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1. INTRODUCTION

Investors in Turkey have access to various financial instruments such as equities, bonds, derivatives, currencies and indices composed of such instruments. Investors use the risk and return characteristics of these securities as inputs in their portfolio allocation decisions. Risk-averse investors want to construct their portfolio mix such that they achieve the minimum risk possible for a specific level of expected return or they achieve the highest possible expected return for a specific level of risk. Financial economics literature has documented a positive relation between risk and return for various asset classes; however, this does not necessarily imply that every investment alternative compensates its investors with the same amount of return per unit of risk. Even in a certain asset class such as equities, various firm-related heterogeneities such as size, propensity to pay dividends or listed-sector may influence the nature of this trade-off.

This research report focuses on the risk and return attributes of various broad and sector-specific equity indices in Borsa Istanbul (BIST). The goal is to observe the distributional properties of a wide range of equity indices and to calculate the reward-to-risk ratios for these indices which will provide an idea about how these indices have performed in terms of generating a high return for a standardized amount of risk. Since investors in Turkey can also invest in foreign equity indices such as the S&P 500 index or move their investments to other asset classes such as US dollar, euro or gold, a comparison between BIST equity indices and these alternative investments are examined. These analyses are conducted for both a longer sample period from January 2001 to August 2016 and a more recent sample period which covers the most recent twenty months. Moreover, figures that capture the time-series of performance measures of selected asset classes are provided in order to observe the tendency of these performance measures to move in tandem or opposition. Although the past is never a perfect predictor of the future, the results of these analyses should be useful to institutional portfolio managers and individual investors.

2. METHODOLOGY

2.1 Reward-to-Risk Metrics

The first measure of reward-to-risk that is employed is the Sharpe ratio which is equal to the ratio of the mean excess return of an index to its standard deviation. The standard deviation is useful as a measure of risk since it captures the dispersion of actual returns around their means. Specifically, the Sharpe ratio is calculated as

$$Sharpe_{i,t} = \frac{R_{i,t} - R_f}{StDev_{i,t}}$$

where $R_{i,t}$ denotes the day t return on index i and R_f is the risk-free rate. All of the subsequent analysis is conducted for returns denominated in US dollars; therefore, the risk-free rate is estimated as the return on a one-month US Treasury bill. For each day t and index i , past 100 trading days is used to compute the standard deviation at the end of each month as

$$StDev_{i,t} = \sqrt{\frac{1}{99} \sum_{j=0}^{99} (R_{i,t-j} - \bar{R}_i)^2}$$

where \bar{R}_i is the arithmetic mean return of index i during the past 100 trading days.

Although it is the most commonly used reward-to-risk ratio, the Sharpe ratio is too broad since it incorporates the total risk of a portfolio and does not differentiate between an investment's upside potential and downside risk. Furthermore, the standard deviation is a valid risk measure only if the return distribution of an index is normal. Past academic research has already established that equity return distributions exhibit asymmetries and possess fatter tails compared to the normal distribution. In this case, in addition to the standard deviation, higher-order moments such as the skewness or kurtosis of a return distribution could affect expected asset returns (Kraus and Litzenberger, 1976; Dittmar, 2002). Also, if investors have different preferences with respect to gains and losses (Kahneman and Tversky, 1979) or aim to maximize their expected returns subject to a maximum loss constraint (Levy and Sarnat, 1972), the behavior of return distributions at their left-tails or downside risk will gain an additional importance

for asset pricing purposes. To take downside risk into account, the analysis incorporates various downside risk measures in the reward-to-risk calculations.

