0.6764 | 0.1132 | 0.0432 | 0.8206 | 0.7774 | -2.3924 | 8.5522 |
| | CONST | 0.6750 | 0.1184 | 0.0504 | 0.8159 | 0.7655 | -2.3208 | 7.1028 |
| | CGOOD | 0.6587 | 0.1121 | 0.0570 | 0.7994 | 0.7424 | -2.3482 | 8.0146 |
| | CSERV | 0.6837 | 0.1165 | 0.0465 | 0.8154 | 0.7689 | -2.7414 | 9.8995 |
| | INDUS | 0.6331 | 0.1235 | 0.0209 | 0.7837 | 0.7629 | -2.2602 | 6.3311 |
| | OILGS | 0.5209 | 0.1340 | -0.0452 | 0.7038 | 0.7490 | -1.9783 | 4.8111 |
| | SCRES | 0.6614 | 0.1132 | 0.0582 | 0.8036 | 0.7453 | -2.4007 | 8.0569 |
| | TELCO | 0.5342 | 0.1137 | 0.0076 | 0.6850 | 0.6774 | -2.0060 | 4.9311 |
| | TRANS | 0.6309 | 0.1244 | 0.0622 | 0.7950 | 0.7329 | -1.8608 | 4.3390 |
| | UTILS | 0.5377 | 0.1323 | 0.0027 | 0.7196 | 0.7169 | -1.7757 | 3.5453 |
| | **Average** | **0.6212** | **0.1201** | **0.0303** | **0.7742** | **0.7439** | **-2.2085** | **6.5584** |

### 5.4 Residual Variances and ANCOVA

We start by looking at average investment performance scores for our Islamic and conventional funds (shown in Table 2). When using our self-constructed indices as the market benchmark, not much sets apart the performance of Islamic funds with that of conventional ones, with the exception of the Treynor ratio, where the measure for conventional funds is statistically significantly higher than that computed for Islamic funds. Interestingly, when the KLCI is made the market proxy for conventional funds, more performance measures favour conventional funds. The KLCI is narrow-based index comprising the top 30 or so stocks by market capitalization. This could indicate that the KLCI's performance, on the average over our analysis period, is relatively inferior compared to a broader-based index, in terms of lower returns and/or greater volatility.

More pertinent to our main research objectives, we find that the Wilcoxon rank-sum (Mann-Whitney) test Z-scores indicate that statistically-speaking, there is no significant difference in residual variances between our sampled Islamic and conventional funds. This says that levels of diversification (or lack thereof) between the two categories of funds are not that dissimilar. This finding stands regardless of whether we use the self-constructed indices or KLCI as the market benchmark.

**Table 2**
**Mean scores for investment performance measures, residual variances and Wilcoxon rank-sum test Z-scores**

| | Sample Mean | | | |
|---|---|---|---|---|
| | Islamic | Conventional | Z-score | Prob. > \|z\| |
| *Panel A: Self-constructed indices as market proxy* | | | | |
| α | -0.0009 | -0.0009 | 0.098 | 0.9221 |
| Sharpe | 0.0628 | 0.0670 | -0.134 | 0.8932 |
| Treynor | 0.0016 | 0.0027 | -3.557 | 0.0004 |
| Information ratio | -0.1314 | -0.1506 | 2.112 | 0.0347 |
| eSDAR | -0.0005 | -0.0010 | 1.791 | 0.0733 |
| Residual Variance | -0.2497 | -0.1443 | -1.287 | 0.1981 |
| *Panel B: KLCI as market proxy (for conventional funds)* | | | | |
| α | -0.0009 | 0.0007 | -8.403 | 0.0000 |
| Sharpe | 0.0628 | 0.0670 | -0.134 | 0.8932 |
| Treynor | 0.0016 | 0.0020 | -1.266 | 0.2056 |
| Information ratio | -0.1314 | 0.0231 | -9.226 | 0.0000 |
| eSDAR | -0.0005 | 0.0017 | -9.528 | 0.0000 |
| Residual Variance | -0.2497 | -0.1252 | -1.504 | 0.1325 |

Notwithstanding that it appears that Islamic and conventional funds do not differ in the extent of portfolio diversification, we examine if after accounting for levels of diversification, investment performance is statistically different between the two groups. Essentially we test the hypothesis $H_0 : \omega_2 = 0$. Results in Table 3 indicate that when self-constructed indices is the market proxy, the fund alphas, Sharpe ratios and the eSDAR measures of Islamic and conventional funds do not differ significantly (Panel A: p = 0.819; Panel B: p = 0.183; Panel E: p = 0.21). However, in terms of the Treynor and Information ratios, the difference is statistically significant. A different set of results emerges when the conventional funds' performance is benchmarked against the KLCI (See Table 3). We refrain from articulating these results further as they are only auxiliary in nature with respect to our primary research aims. Briefly however, what these results show is that level of portfolio diversification is not the only factor that determines relative fund performance. This makes sense as fund performance could be a function of a host of factors like the fund manager's ability (stock selection and market timing skills), the mutual fund company's in-house research capabilities, management acumen and access to less publicly available information or market intelligence, fund size and age, just to name a few. Also, the choice of investment performance measure (in particular the way we measure risk) and market proxy affects the results.

**Table 3**
**Analysis of covariance, without interaction terms**

| Benchmark | ***Self-constructed indices*** | | | ***KLCI (for conventional)*** | | |
|---|---|---|---|---|---|---|
| | Coefficient | Std. Error | p value | Coefficient | Std. Error | p value |
| *Panel A. Dependent Variable:* ***α*** | | | | | | |
| RV | 0.000028 | 0.000166 | 0.867 | 0.000048 | 0.000157 | 0.758 |
| Group | 0.000041 | 0.000179 | 0.819 | 0.001616 | 0.000174 | 0.000 |
| *Panel B. Dependent Variable:* ***Sharpe Ratio*** | | | | | | |
| RV | -0.047994 | 0.006476 | 0.000 | -0.047994 | 0.006476 | 0.000 |
| Group | 0.009321 | 0.006965 | 0.183 | 0.009321 | 0.006965 | 0.183 |
| *Panel C. Dependent Variable:* ***Treynor Ratio*** | | | | | | |
| RV | -0.000504 | 0.000296 | 0.091 | -0.000431 | 0.000239 | 0.073 |
| Group | 0.001104 | 0.000318 | 0.001 | 0.000455 | 0.000264 | 0.087 |
| *Panel D. Dependent Variable:* ***Information Ratio*** | | | | | | |
| RV | 0.047938 | 0.006747 | 0.000 | 0.003875 | 0.006791 | 0.569 |
| Group | -0.024231 | 0.007257 | 0.001 | 0.154044 | 0.007517 | 0.000 |
| *Panel E. Dependent Variable:* ***eSDAR*** | | | | | | |
| RV | -0.001472 | 0.000222 | 0.000 | -0.000386 | 0.000147 | 0.009 |
| Group | -0.000300 | 0.000238 | 0.210 | 0.004178 | 0.000162 | 0.000 |

