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Non-parametric performance measurement of international and Islamic mutual funds

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Abstract

Purpose – The purpose of this paper is to study whether Islamic investors lose portfolio efficiency due to a limited asset universe.

Design/methodology/approach – The paper contributes to prior literature by using non-parametrical measurements of efficiency instead of regular (parametrical) methods. Data envelopment analysis (DEA) was used in order to better characterize the risk and return relationship, as well as estimating a single performance index to rank different funds and compare them to one another.

Findings – Overall, the results are congruent with prior findings. That is, there is strong evidence suggesting that Islamic funds are highly efficient and that they outperform their international counterparts. Also, results are robust to different estimation of DEA, the specification of the asset universe, and the inclusion of financial crisis period in analysis.

Research limitations/implications – Though the paper's findings are robust to different specifications of the DEA model and time periods, the authors caution readers due to the limited sample.

Practical implications – Having defined a performance index, one can therefore isolate the funds which are the most efficient and thus drive trading activities towards said funds.

Social implications – Since the paper's findings suggest that Islamic investors do not lose efficiency, investing into a limited asset universe which follows social and ethical constraints (given by Shariah law) is recommended.

Originality/value – The paper is able to confirm prior literature, even by using a non-parametrical measurement of efficiency. In this way, the authors have accounted for an extra penalty on the risk-return relationship: skewness.

Keywords Islam, Fund management, Unit trusts, Portfolio investment, Islamic mutual funds, Data envelopment analysis, Investment efficiency

Paper type Research paper

1. Introduction

As of April 2010, Muslims represented almost 21 percent of the world's population with an estimated of more than USD 800 billion to invest, which is growing at 15 percent annually (Girard and Hassan, 2008). Because of this, many financial institutions have expanded their services to accommodate for Muslims' religious preferences, resulting in an increasing universe of *Shariah* compliant assets.

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Shariah, which is the moral code and religious law of Islam, rules out the consumption of alcohol and pork and activities related to gambling. As a result, Muslims should not invest in financial assets that derive their income from such activities[1]. This results in the omission of stocks from firms such as hotels, casinos, clubs, bars, restaurants, food producers, alcohol producers, etc. Moreover, *Shariah* compliant assets are types of ethical investment which drive investors towards firms which have a sound social responsibility. Thus, it can be expected that mutual fund managers who follow *Shariah* law, and thus ethical codes, will tend to avoid extreme risk taking behavior.

While one could argue that Islamic funds bear less risk than traditional assets thereby producing smaller average returns, one could also argue that Islamic funds are less diversified than traditional investment, making such investment riskier, thus making investors require higher compensation to hold Islamic funds. In this paper, we characterize a risk-return relationship for Islamic funds, International funds, and American funds in order to explain which set of assets has the best performance.

Though the literature has analyzed the performance of Islamic mutual funds, ours, to our knowledge, is the first study that compares them to traditional unconstraint investment on the bases of efficiency: which types of mutual funds provide the highest level of outputs (returns) conditional on inputs (risk).

One of the major advantages of using data envelopment analysis (DEA) is that it allows for multiple inputs and outputs to be included into a production framework while still offering a single performance index. This in turn, allows easy comparison between funds and thereby groups. Furthermore, the specification of the models under DEA allows for endogenous derived inputs and outputs weights which make this type of models appealing (Glawischnig and Sommersguter-Reichmann, 2010). We apply two types of DEA methods to our sample: a radially driven input-oriented measure, or the BCC's model, as well as a non-radially driven input-oriented measure, or the Russell's model.

Overall, our results are consistent with prior literature. Islamic funds do not seem to lose efficiency despite their smaller asset universe. Furthermore, results are also robust to different specifications of:

- the asset universe; and
- DEA model.

In lieu of the 2007-2008 US financial crisis, we revise if the higher performance of Islamic mutual funds is due their exposure to lower levels of risk; we find that Islamic investment is remarkably efficient regardless of the time period.

The remaining of this paper is structured as follows. Section 2 discusses the previous literature. Section 3 briefly explains further rationales to use DEA as well as stating the relevant models[2]. Section 4 discusses the data. Section 5 shows the empirical results of two DEA models. Section 6 checks the robustness of results to different subsamples that accommodate the latest financial crisis. Finally, Section 7 shows the summary and conclusions.

2. Previous literature

There are several studies which focus on Islamic finance especially after the introduction of several Islamic indices such as: the Dow Jones Islamic market index (DJIMI) which was launched in 1999; FTSE Global Islamic Index Series (GIIS) which was launched at the end

of 1998; MSCI global Islamic indices; and the Global Gulf Cooperation Council (GCC) Islamic index which was launched in 2006. The main theme of these studies is to investigate whether there is a cost in adhering to the *Shariah* law. Some studies find Islamic investing affects performance, while others find otherwise.

Elfakhani *et al.* (2007) findings suggest that there is no statistical evidence of any performance differences between Islamic funds and the employed market benchmarks. However, their findings suggest that Islamic mutual funds do offer a good hedging opportunity against market downturns. Abdullah *et al.* (2007) apply Sharpe index and adjusted Sharpe index, Jensen Alpha, timing and selectivity ability to Malaysian mutual funds and find that Islamic funds performed better than conventional funds during bearish economic trends while, conventional funds showed better performance than Islamic funds during bullish economic conditions.

Mansor and Bhatti (2011) study the monthly performances of 128 Islamic mutual funds (IMFs) in Malaysia for the period of January 1990 to April 2009. They employ Sharpe, Treynor and Jensen ratios to the risk-adjusted return performance based on extended version of CAPM model. They find on average IMFs in Malaysia outperform its conventional peers and the market portfolio proxy by the KLCI returns. Shah *et al.* (2012) show that Pakistani Islamic funds, when compared to Pakistani non-Islamic funds, present a lower average risk rate with higher compensations. Surprisingly, the authors also find Islamic funds are even better diversified than conventional mutual funds.