First, a semi-Sharpe ratio is calculated for each index in the following way:

$$SemiSharpe_{i,t} = \frac{R_{i,t} - R_f}{SemiStDev_{i,t}}$$

where $R_{i,t}$ denotes the day t return on index i and R_f is the risk-free rate. For each day t and index i , past 100 trading days is used to compute the semi-standard deviation at the end of each month as

$$SemiStDev_{i,t} = \sqrt{\frac{1}{99} \sum_{j=0}^{99} (R_{i,t-j} - \bar{R}_i)^2 \text{ if } R_{i,t-j} < 0}$$

One shortcoming of the semi-standard deviation measure is that it considers all the return realizations below zero and does not focus exclusively on the tails which is where the large losses materialize. In order to take tail risk into account, a nonparametric measure of value-at-risk (VaR) which measures how much the value of a portfolio could decline in a fairly extreme outcome if one were to rank order possible outcomes from best to worst is constructed. VaR attempts to highlight how much an investor can expect to lose on an investment in a given time period at a given level of probability. In the analysis, the minimum daily index returns observed during the past 100 trading days are calculated for each index and multiplied by -1 so that higher magnitudes of this VaR measure corresponds to greater downside risk. After these nonparametric VaR measures are calculated in a rolling window fashion at the end of each month, return-to-VaR ratios are calculated as

$$ReturntoVaR_{i,t} = \frac{R_{i,t} - R_f}{VaR_{i,t}}$$

Finally, a parametric return-to-VaR ratio is also constructed by replacing the denominator of the above measure with an alternative downside risk metric that draws on the lower tail of Hansen's (1994) skewed-t distribution which allows for asymmetries but maintains the assumption of zero mean and unit variance. Since the calculation of this parametric VaR measure is highly technical, we defer the details to the appendix of this research report. The parametric

return-to-VaR ratio is calculated at the end of each month as

$$ReturntoPVaR_{i,t} = \frac{R_{i,t} - R_f}{PVaR_{i,t}}$$

As previously mentioned, all of the reward-to-risk ratios are calculated at the end of each month and then the averages of these end-of-month measures are examined.

2.2 Equity Indices and Other Investments

The analysis investigates several broad equity indices and sector-specific indices that Borsa Istanbul provides. The major broad equity indices are the BIST 100, 50 and 30 indices which reflect the performances of 100, 50 and 30 stocks selected among the stocks of companies traded on the BIST Stars and BIST Main markets and the stocks of real estate investment trusts and venture capital investment trusts traded on the Collective and Structured Products Market. Stars market covers those equities whose market value of free float exceeds 100 million TL whereas Main market covers those equities whose market value of free float exceeds 25 million TL, but falls short of 100 million TL. BIST 100 and 30 indices also have capped versions that bound the weight of each stock in the index at 10%. BIST 100-30 index consists of 70 stocks included in the BIST 100 index but not in the BIST 30 index. The All Shares index consists of all stocks traded in BIST except investment trusts whereas the All Shares-100 index consists of the stocks included in the All Shares index but not in the BIST 100 index. The Dividend index selects stocks from the same universe as the BIST 100 index but considers only those which have distributed cash dividends in the last three years. The Dividend 25 index consists of 25 stocks placed in the first 2/3 slice in the ranking of the constituents of the Dividend index in descending order according to dividend yield. Additional broad equity indices include Investment Trusts index which consists of the stocks of investment trusts traded in BIST,

Public Offering index which is composed of stocks that are offered to the public and have started to be traded on Stars and Main markets and stocks of the real estate investment trusts and venture capital investment trusts offered to the public and started to be traded on the Collective and Structured Products Market, SME Industrial index which covers the stocks of industrial companies who satisfy at least one of the annual net sales or financial balance sheet size criteria (except the number of employees criterion) specified by the Ministry of Science, Industry and Technology for small and medium-sized enterprises and Sustainability index that consists of the stocks of those companies which perform over the threshold specified by various international corporate sustainability criteria. More thorough explanations of the selection criteria for each index can be found on the official website of Borsa Istanbul.

In addition to these broad equity indices, the subsequent analysis also investigates the performances of 25 distinct sector indices. The sector indices exclude stocks that are traded on the Pre-Market Trading Platform and the Watchlist Market and stocks included in lists C and D and traded on the BIST Emerging Companies Market. A new sector index is only calculated after the number of companies included in the scope of the index reaches five and the calculation of the index is halted if the number of companies falls to two.