Next we test the hypothesis $H_0 : \omega_3 = 0$, to discover if levels of diversification affect investment performance of Islamic funds differently than they do with conventional funds. Focusing on the resulting p-values of the RV*Group interaction term, we find that for the most part, diversification levels do not impact investment performance of Islamic funds that differently from conventional funds. Only when information ratio is the measurement yardstick (and eSDAR when KLCI is the market proxy) do we find evidence of statistically significant difference (at 5% significance level). See Table 4 for details. We consider this as evidence to argue that Islamic funds are not necessarily disadvantaged in terms of portfolio diversification. That is, our empirical results suggest that differing levels of diversification have less bearing on investment performance when an "Islamic versus conventional" comparison is made. We note however that with performance measures which rely on systematic risk as the measure of portfolio risk (fund alpha and the Treynor ratio) the assumption is that the investor will be making investment in more than one mutual fund. Diversification in mutual fund investment is achieved and hence fund beta is the appropriate measure of portfolio risk. In contrast, for an investor whose preference is to invest in a single mutual fund, measures that use total variability of returns (standard Sharpe ratio, information ratio and eSDAR) would probably make better performance yardsticks. Hence, our results suggest that in order for investors of Islamic funds to avoid conceivable loss of portfolio diversification benefit, they should consider investing in multiple mutual funds.

**Table 4**
**Analysis of covariance, with interaction terms**

| Benchmark | ***Self-constructed indices*** | | | ***KLCI (for conventional)*** | | |
|---|---|---|---|---|---|---|
| | Coefficient | Std. Error | p value | Coefficient | Std. Error | p value |
| *Panel A. Dependent Variable:* ***α*** | | | | | | |
| RV | -0.000210 | 0.000268 | 0.424 | -0.000210 | 0.000260 | 0.411 |
| Group | 0.000123 | 0.000192 | 0.522 | 0.001701 | 0.000186 | 0.000 |
| RV * Group | 0.000394 | 0.000341 | 0.251 | 0.000413 | 0.000326 | 0.207 |
| *Panel B. Dependent Variable:* ***Sharpe Ratio*** | | | | | | |
| RV | -0.050300 | 0.010492 | 0.000 | -0.050300 | 0.010492 | 0.000 |
| Group | 0.010104 | 0.007530 | 0.182 | 0.010104 | 0.007530 | 0.182 |
| RV * Group | 0.003743 | 0.013366 | 0.780 | 0.003743 | 0.013366 | 0.780 |
| *Panel C. Dependent Variable:* ***Treynor Ratio*** | | | | | | |
| RV | -0.000930 | 0.000477 | 0.054 | -0.000930 | 0.000393 | 0.020 |
| Group | 0.001248 | 0.000342 | 0.000 | 0.000614 | 0.000281 | 0.031 |
| RV * Group | 0.000686 | 0.000608 | 0.261 | 0.000779 | 0.000493 | 0.116 |
| *Panel D. Dependent Variable:* ***Information Ratio*** | | | | | | |
| RV | 0.025039 | 0.010616 | 0.020 | 0.025039 | 0.011055 | 0.025 |
| Group | -0.016450 | 0.007619 | 0.033 | 0.147244 | 0.007903 | 0.000 |
| RV * Group | 0.037164 | 0.013524 | 0.007 | -0.033250 | 0.013857 | 0.018 |
| *Panel E. Dependent Variable:* ***eSDAR*** | | | | | | |
| RV | -0.001250 | 0.000358 | 0.001 | 0.000284 | 0.000232 | 0.224 |
| Group | -0.000380 | 0.000257 | 0.147 | 0.003963 | 0.000166 | 0.000 |
| RV * Group | -0.000360 | 0.000456 | 0.432 | -0.001050 | 0.000291 | 0.000 |

Finally, we explore the hypothesis $H_0 : \omega_1 = 0$. Referring to the p-values pertaining to residual variance (RV) in Table 4, in 5 out of 9 instances we are able to reject the null (at 5% significance level), indicating that $\omega_1$ is statistically nonzero[14]. This implies that for Islamic funds, unsystematic risk (as measured by our construct of residual variance) does impact investment performance. Hence, there is evidence that the extent to which a portfolio is diversified ***can*** affect performance of that portfolio although this would be conditional upon how performance is measured and the market proxy assumed in making that measurement.

We recapitulate our key findings under this section as follows. Level of diversification in portfolios matters (at least in the case of Islamic funds in our sample), that is, it affects investment performance. However, there is evidence to suggest that it is not the only factor. In comparing levels of diversification between Islamic and conventional funds, we find that they are statistically not different from one another. Our statistical tests show that, for the most part at least, the manner in which diversification levels impact investment performance of Islamic and conventional funds is not dissimilar. All these findings lend support to the notion that Islamic portfolios are not handicapped in terms of portfolio diversification. This is not to say that conventional portfolios are not superior in terms of risk-adjusted returns or vice versa. We

[14] As the standard Sharpe ratio does not take any risk or return measures from a market proxy and hence the numbers for Panel B are identical for both benchmarks, we count it only once.

simply assert that if there is a difference in investment performance between the two categories of funds, the evidence here suggests that the ***cause*** is unlikely to be level of portfolio diversification. We caution however that the soundness of this conclusion is dependent upon, among other things, how we measure investment performance and market benchmark used.

## 6. CONCLUSIONS

### 6.1 Summary of Empirical Findings

**Table 5 Summary of empirical findings**

| Method | Key Findings | Evidence pertaining to First Research Objective |
|---|---|---|
| Efficient frontiers | • Short selling favours conventional portfolios<br>• Overweighting on the tobacco sector during crisis periods provide conventional portfolios with an edge | • Without short selling, in many scenarios, Islamic and conventional portfolios are substantially similar<br>• When conventional portfolios have minimum weights in all non-Shari'ah compliant sectors, Islamic frontiers are superior |
| Time-varying maximum Sharpe ratio | • Short selling amplifies the advantage conventional portfolios hold over Islamic portfolios<br>• Conventional portfolios have a slight advantage when the investment strategy is to hold the global minimum variance portfolio | • When portfolios are constrained to have minimum weights across all sectors and in equally-weighted portfolios, there is little to distinguish between Islamic and conventional portfolios |
| MGARCH-DCC | • On the average, non-Shari'ah compliant sectors are more volatile, particularly finance and real estate<br>• Conditional volatilities are mean-reverting albeit over a long period<br>• Conventional portfolios have better (relative to Islamic portfolios) opportunities to diversify when the investment period is shorter | • Excluding tobacco, there is no clear evidence that non-Shari'ah compliant sectors offer superior diversification<br>• While during most times, tobacco offers unrivalled diversification benefit, at particular instances of extreme correlations, sectors like oil and gas can offer better diversification |
| Covariance analysis | • Level of portfolio diversification does affect investment performance although it is not the only factor | • Levels of diversification between Islamic and conventional funds are statistically not different<br>• Extent of diversification impacts investment performance of Islamic and conventional funds in a statistically indistinguishable way |