Hoepner *et al.* (2009) find mixed evidence on the performance of Islamic mutual funds. They find that Islamic funds from eight nations (mostly from the Western regions) significantly underperform their respective equity market benchmarks and Islamic funds from only three nations outperform their respective market benchmarks. Furthermore, they find that Islamic funds from the GCC and Malaysia do not significantly underperform their respective market benchmarks. Finally, they argue that Islamic equity funds can offer hedging opportunities because their investment universe is limited to low debt-to-equity ratio stocks.

Donia and Marzban (2010) conclude that *Shariah*-compliant investments outperform conventional investments using the mean-variance frontier because the former benefits from the lower leverage feature. Also, Majid and Maulana (2010) apply a non-parametric performance measure to assess performance and find significant efficiency of Islamic funds, but they limit their study only to Indonesia.

Hassan *et al.* (2010) provide a case study on Malaysian Islamic unit trust funds. Their findings show that there are no convincing performance differences between Islamic and non-Islamic Malaysian unit trust funds.

Girard and Hassan (2008, 2012) study the performance of several Islamic indexes and compare them with non-Islamic equivalents. They use parametrical methods such as Sharpe ratio, Jensen and Fama's selectivity, net selectivity, diversification, and Carhart's (1997) four factor pricing model and find that there is no significant difference between the Islamic and non-Islamic indexes.

BinMahfouz and Hassan (2012) conclude that the assumption that *Shariah* investment constrains lead to inferior performance and riskier investment portfolios because of limited investment universe seems to be rejected. This implies that Muslim investors can choose Islamic investments that are consistent with their beliefs without being forced to either sacrifice performance or become exposed to higher risk.

3. Non-parametric estimations

Since alternative investments or financial assets have different statistical properties, estimating a good performance index is a difficult task due to the different characteristics of assets returns, such as skewed return distributions with fat tails. Because of this, it is expected that parametrical performance measurements fail when accounting distributions that present non-normal characteristics. We expect that use of non-parametric econometric method, such as DEA, will add value to prior literature.

We expected that DEA will contribute a sound estimation of performance indexes as well as a better explanation of the risk-return relationship. In this context, DEA offers a good perspective as it accounts for multiple inputs and outputs simultaneously while still offering a single real number as a performance index. DEA assumes a production framework on which one uses inputs to produce outputs where inputs are defined as bearers of risk while outputs are bearers of wealth.

Prior literature reveals that input candidates should reflect investment risk, which is proxied by the return momentums. Under normality, only the mean return and its standard deviation will suffice. However, if distributions are non-normal, then higher momentums should be required. Thus, the next section focuses on testing normality of returns.

3.1 Normality testing

In order to measure normality, this paper employs the Jarque Bera (JB) test statistic, defined in equation (1). Normality is rejected when JB_j is larger than 5.99 for the 5 percent significance level and 9.21 for the 1 percent significance level:

$$JB_j = \frac{T}{6}\left[S_j^2 + \frac{K_j^2}{4}\right] \tag{1}$$

where:

$$S_j = \frac{E_j(r_t - r_d)^2}{\sigma_j^2}, \text{ the skewness of monthly returns of fund } j$$

$$K_j = \frac{E_j(r_t - r_d)^4}{\sigma_j^4} - 3, \text{ the excess kurtosis of monthly returns of fund } j$$

r_t, monthly return.

r_d, average returns.

σ_j, standard deviation.

3.2 Inputs and outputs description

The specification of the input-output model is given by the risk-return relationship. In this case, all risk measures are considered as inputs while all return measurements will be considered outputs. The input candidates are given by the fund's standard deviation, the lower partial momentums (*LPM*), and maximum drawdown period. The output candidates are expected returns, the upper partial momentums (*UPM*), and the maximum period of consecutive gain.

The partial momentums, both upper and lower, are estimated as the m^{th} root of the *LPMs* and *UPMs* given by equation (2), in percentages. The paper uses $r_{\min}$ as the mean return to differentiate between the downside and the upside of the investment strategy. While the *LPMs* capture the downside or risk of holding a specific investment asset, the *UPMs* will capture the upside or benefit of the investment. Finally, *UPM0* is disregarded while *LPM0* is further used; *LPM0* is the percentage return of funds below the target rate[3]:

$$LPM_{j,m} = \frac{1}{T}\sum_{t=1}^{\tilde{T}} (r_{\min} - \underline{r}_{t,j})^m \forall \;\; m = 0, \ldots, 4$$

$$UPM_{j,m} = \frac{1}{T}\sum_{t=1}^{\widehat{T}} (\bar{r}_{t,j} - r_{\min})^m \forall \;\; m = 0, \ldots, 4 \tag{2}$$

where:

- $r_{\min}$, target rate.
- $\underline{r}_{t,j}$, monthly return of fund j below target rate.
- $\tilde{T}$, number of returns of fund j below target rate.
- $\bar{r}_{t,j}$, monthly return of fund j above target rate.
- $\widehat{T}$, number of returns of fund j above target rate.

The maximum drawdown period (*MDP*) is estimated as the maximum number of months that fund j has been below historically high net asset value (NAV). On the other hand, the remainder outputs are the funds expected return, $E(r_j)$, and the maximum number of months fund j has been above the minimum target rate, or *MCG*.

3.3 The input-output DEA model

Prior literature has shown that the input-oriented BCC (Banker *et al.*, 1984) with radial[4] inputs is the dominating method to estimate fund performance. According to Glawischnig and Sommersguter-Reichmann (2010), the use of the BCC model can be justified because:

- as the CCR (Charnes *et al.*, 1978) model and the output-oriented BCC model are not translation invariant[5] towards outputs, the input-oriented BCC model is often the metric of choice;
- the assumption of variable returns to scale (VRS) is justified by the fact that alternative investment funds might operate in regions of increasing or decreasing return to scale due to, for example, minimum investment requirements or fixed cost digression; and
- the use of the BCC model is advisable whenever ratios are used as inputs or outputs.