Although BIST provides both a price index and a return index for each series, the analysis focuses on the latter which takes the effect of cash dividends into account. The return indices reflect the actual return of an investor who holds the index portfolio. All equity indices are weighted by free float market capitalization and the divisor for each index is adjusted for events such as capital increases in cash through or without right offerings, inclusion and exclusion of new stocks in the indices, changes in free float ratio, spin-offs and mergers.

Finally, to compare the performances of these broad and sector-specific equity indices with other investments, the analysis utilizes data on the performances of US dollar, euro, gold and the S&P index adjusted for cash distributions. The sample period used in this research report begins on January 2001 and ends at August 2016 unless a specific return series is initiated at a later date.

3. DESCRIPTIVE STATISTICS

Table 1 presents descriptive statistics for the daily returns of BIST equity indices and other investments for the full sample period in an alphabetical order. The first focus is given to the BIST 100/50/30/All Shares indices since they have data starting from 2001. BIST 100 index has a daily mean return of 6 basis points with a high standard deviation of 2.65%. The index has experienced a maximum daily loss of 21.37% whereas the maximum daily return has been 21.00%. The low skewness statistics indicates that the return distribution for BIST 100 has been fairly symmetric; however, the kurtosis statistic of 10.84 points out to the existence of fat tails. Since BIST equity indices are market capitalization-weighted and BIST 100 index automatically covers BIST 30 and BIST 50 indices, the descriptive statistics for these two indices are very similar to those of BIST 100. This observation also holds for the All Shares index. The other broad index that has been tracked since 2001 is the Investment Trusts index which has a mean daily return of 5 basis points, a large standard deviation of 2.46%, low skewness and a highly leptokurtic distribution. The other broad indices are initiated at a later period, thus, care should be taken in comparing their descriptive statistics with those of BIST 100/50/30/All Shares indices. For example, the capped versions of BIST 100 and BIST 30 indices have mean daily returns of -3 and -2 basis points, respectively. However, as will be seen later in the report, this negative performance is not due to the capping itself, but rather to the fact that

the sample period for these indices begin from December 2013 which is a period that has not been generally kind to stock market investors. A similar point can be made for the SME Industrial index which also began to be covered at the end of 2013. The mean daily return for this index is -12 basis points with a standard deviation of 1.74%, negative skewness of -1.35 and a high kurtosis value of 17.34. The Dividend and Dividend 25

indices are calculated since July 2011 and the mean return for the former (latter) index has been 0 (3) basis points. Finally, Star and Main indices have mean daily returns of 2 and 4 basis points, respectively; however, since the return series for these indices begin from only December 2015, little emphasis is given to their discussion in the rest of the research report.

TABLE 1. Descriptive Statistics for Borsa Istanbul Indices (2001/01 - 2016/08)