With these results we are in a position to address our two research objectives. Firstly, we believe that we have adequate statistical evidence to raise substantial doubt on the claim that Islamic portfolios unconditionally suffer a diversification disadvantage in comparison to conventional portfolios. Notwithstanding the intuitive appeal of the argument that conventional portfolios will always be either at par or better compared to Islamic portfolios, our empirical findings show that beyond a purely theoretical plane, Islamic portfolios are not necessarily constantly at a disadvantage in terms of portfolio diversification. In fact, under certain circumstances, Islamic portfolios outshine their conventional counterparts. At the same time, our results do not permit us to claim that Islamic portfolios will never be in a subordinated position in terms of portfolio diversification. The results show that there is ample evidence to reject the claim that Islamic portfolios are ***invariably*** at a disadvantaged position in terms of portfolio diversification.

Secondly, we discover evidence to suggest that the differences (between Islamic and conventional) in portfolio diversification levels and their impact on investment performance can vary with a number of parameters, namely:

i. Whether short selling is allowed
ii. Are there portfolios constraints such as stipulated weights across allocated sectors or restrictions on heavy overweighting on a particular sector
iii. Whether the portfolio is specified to target a particular risk/return profile (for example, low volatility or minimum variance)
iv. The relative length of investment horizon
v. Market conditions or extent of exuberance in trading activity – bull/bear market, crisis/non-crisis periods
vi. Investment performance yardstick used in the evaluation and comparison, in particular the assumptions made about portfolio risk or how we measure risk
vii. Market return proxy or benchmark assumed

Incidentally, the findings related to the second research objective provide additional credence to our conclusion for the first research question. The fact that under different circumstances, different "winners" emerge in the "Islamic versus conventional" comparison substantiates our contention that Islamic portfolios are not consistently deprived of diversification benefit, relative to conventional portfolios.

## 6.2 Contribution to Literature

To the best of our knowledge, existing literature dealing specifically with the diversification dimension in making comparison between Islamic and conventional equity portfolios leaves much to be desired. Beyond superficial mention of the issue at hand, very few published works have explored in detail the role that portfolio diversification plays in affecting the performance of Islamic funds relative to conventional portfolios, let alone carry out substantial empirical analysis. Thus we believe that our work here makes a notable contribution to this area of research. While our study is surely not without its limitations (discussed below), it is hoped that it would generate some research interest on this specific issue and pave the way for future research work. We consider our analysis exploratory in nature. Our conclusions should be read within the specified context and with reference to the explicit and tacit assumptions of our empirical models. We have also endeavoured to make our analysis robust by employing not one but four different methods.

We reiterate the contribution of this work:

i. An in-depth articulation of the portfolio diversification perspective as it pertains to the comparative analysis of Islamic and conventional equity funds.

ii. Conducting of empirical analysis to substantiate lines of intuitive reasoning in discussing the aforementioned diversification dimension.
iii. Use of multiple empirical methods to arrive at a consolidated research conclusion.

## 6.3 Implications of Results

The primary finding of our research work is that there is substantial empirical evidence that Islamic equity portfolios are not unconditionally at a disadvantaged position in comparison with conventional portfolios, at least in terms of portfolio diversification. Stated differently, that Islamic funds are, by design, inferior to conventional ones because Islamic funds have less portfolio diversification is far from a foregone conclusion. This has important implications to the various stakeholders of the Islamic equity market.

Market regulators and institutions promoting Islamic equity investments including companies offering Shari'ah-compliant equity mutual funds could use our empirical findings as a selling point, in further developing the potential of this market segment. Muslim investors can take comfort in the knowledge that their religious convictions does not necessarily come at a pecuniary cost. This same idea can be used to market Shari'ah compliant mutual funds to a wider base of non-Muslim investors. Thus Islamic equity funds can be seen as a competitive alternative equity investment class and not merely a niche segment reserved exclusively for Muslim investors seeking conformance to the Shari'ah in their investment activities. Our results are applicable to the Malaysian equity market. Whether similar conclusions can be drawn for other markets (Asia-Pacific, GCC, US, UK, and Europe, to name a few) would require a separate research endeavour. However, we hope that our findings here would spawn research interest to conduct similar work for other markets. In the event that such research is carried out and the findings are similar, this could foster development of the Islamic equity investment sector at a global scale.

The implications of our findings go beyond simply reassuring investors of Islamic equities that they are not investing in a substandard category of investment. This would be of particular interest to Muslim investors. After all, for many of these investors, piety drives their decision to limit themselves to Shari'ah compliant stocks. To what extent levels of portfolio diversification are detrimental in terms of risk-adjusted returns would be viewed purely academically and is unlikely to sway them away from Shari'ah compliant investing. However, what would attract keener attention is how Islamic equity portfolios can be managed in order to reduce, if not eliminate, any inherent disadvantages such portfolios may have. More specific results emanating from our second research objective can, to some extent, aid investors in this respect.

Our results show that when the portfolio strategy is low volatility or minimum variance, conventional portfolios tend to fare better. This is owing to non-Shari'ah compliant sectors (in particular, tobacco) having very low correlations with other sectors. To avoid this apparent handicap, investors of Islamic equities can opt for structuring portfolios that lie more at the mid-range or higher end of the volatility spectrum. Such an attitude towards risk is not foreign to the Islamic finance philosophical framework. If anything, it fits well as many Shari'ah scholars have been making calls for greater embracing of risk. Not to be misinterpreted as implying reckless or excessively risky investing, Islamic principles merely accentuate the point that risk-taking is a prerequisite of profit-making (juristic principle of "*al ghunm bil ghurm*", meaning "there is no return without risk"). Risks of equity investments should be judiciously measured and accounted for when making investment decisions and managing equity portfolios.

Length of investment horizon has also been shown to be a differentiating factor. More specifically, it can be argued that our results suggest that for Islamic portfolios to get the upper hand, investment periods should be lengthier. This again is congruent with Islamic

prescriptions pertaining to equity investment. Shorter-termed investments are often associated with speculative trading which many Shari'ah scholars frown upon. Hence, a "buy and hold" strategy would not only accord the investor with better diversification opportunities, it steers away from the stigma of speculation in the stock market which Islamic scholars take a dim view of.