Having identified the input-output specifications, we estimate a frontier (the production possibility frontier (PPF)) to the production possibility set (PPS) that envelops the PPS as tightly as possible. When comparing the DEA frontier with standard portfolio theory (the Markowitz portfolio theory) the DEA frontier is essentially the same but with a different approach. The DEA frontier is resulting from the convex combination

of the best practices[6] followed by the industry given the multiple hyperplanes resulting from the use of multiple inputs and outputs; thereby making it is possible to construct a performance index based upon the distance between specific funds and the constructed frontier.

Formally, it is assumed that there are $j = 1, \ldots, N$ funds where each uses $x_m \forall m = 1, \ldots, M$ inputs to produce $y_r \forall r = 1, \ldots, R$ outputs. Then the performance for the k^{th} fund, p^{BCC}, is estimated by the linear program (LP) given by equation (3):

$$p^{BCC} = \min\theta \;\; s.t.$$

$$\sum_{j=1}^{N} x_{mj}\lambda_j \leq \theta \cdot x_{mk} \;\; \forall m = 1, \ldots, \mathrm{M}$$

$$\sum_{j=1}^{N} y_{rj}\lambda_j \leq y_{rk} \;\; \forall r = 1, \ldots, \mathrm{R} \tag{3}$$

$$\sum_{j=1}^{N} \lambda_j = 1 \;\; with \;\; \lambda_j \geq 0 \forall j, m, r$$

The LP given in equation (3) represents the percentage of efficiency of each particular fund k. equation (3) minimizes the equiproportionate (radial) contraction θ of the inputs produced by unit k. The performance index, P^{BCC}, satisfies $P^{BCC} \leq 1$ where $P^{BCC} = 1$ represents a fund which is 100 percent efficient. That is, given the input-output combination which characterizes the best practice frontier, $P^{BCC} = 1$ represents the k^{th} fund which is on the actual frontier and thus the fund is efficient. Any deviation from the PPF, given by $P^{BCC} < 1$, will result in inefficiencies. Furthermore, the LP uses exogenous weights, λ_j, to fit the best linear combination of all funds given a specific input-output combination; $\lambda_j \neq 0$ represents the best practice units that delimit the frontier.

As with every liner program, equation (4) shows a dual to the primal in equation (3). The dual is helpful as it also estimates the number of inputs and outputs used in the production framework. In this case, the weights μ_r and v_m represent which particular inputs/outputs are incorporated into the fund performance index estimation. The dual P^{BCC} is estimated using the endogenously derived weighs on the $m = 1, \ldots, M$ inputs and $r = 1, \ldots, R$ outputs instead of applying the weights onto the funds as in equation (3). From the economic stand point, the efficient funds should have all inputs and outputs incorporated when estimating the fund performance index to include the investor's gain given the risk exposure. Finally, the variable μ^0 in the dual LP (4) is free and guaranties VRS (Glawischnig and Sommersguter-Reichmann, 2010, footnote 12):

$$P^{BCC} = \max_{v_m, \mu_r, \mu^0} \sum_{r=1}^{R} \mu_r y_{rk} + \mu^0 \;\; s.t.$$

$$\sum_{r=1}^{R} \mu_r y_{rj} - \sum_{m=1}^{M} v_m x_{mj} + \mu^0 \leq 0 \;\; \forall j = 1, \ldots, N \tag{4}$$

$$\sum_{m=1}^{M} v_m x_{mk} = 1$$

$$\mu_r, v_m \geq 0 \text{ and } \mu^0 \text{ free}$$

A limitation of the BCC model is that it assumes all inputs to be radial. But the possibility of non-radial inputs exists. Thus, the results are checked using an input-oriented non-radial model, $P^{Russell}$. This model incorporates non-proportional input reductions using data driven lower bounds regarding input weights under VRS. In other words, the model does not assume a constant θ common for all inputs. Instead, it weights each input independently and then estimates the overall performance of the index as the sum of the individual weights. Again, efficiency is achieved when $P^{Russell} = 1$. Formally:

$$P^{Russell} = \min \frac{\sum_{m=1}^{M} \theta_m}{M} s.t.$$

$$\sum_{j=1}^{N} x_{mj}\lambda_j = \theta_m \cdot x_{mk} \quad \forall m = 1, \ldots, \mathrm{M}$$

$$\sum_{j=1}^{N} y_{rj}\lambda_j \leq y_{rk} \forall r = 1, \ldots, \mathrm{R} \tag{5}$$

$$\sum_{j=1}^{N} \lambda_j = 1 \text{ with } \lambda_j \geq 0 \forall j, r \text{ and } \theta_m \leq 1$$

4. Data description

In this section, the DEA models described in Section 3 are estimated based on a comprehensive data set of mutual funds. Two datasets are employed to form the fund universe. The fund universe is defined as the merger between Saudi Arabia funds (which proxy for Islamic investments), International funds, and American funds. Initially, the fund universe consists of 45096, from which 42,340 are regarded as American, 2,614 are International, and only 142 are Islamic.

For the Islamic funds, a sample data consisting of daily NAVs of 143 out of 234 mutual funds available in Saudi Arabia during the period from January 2003 to December 2010 is selected. Information on these funds is obtained from three main sources: the official site of the Saudi Stock Exchange (Tadawul) (www.tadawul.com.sa), the official site of HSBC Saudi Arabia Limited (www.hsbcsaudi.com), and Zawya database[7]. Because the data on Islamic funds is not continuous, a one month holding period return estimated at the end of the month is computed.

Additionally, we take data from CRSP to account for the remaining funds. International funds are defined as those funds listed in CRSP with objective code "International Fund," "International," or "IF." Finally, everything else is defined as American funds. Only monthly returns as well as monthly NAV's from CRSP for the period of January 1999 to September 2011 are considered. For robustness check, CRSP sample data is restricted to match Islamic funds data sample.

Furthermore, funds employed in the sample are only those which have continuous returns data with at least two years' worth of observations. That is, those funds which have complete years (no missing monthly returns or NAV), and no missing years in between the series. After controlling for this, the sample reduces to 20,946 American funds, 1,504 International funds, and only 95 Islamic ones.

The effective asset universe then results in 56 percent of the original Islamic funds, 51 percent of American funds, and 57 percent of International funds. Despite the high reduction of the data universe, we still expect to get more robust results as most of surviving funds will be accounted for.

5. Empirical results

5.1 Normality testing

Based on the information provided in Section 3.1, in this section, equation (1) is tested to check whether or not the returns show normality. Two types of testing groups are defined: the whole universe and independent individual subgroups. Table I summarizes the results. When the whole fund universe is considered, only about 34 percent of returns can be considered as normally distributed with a 95 percent confidence level.

Moreover, when analyzing individual subgroups, each group is analyzed independently; it is observable that Islamic returns show the highest normality results, with around 50 percent of funds following normality. This is quite a puzzle, since it is expected that American returns to be closer to normality, per the Central Limit Theorem, as there are more observations for American funds than there are for International and Islamic funds. However, these results pave the way for future measurements of DEA based performance indexes that include higher momentums, especially when the fund universe is considered.

5.2 Inputs and outputs specifications

Based on Section 3.2., the different input and output candidates are estimated. Following the literature, the correlation of the different inputs and outputs to define a suitable production framework for the BCC model is investigated. This paper uses such production framework on which risk and return are positively correlated, thus requiring inputs and outputs to be positively correlated. Therefore, the inputs *MCG* and *LPM0-LPM4*, as well as the outputs *MDP* and *UPM1-UPM4* are initially considered.

	Total number of funds	5% significance	1% significance
Fund universe	22,545	7,829 (34.72%)	9,090 (40.31%)
American funds	20,946	7,127 (34.02%)	8,302 (39.63%)
International funds	1,504	654 (43.45%)	716 (47.57%)
Islamic funds	95	48 (50.52%)	72 (75.78%)

Note: The table shows how many funds are normally distributed with the corresponding percentage of the group

Table I.
The JB test statistic for normality of time series

The forth momentums, *LPM4* and *UPM4,* are disregarded due to the extreme high correlations; *LPM3* and *LPM4* as well as *UPM3* and *UPM4* show a correlation greater than 0.999[8]. Still, using the third momentum is enough to apply an extra penalty (bonus) to funds with extremely low (high) returns. Table II summarizes the descriptive statistics of the input-output specifications considered for the production framework used in further tests.

It is worthwhile mentioning that it is striking that there are funds among the fund universe that achieve 100 percent on *LPM0*. That means that there are funds that have had only returns below average ($LPM0 = 1$) during the time window of the study. Further analysis between the subgroups, when each group is analyzed independently, shows that these funds come from the American and Islamic subsamples. In addition, it comes as no surprise that the American subsample is quite similar to the fund universe, as the American subsample accounts for almost 93 percent of the data.

Further analysis of Table II gives additional information about the performance of each of the subsamples. It is observable that the International subgroup has the best performance, followed by the Islamic funds and finally the American funds. As International funds show the smallest average input values with the highest average output values as well as the smallest maximum drawback period.

The only estimate on which the Islamic funds show superiority comes from the maximum consecutive gain. Not only is the mean *MCG* remarkably higher for Islamic funds (63 months compared to 1.5 months for American funds and one month for the International subgroup), the minimum and maximum values are quite impressive as well. That is, while the minimum *MCG* for the Islamic funds (24 months) is well above the minimum *MCG* for both American and International funds (0 months for both, respectively), the maximum *MCG* for the Islamic funds (84 months) is astonishing

Table II.
The descriptive statistics of the proposed input-output specification used to estimate the DEA performance index

	MDP (months)	LPM0 (%)	LPM1 (%)	LPM2 (%)	LPM3 (%)	MCG (months)	UPM1 (%)	UPM2 (%)	UPM3 (%)
Panel A: the fund universe									
Minimum	1	0.125	0.0012	0.0028	0.0035	0.0000	0.0000	0.0000	0.0000
Maximum	96	1	0.1166	0.1834	0.2386	10.0000	0.1274	0.1799	0.2160
Mean	33.1261	0.4718	0.0175	0.0347	0.0486	1.4912	0.0185	0.0306	0.0393
SD	25.0836	0.1095	0.0091	0.0169	0.0233	1.4573	0.0115	0.0175	0.0220
Panel B: American funds									
Minimum	1	0.125	0.0012	0.0028	0.0034	0.0000	0.0000	0.0000	0.0000
Maximum	96	1	0.1165	0.1833	0.2385	10.0000	0.1275	0.1800	0.2160
Mean	33.4684	0.4697	0.0170	0.0338	0.0474	1.5342	0.0180	0.0298	0.0383
SD	25.5837	0.1094	0.0091	0.0169	0.0233	1.5026	0.0115	0.0175	0.0221
Panel C: International funds									
Minimum	1	0.2917	0.0087	0.0145	0.0215	0.0000	0.0043	0.0140	0.0220
Maximum	64	0.8333	0.0645	0.1152	0.1542	4.0000	0.0507	0.0890	0.1171
Mean	29.0705	0.4721	0.0243	0.0468	0.0651	1.0007	0.0250	0.0416	0.0528
SD	16.2616	0.0470	0.0060	0.0090	0.0116	0.2861	0.0064	0.0091	0.0104
Panel D: Islamic funds									
Minimum	4	0.3452	0.0020	0.0024	0.0026	24.0000	0.0000	0.0000	0.0000
Maximum	83	1	0.0595	0.1137	0.1534	84.0000	0.0506	0.0873	0.1244
Mean	33.6526	0.6781	0.0208	0.0412	0.0569	63.9474	0.0194	0.0343	0.0452
SD	17.1121	0.2498	0.0176	0.0351	0.0483	21.7556	0.0186	0.0319	0.0421

higher than the maximum MCG for both the American and International subgroups (ten and four months, respectively).