A recurring observation is that the tobacco sector yields a risk/return profile that is advantageous to the investor, particularly from a portfolio diversification perspective. Investors of Islamic equities, of course, are not able to profit from this. Thus the tobacco sector can be viewed as the bane of the Islamic portfolio's endeavour to achieve competitive diversification. During periods of market crisis, the tobacco sector has shown to be particularly resilient. At other times, the tobacco sector's correlations with other sectors are among the lowest. Of course, there is nothing that the Islamic investor can directly do to mitigate this ostensible handicap. At best, one could identify Shari'ah compliant sectors that have high correlations with the tobacco sector and overweight portfolio allocation on that sector. Such a sector would serve as a "substitute" sector for tobacco and hence could potentially harness some of the portfolio diversification benefits otherwise lost by not being able to invest in tobacco.

Another means of alleviating the abovementioned disadvantage is by dynamically reviewing sector correlations to identify and make the most of temporary spikes in correlations. A number of Shari'ah compliant sectors (for example, oil and gas) have produced correlations much lower than that of the tobacco sector, at certain times. If the investor is able to exploit such anomalies, diversification opportunity loss (relating to non-investment in tobacco) can be somewhat "recouped". However, while theoretically possible, this may be difficult to bring to fruition. Without the benefit of hindsight, anticipating such instances of extreme correlations can be quite a challenging proposition, if not a result of pure coincidence. Historical trends can provide indications of possible future behaviour but their predictive value may disappoint.

While we cannot deny that the tobacco sector provides some additional diversification benefits that are not accessible to Islamic portfolios, too much should not be taken of this point. The tobacco sector in Malaysia is made up of only two firms. It is unlikely that many portfolios would overweight substantially on just these two stocks. Hence, the diversification handicap stemming from non-allocation to the tobacco sector is expected to be limited or moderated. Most conventional portfolios would only allocate modest investment proportions to this sector. When this is the case, little sets apart the performance of Islamic and conventional portfolios, as evidenced by our empirical scenarios where we limit overweighting on a single sector.

It is observed that comparing performances of Islamic and conventional portfolios, the measurement yardstick employed as well as the chosen market return proxy can influence the end results. Such knowledge could serve as important inputs for equity investors. A shrewd investor should exercise some caution in interpreting published reports on stock performances and in accepting claims of fund performances. The way investment performance is measured (especially how we fashion risk-adjusted returns) and the particular market return indicator funds benchmark themselves to can sometimes swing the results in favour of the party reporting those results. For instance, investors should appreciate the distinction between risk measurements on the basis of systematic risk and those based on total variability of returns. Our results indicate that Malaysian equity funds (both Islamic and conventional) are inadequately diversified. This implies that investors choosing to invest in equities via mutual funds should spread their investment monies across a number of funds instead of putting all their money into a single fund. Further, in doing this, the more appropriate investment performance yardstick would be those based on systematic risk (such as Jensen's alpha and the Treynor ratio).

Finally, regulators of the Islamic equity market should note that short selling magnifies differences in the risk/return profile between Islamic and conventional portfolios. For example, investors of conventional portfolios are able to exploit the apparent low volatility anomaly and low correlations of the tobacco sector to boost risk-adjusted returns. Notwithstanding Malaysia's Shari'ah authorities' liberal views on the permissibility of short selling of stocks, if a more level playing field is a desired objective, disallowing or limiting of short selling activities should be on the cards.

### 6.4 Research Limitations

For the most part, we have previously discussed important limitations and caveats of our work. We reiterate them briefly here:

i. Two of our methods in particular (efficient frontiers and maximum Sharpe ratios) deal with hypothetical portfolios. As such, inferences are about potential for gains or losses. We attempt to incorporate more realism in our analysis by including scenarios that reflect more typical portfolios.
ii. Our conclusions are only as good as the performance measurement yardsticks we have adopted. Our first three methods employ basic risk and return measures (excess total returns, standard deviation of those returns). In our fourth method we introduce more variety in performance measures and indulge in relatively more sophisticated yardsticks.
iii. Some of our findings are based on the validity of established theoretical foundations such as Markowitz's Modern Portfolio Theory and the Capital Asset Pricing Model. To the extent that the underlying assumptions of these models do no hold true, as some published empirical works claim to attest, our inferences require revisiting or refinement.
iv. There are certain degrees of arbitrariness in our empirical models which we believe is unavoidable (for example, designated minimum/maximum weights imposed on certain portfolios). In most cases, we feel that it should not invalidate our findings which are mostly suggestive and not definitive in nature.
v. The Malaysian equity market is comparatively small and new. Thus, there may be data inadequacy issues owing to small number of observations in performing our computations and estimations.
vi. In employing our empirical methods, level of sophistication was intentionally moderated, to make the research endeavour more manageable and not excessively copious. For example, in computing fund alphas, we have limited ourselves to the garden variety CAPM without also including additional risk factors as per the stylized Fama and French 3-factor model or for that matter, Carhart's 4-factor model. Another case in point, we did not perform any back-testing of our estimation models (out-of-sample results).
vii. Our findings are applicable to the Malaysian equity market. Whether the observations can be extended to other markets can only be answered by further research.

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## 8. APPENDICES

**Notation 1**
**Portfolio Optimization Method**

To perform portfolio optimization, we rely on Microsoft Excel's built-in array formulas which are capable of executing basic matrix algebra operations, as well as its Solver Add-in toolkit. The Microsoft Excel Solver tool uses the Generalized Reduced Gradient (GRG2) nonlinear optimization code developed by Leon Lasdon of University of Texas at Austin and Allan Waren of Cleveland State University.

Briefly, the steps taken to form the said efficient frontier are as follows:

i. The global minimum variance portfolio is identified by solving the optimization problem,

$$\min_{m} \sigma_{p,m}^2 = m' \sum m \; s.t. m'1 = 1$$

Asset weights that lead to a portfolio with the lowest overall variance are identified subject to those asset weights adding up to 1.

ii. A minimum variance portfolio with target expected return equal to $\mu_0$ (usually the highest expected return among all individual assets making up the set of investable assets) is identified.

$$\min_{y} \sigma_{p,y}^2 = y' \sum y \; s.t. y'\mu = \mu_0 \; and \; y'1 = 1$$

iii. Upon identifying these two portfolios, we then construct the efficient frontier of risky assets. Given any two efficient portfolios with weight vectors $\boldsymbol{m}$ and $\boldsymbol{y}$, the convex combination of

$$z = \alpha.\boldsymbol{m} + (1 - \alpha).\boldsymbol{y}$$

for any constant α is also an efficient portfolio. The expected return and variance of this portfolio are

$$\mu_{p,z} = \alpha.\mu_{p,m} + (1 - \alpha).\mu_{p,y}$$

$$\sigma_{p,z}^2 = \alpha^2\sigma_{p,m}^2 + (1 - \alpha)^2\sigma_{p,y}^2 + 2\alpha(1 - \alpha)\sigma'_{my}$$

where the covariance between the returns on portfolio $\boldsymbol{m}$ and $\boldsymbol{y}$ is computed using $\sigma_{my} = \boldsymbol{m}'\Sigma\boldsymbol{y}$. To create the efficient frontier, a grid of α-values is created starting with 1 and decreasing in increments of 0.025[15].

[15] We wish to credit a guide to using Excel to construct efficient portfolios obtained at http://faculty.washington.edu/ezivot/econ424/Efficient%20Portfolios%20in%20Excel%20Using%20the%20Solver%20and%20Matrix%20Algebra.pdf, retrieved 3 Jan 2013.

**Table A1**
**List of Dow Jones indices selected to construct efficient portfolios**

| Shari'ah-compliant Sectors | Non-Shari'ah-compliant Sectors |
|---|---|
| Airlines | Banks |
| Automotive and Parts | Broadcast and Entertainment |
| Basic Materials | Brewers |
| Chemicals | Gambling |
| Construction and Materials | Hotels |
| Farm and Fish | Insurance |
| Food Products | Tobacco |
| Healthcare | |
| Industrials | |
| Marine Transportation | |
| Oil and Gas | |
| Personal and Household Goods | |
| Real Estate | |
| Technology | |
| Telecommunications | |
| Utilities | |

**Table A2**
**List of sectors resulting from self-construction of indices**

| Shari'ah-compliant Sectors | Non-Shari'ah-compliant Sectors |
|---|---|
| Basic Materials | Banks |
| Construction | Financials |
| Consumer Goods | Gambling |
| Consumer Services | Hotels |
| Industrials | Non-Shari'ah compliant Goods and Services |
| Oil and Gas | Non-Shari'ah compliant Miscellaneous |
| Shari'ah Compliant Real Estate | Non-Shari'ah compliant Real Estate |
| Telecommunications and Technology | Tobacco |
| Transportation and Automotive | |
| Utilities | |

**Table A3**
**Defined sub-periods in constructing additional efficient frontiers**

| Sub-Period | Date Range |
|---|---|
| Pre-Asian Financial Crisis | 9 Jan 1992 – 1 Jul 1997 |
| Asian Financial Crisis (AFC) | 2 Jul 1997 – 31 Dec 1998 |
| Post-Asian Financial Crisis | 1 Jan 1999 – 8 Aug 2007 |
| Global Financial Crisis (GFC) | 9 Aug 2007 – 31 Dec 2010 |
| Post-Global Financial Crisis | 1 Jan 2011 – 9 May 2013 |

**Table A4**
**Descriptive statistics of conditional volatilities**

| | Mean | SD | Min | Max | Range | Skew | Kurtosis |
|---|---|---|---|---|---|---|---|
| Banks | 0.0365 | 0.0222 | 0.0150 | 0.1755 | 0.1605 | 2.7165 | 8.9269 |
| Financials | 0.0409 | 0.0171 | 0.0161 | 0.1589 | 0.1428 | 2.1491 | 7.1228 |
| Gambling | 0.0475 | 0.0210 | 0.0193 | 0.1119 | 0.0926 | 0.6540 | -0.5719 |
| Hotels | 0.0431 | 0.0101 | 0.0281 | 0.0890 | 0.0609 | 1.1054 | 1.4400 |
| NSC Goods & Services | 0.0333 | 0.0118 | 0.0191 | 0.0824 | 0.0633 | 1.4212 | 1.8672 |
| NSC Misc. | 0.0407 | 0.0141 | 0.0201 | 0.1079 | 0.0878 | 1.2707 | 1.6036 |
| NSC Real Estate | 0.0463 | 0.0228 | 0.0178 | 0.1420 | 0.1242 | 1.3008 | 1.5909 |
| Tobacco | 0.0300 | 0.0121 | 0.0173 | 0.1192 | 0.1018 | 2.9053 | 11.832 |
| Basic Materials | 0.0377 | 0.0115 | 0.0175 | 0.0857 | 0.0682 | 1.3875 | 2.2372 |
| Construction | 0.0403 | 0.0144 | 0.0187 | 0.1190 | 0.1003 | 1.9045 | 4.4171 |
| Consumer Goods | 0.0306 | 0.0120 | 0.0152 | 0.1115 | 0.0963 | 2.1261 | 6.6903 |
| Consumer Services | 0.0334 | 0.0170 | 0.0169 | 0.1375 | 0.1206 | 2.1114 | 5.9799 |
| Industrials | 0.0353 | 0.0172 | 0.0155 | 0.1156 | 0.1001 | 1.8000 | 3.6672 |
| Oil & Gas | 0.0281 | 0.0119 | 0.0154 | 0.1135 | 0.0982 | 3.0033 | 12.122 |
| SC Real Estate | 0.0445 | 0.0164 | 0.0228 | 0.1363 | 0.1135 | 1.7040 | 3.3847 |
| Telco & Technology | 0.0377 | 0.0144 | 0.0206 | 0.0967 | 0.0761 | 1.5600 | 2.3003 |
| Transportation | 0.0301 | 0.0130 | 0.0143 | 0.1085 | 0.0942 | 2.5751 | 7.4663 |
| Utilities | 0.0353 | 0.0184 | 0.0176 | 0.1349 | 0.1173 | 2.4222 | 6.6177 |
| Average NSC | **0.0398** | **0.0164** | **0.0191** | **0.1234** | **0.1043** | **1.6904** | **4.2264** |
| Average SC | **0.0353** | **0.0146** | **0.0174** | **0.1159** | **0.0985** | **2.0594** | **5.4882** |

SD = Standard Deviation, NSC = Non-Shari'ah Compliant, SC = Shari'ah Compliant
The first 8 sectors are non-Shari'ah compliant while the remaining sectors are Shari'ah compliant.