5.3 The fund universe performance

In this section, the performance of the overall fund universe is estimated and then it is compared to each individual subgroup. In other words, the DEA efficiency frontier based on the fund universe is estimated and then each subgroup is compared to the estimated frontier. Table III summarizes the findings. The overall efficiency of the fund universe is estimate based on equation (3) (panel A) and equation (5) (panel B). That is, the fund performance index is estimated based on radial inputs, P^{BCC}, and non-radial inputs, $P^{Russell}$.

At first glance, it is found that efficiency is highly penalized under the assumption of non-radial inputs. This might be driven by the non-proportional input reduction condition on the Russell's model which applies higher penalties to different inputs. The question of whether a radial or non-radial production framework should be assumed remains unanswered because it is beyond the scope of this paper. The main focus of this paper is to investigate which specific subset is more efficient than the other. Thus, the difference amongst groups, rather than the difference amongst methods is analyzed.

Focusing on panel A, results indicate that 3,944 funds out of the whole fund universe can be considered as efficient, which accounts for 17.49 percent of all funds. Granted, the majority of them are American, 3,587 funds accounting for 90 percent of all efficient funds. Yet when comparing them to their own subsample, they only account for 17.12 percent. That is, about 17 percent of American funds can be considered efficient with respect to the PPF which envelops the whole fund universe. In fact, American funds seem to be the least efficient of all three subsamples.

International founds account for 320 efficient funds, or 21.28 percent of their subgroup while Islamic funds account for 37 efficient funds, or 39 percent of all Islamic funds. Thus, it is observable that there are more efficient funds within the Islamic subsample than either the American or International subsamples. These results are consistent even to different comparisons.

Because BCC provides an actual performance index, it is possible to estimate the average performance of each subgroup and then compare each fund to the proposed

		Panel A: P^{BCC}			Panel B: $P^{Russell}$		
	No of funds	Efficient funds	Average (%)	Funds above average	Efficient funds	Average (%)	Funds above average
Fund universe	22,545	3,944 (17.49%)	52.00	8,574 (38.03%)	6 (0.03%)	27.52	8,431 (37.39%)
American funds	20,946	3587 (17.12%)	52.47	8,149 (38.90%)	4 (0.02%)	27.85	8,007 (38.23%)
International funds	1,504	320 (21.28%)	44.84	339 (22.54%)	0 (0.00%)	21.55	362 (24.07%)
Islamic funds	95	37 (38.95%)	60.89	38 (40.00%)	2 (2.11%)	47.16	38 (40.00%)

Notes: The American, International, and Islamic subsets are compared to the PPF based on the whole fund universe; the percentages in parenthesis correspond to the fraction of efficient funds or funds above average with respect to its subgroup

Table III. The estimation of equation (3), panel A, and equation (5), panel B, based on the whole fund universe

performance index. It is worthwhile mentioning that the Islamic subgroup shows the highest average performance, 60.89 percent, followed by the American and International funds with 52.47 and 44.84 percent average performance, respectively. Finally, Islamic funds also show the highest efficiency levels when measuring the number of funds above average. Islamic funds lead with 38 efficient funds above average, or 40.0 percent of their subgroup, followed by the American and International funds with 8,149 funds, or 38.9 percent of the subsample, and 339 funds, or 22.54 percent of the subsample, respectively.

Likewise, the non-radial model on panel B confirms observed results, despite a penalty imposed on the estimation. Though the number of actual efficient funds drops considerably, we find the same dominance by Islamic funds. Around 2 percent of Islamic funds are efficient, while only 0.02 percent of American funds are efficient and no International funds are efficient. As for the average performance and number of funds above average, the results are consistent with the estimation under the BCC model; the average performance is quite smaller but the number of funds above average remains similar to the results in panel A.

Despite the limitation on Islamic funds due to investing only in *Shariah* compliant assets, the results suggest that such assets do not loose efficiency when comparing them to more "free investment" opportunities. In fact, *Shariah* investments seem to be even better than those traditional investment strategies. Overall, our results indicate that when comparing individual subgroups to the whole envelop of the DEA performance index, Islamic funds seem to dominate the efficiency measures. Taken together with the results on Table II, one can consider Islamic funds to be a solid investment alternative, if not the best.

Still, a question remains on whether Islamic mutual funds together with other investment assets should be analyzed. This is because those who invest in Islamic assets are not going to invest in non-*Shariah* compliant assets in any case. In other words, when analyzing Islamic investments, the fund universe should be limited to only Islamic assets, since Islamic investors will not even consider investing in assets that are not *Shariah* compliant. The following section analyzes individual subgroups independently of one another.

5.4 Independent subgroups

Because Islamic investors are constraint for non-*Shariah* investment, it is logical to study Islamic mutual funds independently. In this section, the efficiency of the individual subgroups is investigated. However, results for the American subgroup are not included due to their similarities with those for the fund universe. Both DEA methods are applied, the radial and non-radial inputs, to the individual subgroups: International funds and Islamic funds. Moreover, results of equation (4) are included to analyze the input-output composition of the radial input BCC.

Table IV summarizes the results of the BCC model for the fund universe and both International and Islamic subgroups. The results suggest that when limiting the universe to their own subgroup thus reshaping the PPF, the International and American funds gain little efficiency while the Islamic subgroup remains the same; the number of efficient International and American funds increases from 320 to 338 and 3,587 to 3,590, respectively, but the number of efficient Islamic funds stays on 37.