**Table A5**
**Ranking by mean conditional correlations (for Shari'ah compliant sectors)**

| BMATS | | CONST | | CGOOD | | CSERV | | INDUS | |
|---|---|---|---|---|---|---|---|---|---|
| **TOBAC** | 0.3010 | **TOBAC** | 0.2996 | **TOBAC** | 0.3311 | **TOBAC** | 0.2874 | **TOBAC** | 0.2895 |
| TELCO | 0.5170 | OILGS | 0.5230 | UTILS | 0.5136 | OILGS | 0.5431 | OILGS | 0.5355 |
| OILGS | 0.5271 | TELCO | 0.5424 | TELCO | 0.5348 | UTILS | 0.5553 | TELCO | 0.5552 |
| UTILS | 0.5271 | UTILS | 0.5490 | OILGS | 0.5367 | TELCO | 0.5613 | UTILS | 0.5570 |
| **HOTEL** | 0.6407 | **GAMBL** | 0.6296 | **GAMBL** | 0.5944 | **HOTEL** | 0.6477 | **GAMBL** | 0.5830 |
| **GAMBL** | 0.6454 | **HOTEL** | 0.6487 | **HOTEL** | 0.6302 | **GAMBL** | 0.6554 | **HOTEL** | 0.6125 |
| **BANKS** | 0.6694 | TRANS | 0.6827 | **BANKS** | 0.6421 | INDUS | 0.6875 | **NSCRE** | 0.6222 |
| TRANS | 0.6780 | INDUS | 0.6923 | INDUS | 0.6746 | TRANS | 0.7068 | **NSCMS** | 0.6290 |
| INDUS | 0.6862 | **BANKS** | 0.6995 | TRANS | 0.6787 | **NSCRE** | 0.7127 | TRANS | 0.6427 |
| **NSCRE** | 0.7333 | **NSCRE** | 0.7248 | **NSCRE** | 0.6800 | **BANKS** | 0.7196 | **NSCGS** | 0.6645 |
| **NSCGS** | 0.7528 | **NSCGS** | 0.7271 | **NSCMS** | 0.7175 | **NSCGS** | 0.7419 | SCRES | 0.6674 |
| CGOOD | 0.7656 | CGOOD | 0.7301 | **FINAN** | 0.7284 | **NSCMS** | 0.7444 | **FINAN** | 0.6736 |
| **NSCMS** | 0.7685 | **NSCMS** | 0.7450 | CONST | 0.7301 | CGOOD | 0.7554 | CGOOD | 0.6746 |
| **FINAN** | 0.7841 | **FINAN** | 0.7703 | **NSCGS** | 0.7347 | CONST | 0.7727 | BMATS | 0.6862 |
| CONST | 0.7882 | CSERV | 0.7727 | SCRES | 0.7389 | SCRES | 0.7790 | CSERV | 0.6875 |
| CSERV | 0.7918 | BMATS | 0.7882 | CSERV | 0.7554 | **FINAN** | 0.7908 | CONST | 0.6923 |
| SCRES | 0.8070 | SCRES | 0.7945 | BMATS | 0.7656 | BMATS | 0.7918 | **BANKS** | 0.6940 |

| OILGS | | SCRES | | TELCO | | TRANS | | UTILS | |
|---|---|---|---|---|---|---|---|---|---|
| **TOBAC** | 0.3334 | **TOBAC** | 0.2724 | **TOBAC** | 0.2613 | **TOBAC** | 0.3515 | **TOBAC** | 0.2924 |
| **NSCRE** | 0.4459 | OILGS | 0.4915 | **GAMBL** | 0.4651 | TELCO | 0.5184 | **NSCRE** | 0.4685 |
| **GAMBL** | 0.4476 | TELCO | 0.5060 | **NSCRE** | 0.4859 | UTILS | 0.5548 | OILGS | 0.4804 |
| UTILS | 0.4804 | UTILS | 0.5157 | OILGS | 0.4869 | OILGS | 0.5636 | **GAMBL** | 0.4817 |
| TELCO | 0.4869 | TRANS | 0.6525 | **NSCMS** | 0.4916 | **GAMBL** | 0.5738 | **NSCMS** | 0.4945 |
| SCRES | 0.4915 | **HOTEL** | 0.6569 | SCRES | 0.5060 | **NSCRE** | 0.5869 | CGOOD | 0.5136 |
| **NSCMS** | 0.4930 | **GAMBL** | 0.6670 | **NSCGS** | 0.5116 | **HOTEL** | 0.5997 | SCRES | 0.5157 |
| **NSCGS** | 0.5013 | INDUS | 0.6674 | **FINAN** | 0.5141 | **NSCMS** | 0.6419 | **NSCGS** | 0.5233 |
| **FINAN** | 0.5063 | **BANKS** | 0.6740 | BMATS | 0.5170 | INDUS | 0.6427 | **FINAN** | 0.5268 |
| **HOTEL** | 0.5164 | CGOOD | 0.7389 | TRANS | 0.5184 | SCRES | 0.6525 | BMATS | 0.5271 |
| CONST | 0.5230 | **NSCGS** | 0.7712 | CGOOD | 0.5348 | **FINAN** | 0.6551 | **HOTEL** | 0.5394 |
| BMATS | 0.5271 | CSERV | 0.7790 | CONST | 0.5424 | **NSCGS** | 0.6600 | CONST | 0.5490 |
| INDUS | 0.5355 | **NSCRE** | 0.7827 | INDUS | 0.5552 | **BANKS** | 0.6764 | TRANS | 0.5548 |
| CGOOD | 0.5367 | CONST | 0.7945 | **HOTEL** | 0.5583 | BMATS | 0.6780 | CSERV | 0.5553 |
| CSERV | 0.5431 | **NSCMS** | 0.7951 | CSERV | 0.5613 | CGOOD | 0.6787 | INDUS | 0.5570 |
| **BANKS** | 0.5471 | BMATS | 0.8070 | UTILS | 0.5861 | CONST | 0.6827 | TELCO | 0.5861 |
| TRANS | 0.5636 | **FINAN** | 0.8152 | **BANKS** | 0.6161 | CSERV | 0.7068 | **BANKS** | 0.6533 |

*Shari'ah compliant sectors*: BMATS = Basic Materials, CONST = Construction, CGOOD = Consumer Goods, CSERV = Consumer Services, INDUS = Industrials, OILGS = Oil and Gas, SCRES = Shari'ah Compliant Real Estate, TELCO = Telecommunications and Technology, TRANS = Transportation, UTILS = Utilities
*Non-Shari'ah compliant sectors (in bold)*: BANKS = Banks, FINAN = Financials, GAMBL = Gambling, HOTEL = Hotels, NSCGS = Non-Shari'ah Compliant Goods and Services, NSCMS = Non-Shari'ah Compliant Miscellaneous, NSCRE = Non-Shari'ah Compliant Real Estate, TOBAC = Tobacco

**Table A6**
**Descriptive statistics of conditional correlations by sub-periods, comparing non-Shari'ah compliant and Shari'ah compliant sectors**

| | | Mean | SD | Min | Max | Range | Skew | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| Whole Period | NSC | 0.5940 | 0.1102 | 0.0548 | 0.7464 | 0.6916 | -1.9597 | 6.1944 |
| | SC | 0.6212 | 0.1201 | 0.0303 | 0.7742 | 0.7439 | -2.2085 | 6.5584 |
| Pre AFC | NSC | 0.5025 | 0.1513 | 0.0548 | 0.6804 | 0.6256 | -1.1561 | 0.7822 |
| | SC | 0.5021 | 0.1662 | 0.0303 | 0.6861 | 0.6557 | -1.1505 | 0.4433 |
| AFC | NSC | 0.6579 | 0.0438 | 0.5369 | 0.7162 | 0.1793 | -1.0175 | 0.9722 |
| | SC | 0.6933 | 0.0413 | 0.5772 | 0.7454 | 0.1682 | -1.1506 | 0.9788 |
| Post AFC | NSC | 0.6300 | 0.0606 | 0.4704 | 0.7403 | 0.2699 | -0.4307 | -0.1361 |
| | SC | 0.6625 | 0.0589 | 0.5064 | 0.7654 | 0.2590 | -0.3790 | -0.2240 |
| GFC | NSC | 0.6142 | 0.0415 | 0.5051 | 0.6851 | 0.1800 | -0.5822 | 0.2220 |
| | SC | 0.6531 | 0.0368 | 0.5590 | 0.7125 | 0.1535 | -0.6092 | 0.3377 |
| Post GFC | NSC | 0.5810 | 0.0424 | 0.4877 | 0.6593 | 0.1716 | -0.2019 | -0.4153 |
| | SC | 0.6231 | 0.0346 | 0.5441 | 0.6889 | 0.1448 | -0.2769 | -0.0621 |

AFC = Asian Financial Crisis, GFC = Global Financial Crisis

**Figure A1**
**Efficient Frontiers – Dow Jones Indices – Monthly – Pre AFC**
To save space, we omitted axis labels and the legend. In all cases, the y-axis is expected return and the x-axis represents standard deviation of returns. The solid and dotted lines represent conventional and Islamic efficient frontiers, respectively.