However, the most significant result comes from the increase on the average performance of Islamic funds when their PPS is limited to account only for their own subgroup:

while American funds decreased from 52.47 to 51.74 percent and International funds increased from 44.84 to 80.01 percent, Islamic funds increased from 60.89 to 92.60 percent which is magnificently high. Moreover, even the number of funds above average increases for the Islamic subgroup from 40 to 61 percent. Overall, it can be concluded that despite the limitations of the asset universe faced by Islamic funds, they are most efficient than their counterparts.

As a comparison benchmark for efficiency, Table V shows similar results under the non-radial production framework. The trend is quite similar to those of the input-oriented BCC model. Results show a higher number of efficient Islamic funds (8 or 8.42 percent of their subgroup), compared to the number of efficient International funds (9 or 0.6 percent of their subgroup), and efficient American funds (11 or 0.05 percent of their subgroup). The average performance is also consistent with the prior results giving the highest average performance to the Islamic funds with an average efficiency of 68.05 percent followed by the International and American counterparts with an average of 50.93 and 27.74 percent, respectively.

It is noteworthy to mention that the use of individual subgroups shows a remarkable increase on efficiency under equation (5), the non-radial production framework. While the results of the radial model under either the full universe PPF or

	Total number of funds	Number of efficient funds $P^{BCC} = 1$	Expected efficiency (%)	Number of funds above average
Fund universe	22,545	3,944 (17.49%)	52.00	8,574 (38.03%)
American funds	20,946	3,590 (17.14%)	51.74	7,658 (36.56%)
International funds	1,504	338 (22.47%)	80.01	664 (44.15%)
Islamic funds	95	37 (38.95%)	92.60	58 (61.05%)

Note: The percentages in parenthesis correspond to the fraction of efficient funds or funds above average with respect to its subgroup

Table IV. The results from equation (3), the radially driven input-oriented model, based on the fund universe and the independent subgroups (each subgroup has its own PPF)

	Total number of funds	Number of efficient funds $P^{Russell} = 1$	Expected efficiency (%)	Number of funds above average
Fund universe	22,545	6 (0.03%)	27.52	8,431 (37.40%)
American funds	20,946	11 (0.05%)	27.74	8,028 (38.33%)
International funds	1,504	9 (0.6%)	50.93	504 (33.51%)
Islamic funds	95	8 (8.42%)	68.05	47 (49.47%)

Note: The percentages in parenthesis correspond to the fraction of efficient funds or funds above average with respect to its subgroup

Table V. The results from equation (5), the non-radially driven input-oriented model, based on the fund universe and the independent subgroups (each subgroup has its own PPF)

the self-group-limited-universe PPF are quite close. For instance both show 37 efficient Islamic funds, assuming the latter changes the results considerably when assessing a non-radial production framework. All the studying parameters (number of efficient funds, average performance, and number of funds above average performance) seem considerably higher when limiting the universe to the specific subgroups. Still, despite the increase in all subgroups, Islamic funds are still the most efficient.

5.5 Specifics of the inputs and outputs

By using a dual programming to equation (3), it is possible to compare the number of inputs and outputs being used to analyze the production framework. This subsection focuses on the BCC model since it is the model of choice in prior literature[9]. It is expected that efficient funds would incorporate as few inputs as possible in order to produce as much outputs as possible. Yet, it is found that a significant number of efficient funds are unable to generate any output whatsoever. Table VI summarizes the results.

Panel A shows the input-output mix for the fund universe. Results indicate that there are 3,886 efficient funds, which accounts for 17 percent of all funds. Further analysis shows that neither efficient nor inefficient funds could incorporate all inputs together. In fact, the majority of funds could only use a maximum of three inputs at the same time (of a maximum of five), and only a few could even achieve four inputs simultaneously.

Examining the outputs, on the other hand, show that efficient funds can achieve more outputs than inefficient funds. For instance, almost 5 percent of efficient funds, that is 194 funds, can achieve three outputs (of a maximum of four) simultaneously compared to only one fund achieving the same number of outputs for the inefficient funds. In addition, only efficient funds can achieve the maximum number of outputs, although they account for less than 0.1 percent of efficient funds. Despite the highest performance of efficient funds, there is still some inefficiency within them. That is, 37.3 percent of efficient funds cannot achieve any output at all. What is more puzzling, however, is that there are less funds with zero outputs, 31.5 percent, coming from the inefficient subsample.

		Inputs					Outputs				
Number of funds		1	2	3	4	5	0	1	2	3	4
Panel A: fund universe											
Inefficient	18,659	817	15,062	2,756	24	–	5,886	9,410	3,362	1	–
Efficient	3,886	1,486	725	1,649	26	–	1,450	828	1,411	194	3
Panel B: American funds											
Inefficient	17,417	3,133	12,121	2,153	10	–	10,476	4,901	2,040	–	–
Efficient	3,529	1,096	964	1,465	4	–	1,058	1,883	473	104	11
Panel C: International funds											
Inefficient	1,177	249	927	1	–	–	43	1,076	58	–	–
Efficient	327	107	9	188	23	–	54	94	178	1	–
Panel D: Islamic funds											
Inefficient	66	1	22	39	4	–	12	39	12	3	–
Efficient	29	5	11	12	1		3	10	10	6	–

Table VI.
The results from equation (4), the dual to the radially driven input-oriented model, based on the fund universe and the independent subgroups

Notes: Table VI shows the input-output combination used in the production process; it also shows production inefficiencies given by the number of funds with zero outputs

Though panel A shows important results, other panels show further means to comparing efficiency between Islamic, International, and American funds. At first inspection, there seems no significant difference in the input mix between the subgroups, but results do indicate that only American efficient funds can achieve the maximum number of outputs. Note that the same pattern presented in panel A is confirmed:

- most funds, regardless if they are efficient or inefficient, use a maximum of three inputs; and
- even efficient funds present some level of inefficiency due to the presence of funds that produce zero outputs.

Deeper examination of Table VI shows that Islamic funds can still be considered better performing than their counterparts. Results show that 30.5 percent of Islamic funds can be regarded as efficient with inefficiencies accounting for only 10.3 percent, whereas 21.7 percent of International funds are efficient with inefficiencies of 16.5 percent, and only 5.2 percent of American funds are efficient with inefficiencies accounting for almost 30 percent. In this context, inefficiencies are regarded as the percentage of efficient funds which produced zero-outputs.

Overall, results suggest that Islamic mutual funds do not lose efficiency even though they are limited to a smaller universe of assets. Perhaps a possible explanation for such efficiency gain is that despite limitations, Islamic investors are ethically driven and thus they prefer to avoid investing onto the most risky assets. Therefore, these results might be biases in favor of Islamic funds due to the fact that the latest 2007-2008 crisis was mainly driven by excessive investment onto risky assets (Gorton, 2010). Such results are also consistent with findings of Merdad *et al.* (2010) who compared Islamic and conventional mutual funds managed by HSBC, the fourth largest fund manager in Saudi Arabia, from January 2003 to 2010. They show that Islamic funds underperform conventional funds during both the full sample period and the bullish period, but outperform conventional funds during bearish and financial crisis periods. The next section covers this issue by splitting the dataset in order to account for the 2007-2008 financial crises.

6. Robustness check

The 2007-2008 financial crisis swept through globally, and thus it is expected to have affected worldwide assets. However, due to the constraints on *Shariah* law, it is believed that Islamic funds have been somehow immunized to the effects of the crisis, which would explain their higher efficiency compared to their counterparts. Therefore, in this section, equation (3) is estimated based on the re-estimation of the inputs and outputs to account for the financial crisis.

As before, results are presented based on the full universe PPF and individual groups PPF for the BCC model. The same input/output combinations proposed in the prior section are still used, but they are now estimated based on two subsamples: January 2003 to December 2006 and January 2007 to December 2010. This generates two subsamples with different number of funds. The pre-crisis subsample accounts for 14,509 funds in the fund universe from which 13,589 are American, 843 are International, and 77 are Islamic, while the post-crisis subsample, which is fairly similar in number of funds in the whole sample, has 22,531 assets in the fund universe from which 20,932 are American, 1,504 are International, and 95 are Islamic.

6.1 The fund universe performance

As before, a PPF is defined as that which envelops all assets in the universe and then each subgroup is compared to the proposed PPF. Table VII summarizes the results. As expected, there is a decrease on efficiency as the crisis starts. Although all subgroups are affected, American funds remain quite the same. In fact, only a decrease of 0.53 percent on the percentage of efficient American funds is observed, while International and Islamic both have a decrease of 18.7 and 9.1 percent, respectively. Furthermore, results show a significant decrease on the average performance as well as number of funds above average performance consistent for all funds.

Still, when comparing the funds with one another, the same results are found; Islamic funds outperform their counterparts regardless of the subsample period. In fact, sorted by efficiency, the order remains the same regardless of the time period: Islamic funds followed by International funds and American funds at last. Although the order changes when comparing average performance and the number of funds above average, it can be safely concluded that Islamic funds are still more efficient despite the financial crisis.

It is worthwhile noting that though the number of efficient Islamic funds is the same regardless of the time period (37 funds), they are not all the same funds. In fact, results indicate that five funds differ; that is, five funds stopped being efficient and five started being efficient after the crisis.

6.2 Subgroups performance

We estimate PPF for each group and then compare their performances. This is done with the rational that Islamic investment is self-constraint to a limited asset universe and thus it makes sense to limit the PPF which will only envelop such assets. Table VIII summarizes the results.

Once again, prior results are confirmed at the first glance; Islamic funds are always the most efficient regardless of the time period followed by International and American funds. However, focusing on panel A, it is noticeable that International and Islamic funds have more efficient funds when the PPF is limited to their own subgroup. This result shows that the post-crisis decrease is even more significant.

	Panel A: 2003-2006				Panel B: 2007-2010			
	No of funds	Efficient funds	Average (%)	Funds above average	No of funds	Efficient funds	Average (%)	Funds above average
Fund universe	14,509	2,792 (19.24%)	73.10	5,934 (40.90%)	22,531	3,969 (17.62%)	46.32	7,176 (31.85%)
American funds	13,589	2,418 (17.79%)	73.00	5,596 (41.18%)	20,932	3,612 (17.26%)	46.66	6,778 (32.38%)
International funds	843	337 (39.98%)	74.40	340 (40.33%)	1,504	320 (21.28%)	40.93	320 (21.28%)
Islamic funds	77	37 (48.05%)	76.93	42 (54.55%)	95	37 (38.95%)	58.07	38 (40.00%)

Notes: This estimation is based on the whole fund universe; the American, International, and Islamic subsets are compared to the PPF based on the whole fund universe; the percentages in parenthesis correspond to the fraction of efficient funds or funds above average with respect to its subgroup

Table VII.
The estimation of equation (3) for the two subsamples: 2003-2006 on panel A and 2007-2010 on panel B

	Panel A: 2003-2006				Panel B: 2007-2010			
	No of funds	Efficient funds	Average (%)	Funds above average	No of funds	Efficient funds	Average (%)	Funds above average
Fund universe	14,509	2,792 (19.24%)	73.10	5,934 (40.90%)	22,531	3,969 (17.62%)	46.32	7,176 (31.85%)
American funds	13,589	2,382 (17.53%)	71.77	57,100 (42.02%)	20,932	3,600 (17.20%)	46.39	6,582 (31.44%)
International funds	843	354 (41.99%)	91.48	404 (47.92%)	1,504	330 (21.94%)	69.32	380 (25.27%)
Islamic funds	77	41 (53.25%)	93.69	52 (67.53%)	95	37 (38.95%)	62.88	37 (38.95%)

Notes: This estimation is based on independent universes; the American, International, and Islamic subsets are compared to the PPF based on their own universe; the percentages in parenthesis correspond to the fraction of efficient funds or funds above average with respect to its subgroup

Table VIII. The estimation of equation (3) for the two subsamples: 2003-2006 on panel A and 2007-2010 on panel B

Further analysis shows that Islamic funds lost average performance lead to International funds after the crisis. While panel A shows an Average performance of 93.69 percent for Islamic funds and 91.48 percent for International funds, panel B gives the lead to International funds with 69.32 percent followed by Islamic funds with 62.88 percent. Yet the number of above average performance funds is still higher for Islamic funds.