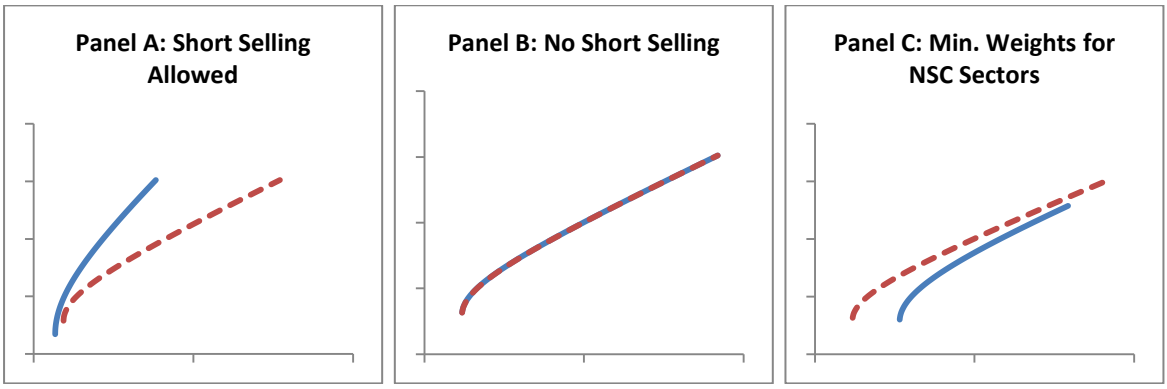


**Figure A2**
**Efficient Frontiers – Dow Jones Indices – Monthly – AFC**

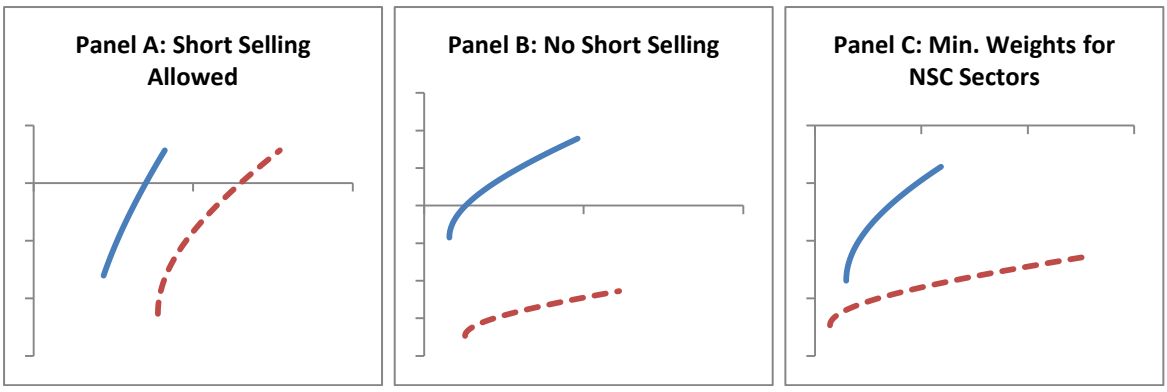

**Figure A3**
**Efficient Frontiers – Dow Jones Indices – Monthly – Post AFC**

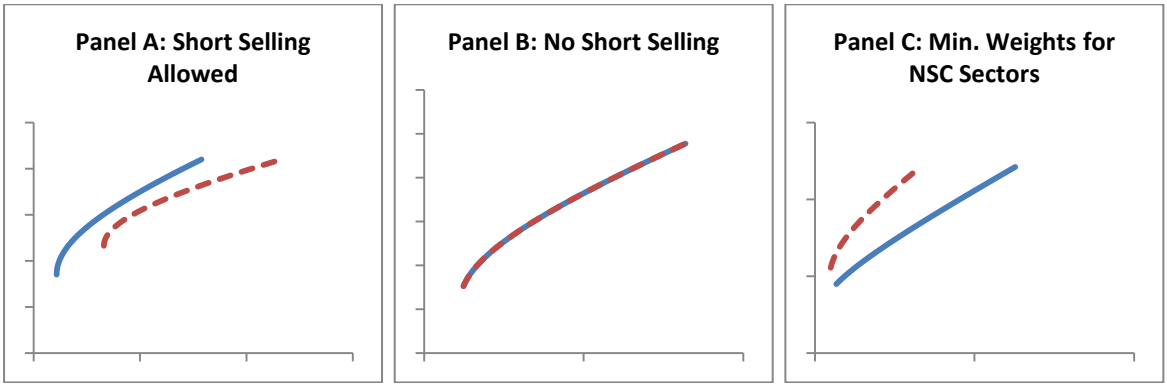


**Figure A4**
**Efficient Frontiers – Dow Jones Indices – Monthly – GFC**

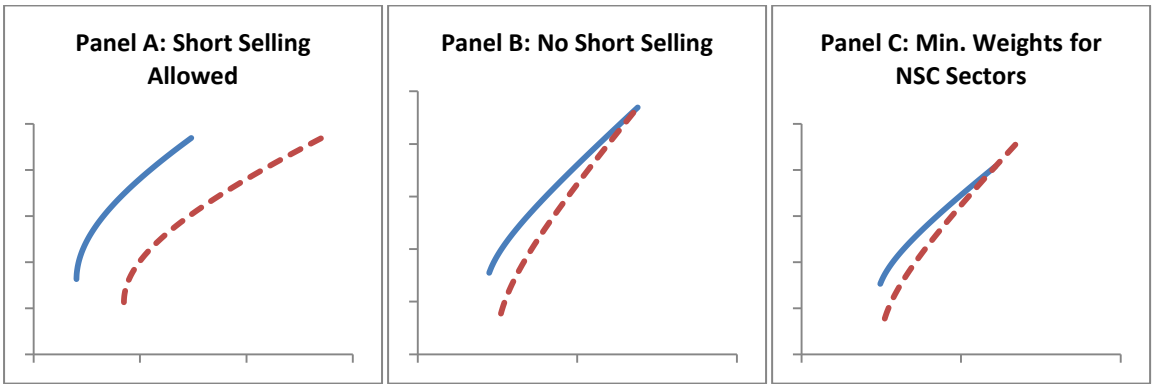


**Figure A5**
**Efficient Frontiers – Dow Jones Indices – Monthly – Post GFC**

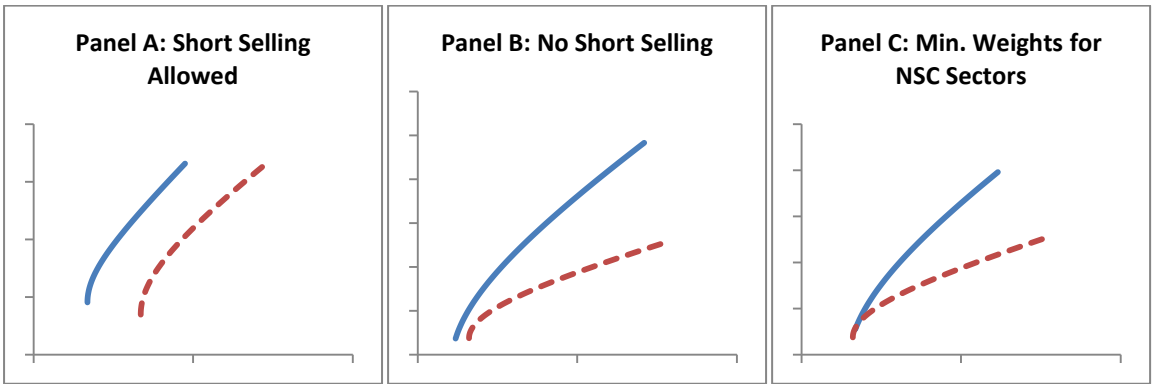

**Figure A6**
**Efficient Frontiers – Dow Jones Indices – Weekly – Entire Period**

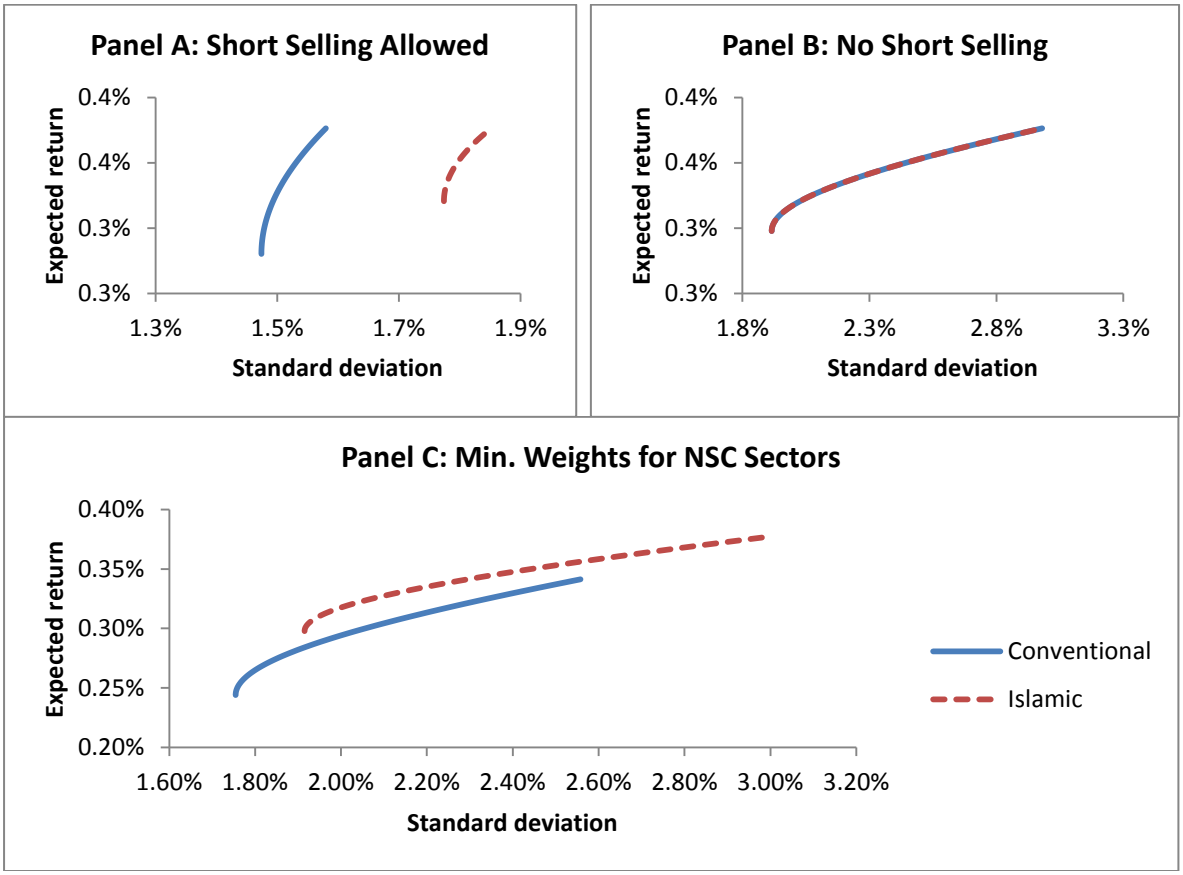

**Figure A7**
**Efficient Frontiers – Self-constructed Indices – Weekly – Entire Period**