Deeper examination reveals that all Islamic efficient funds are the same regardless of the PPF specification for the post-crisis subsample. This is an extra robustness check as this incorporates both specification of the PPF or time period. This also suggests that even if Islamic investors where to open themselves towards the whole asset universe, they will not achieve any extra efficiency. In fact, Islamic funds appear as efficient as if they were part of the whole asset universe.

7. Summary and conclusions

The main purpose of this paper is to investigate whether or not Islamic funds loose efficiency due to investment limitations towards *Shariah* compliant assets. With this purpose, an extensive dataset with three different types of investment assets is created: Islamic mutual funds, International mutual funds, and American mutual funds. A DEA performance index is employed to measure efficiency in order to account for the fact that different investment alternatives present different data characteristics and DEA can account for such characteristics as it can handle multiple inputs and outputs.

Initially, a PPS that accounted for all the assets in the obtained sample is considered. Then a PPF that envelops the whole universe of assets is created. However, Islamic investors would not even consider non-*Shariah* compliant assets as investment opportunities and thus they should not be part of their fund universe. For this reason, PPS is limited to include only individual subgroup's assets thereby reshaping the overall PPF. Regardless of the frontier definition, efficiency is always defined as the percentage number of funds that are on the frontier. Finally, to extend comparison between subgroups, identifying which subgroup had the highest percentage number of funds closer to the PPF is considered, which is measured by the percentage number of funds above average performance.

In summary, obtained results suggest that though Islamic funds are limited to a smaller asset universe, they do not lose efficiency regardless of the specification of the PPF. Islamic funds are the most efficient followed by International and then American funds. Overall, these results are persistent for the percentage number of efficient funds, the average performance index, and the percentage number of funds above average performance. Also, these results are robust to different specifications of the DEA model. In this regard, two different models are analyzed:

(1) an input-oriented DEA model with a proportional input framework; and

(2) a DEA model with a non-proportional input-oriented framework.

But we focus more on the BCC model, as it is the method of choice in prior literature.

Even though results indicate that there is some level of inefficiencies remaining within the efficient funds, it can be safely concluded that Islamic funds remain highly efficient despite their investment limitations, and they show the smallest number of inefficiencies amongst the subgroups.

Finally, since Islamic investors are limited to *Shariah* and Ethical investment, thus preferring less risky assets, it is believed that the obtained results would be biased in favor of Islamic investment. That is, given that the 2007-2008 financial crisis originated due to high investment on toxic assets and Islamic investor would rather avoid them, it is expected that Islamic funds be somehow immunized to the effects of the crisis. Results show evidence suggesting that even though all assets lost efficiency and average performance, Islamic funds remain the most efficient.

On a practical perspective, regardless of the investment preference, our results indicate that Islamic funds are an effective investment opportunity. Non-Muslim Investors who seek to maximize their risk-adjusted returns could highly profit from diversifying towards Islamic mutual funds. While Muslin investors should not be concerned about the opportunity cost of investing only in *Shariah* compliant assets. That is, a typical investor could reduce their risk exposure by swapping their portfolios to also include Islamic funds. In fact, since DEA allows for an identification of fully efficient funds, such funds should be considered for every investor's portfolio. All in all, Islamic mutual funds create a highly profitable new avenue of investment.

Nonetheless, caution must be taken before generalizing the results due to the limitations of the data. First, the dataset on Islamic mutual funds accounts for roughly 60 percent of all available Islamic mutual funds, thus putting an initial limitation onto the Islamic universe sample. Second, the obtained Islamic fund universe is by far the smallest; it only accounts for 0.4 percent of the overall fund universe, hence making it almost irrelevant to the estimation of the fund universe's PPF. However, the latter concern is mitigated by studying each subgroup individually.

Notes

1. For a deep explanation on *Shariah* complaint assets refer to Derigs and Marzban (2009).
2. For a deeper lit review on the evolution of DEA models refer to Glawischnig and Sommersguter-Reichmann (2010). Or for an in-depth analysis of DEA methods refer to Cooper *et al.* (2000).
3. $LPM0 = 1\text{-}UPM0$ which makes the use of both simultaneously redundant.

4. Given the inputs ($x_1, x_2, \ldots, x_n$), they are consider radial if they increase proportionally given an $\alpha > 0$, such that the inputs increase as ($ax_1, ax_2, \ldots, ax_n$) (Cooper *et al.*, 2000).
5. Translation invariance is meant by the fact that dealing with alternative investments is likely that some of the outputs, such as average and minimum return, are negative. Translation invariance of the respective DEA model towards outputs therefore becomes an issue because DEA cannot handle negative data.
6. Best practices, in this context, refer to those funds with the highest level of outputs given the prevailing level of inputs.
7. Zawya is one of leading Middle Eastern business information firms. Their main web site is: www.zawya.com we would like to express my deep appreciation to Mr James Randall, the International business manager, for providing me a trial excess to the database.
8. Just like Glawischnig and Sommersguter-Reichmann (2010), the results show high correlation among *LPM2* and *LPM3* (*UPM2* and *UPM3*), as well as *LPM2* and *LPM4* (*UPM2* and *UPM4*). Despite that high correlation, they are still incorporated into the model to apply an extra penalty/benefit for higher momentums due to non-normality of returns.
9. See the introduction of Glawischnig and Sommersguter-Reichmann (2010).

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