Panel A. Broad Indices

	Obs	Mean	St. Dev.	Min	25th	Median	75th	Max	Skew	Kurtosis
100 INDEX	3,931	0.0006	0.0265	-0.2137	-0.0122	0.0010	0.0141	0.2100	0.0320	10.8390
100 CAPPED INDEX	693	-0.0003	0.0182	-0.0913	-0.0112	0.0006	0.0106	0.0958	-0.1882	5.9765
100-30 INDEX	1929	0.0006	0.0168	-0.1141	-0.0078	0.0020	0.0098	0.1026	-0.6112	8.3144
30 INDEX	3,931	0.0006	0.0274	-0.2108	-0.0132	0.0009	0.0147	0.2221	0.1271	10.3531
30 CAPPED INDEX	693	-0.0002	0.0186	-0.0869	-0.0120	0.0007	0.0109	0.0960	-0.1154	5.5444
50 INDEX	3,931	0.0006	0.0268	-0.2117	-0.0126	0.0010	0.0144	0.2158	0.0767	10.6347
ALL SHARES INDEX	3,931	0.0006	0.0258	-0.2164	-0.0119	0.0012	0.0137	0.2074	-0.0213	11.2338
ALL SHARES-100 INDEX	1,929	0.0006	0.0154	-0.1075	-0.0061	0.0018	0.0086	0.1040	-0.8674	10.6130
DIVIDEND 25 INDEX	1,299	0.0003	0.0174	-0.1029	-0.0097	0.0011	0.0103	0.0830	-0.4051	6.3767
DIVIDEND INDEX	1,299	0.0000	0.0187	-0.1082	-0.0102	0.0007	0.0108	0.0985	-0.2785	6.4403
INVESTMENT TRUSTS INDEX	3,931	0.0005	0.0246	-0.2408	-0.0093	0.0009	0.0111	0.2158	-0.0064	14.3261
MAIN INDEX	191	0.0004	0.0160	-0.1087	-0.0054	0.0016	0.0075	0.0542	-1.9387	15.1013
PUBLIC OFFERING INDEX	1,597	0.0003	0.0173	-0.1057	-0.0085	0.0006	0.0101	0.0865	-0.5329	7.2774
SME INDUSTRIAL INDEX	693	-0.0012	0.0174	-0.1421	-0.0085	0.0001	0.0082	0.1119	-1.3542	17.3410
STARS INDEX	191	0.0002	0.0178	-0.0889	-0.0087	0.0008	0.0107	0.0433	-0.7571	6.1777
SUSTAINABILITY INDEX	462	-0.0004	0.0189	-0.0887	-0.0120	0.0011	0.0104	0.0937	-0.2146	5.6807

Panel B. Sector Indices

	Obs	Mean	St. Dev.	Min	25th	Median	75th	Max	Skew	Kurtosis
BANKING	3,931	0.0007	0.0310	-0.2436	-0.0153	0.0010	0.0166	0.2379	0.2120	9.7533
BASIC METAL	3,931	0.0010	0.0290	-0.2274	-0.0128	0.0017	0.0153	0.2697	0.0630	10.2498
BROKERAGE HOUSES	2,263	0.0001	0.0212	-0.1122	-0.0105	0.0016	0.0110	0.1894	-0.0801	9.0894
CHEMISTRY, PETRO- LEUM, PLASTIC	3,931	0.0007	0.0253	-0.1733	-0.0112	0.0012	0.0135	0.1763	-0.1136	8.6267
CONSTRUCTION	898	-0.0001	0.0196	-0.1045	-0.0108	0.0003	0.0121	0.0694	-0.3550	5.0151
ELECTRICITY	3,931	0.0002	0.0277	-0.1867	-0.0125	0.0003	0.0132	0.2388	-0.0186	9.5532
FINANCIALS	3,931	0.0006	0.0292	-0.2347	-0.0140	0.0010	0.0156	0.2353	0.1420	10.3694
FOOD, BEVERAGE	3,931	0.0007	0.0251	-0.1450	-0.0112	0.0009	0.0137	0.2311	-0.0394	10.1083
HOLDING AND IN- VESTMENT	3,931	0.0005	0.0278	-0.2028	-0.0130	0.0008	0.0145	0.2381	0.0917	10.4971
INDUSTRIALS	3,931	0.0007	0.0234	-0.1899	-0.0099	0.0018	0.0120	0.1925	-0.2574	11.2076
INFORMATION TECH- NOLOGY	3,931	0.0002	0.0279	-0.2359	-0.0123	0.0009	0.0139	0.1977	-0.1530	9.9585
INSURANCE	3,931	0.0007	0.0282	-0.2460	-0.0114	0.0009	0.0140	0.2201	-0.1938	10.5195
LEASING, FACTORING	3,931	0.0006	0.0287	-0.3131	-0.0119	0.0008	0.0137	0.1948	-0.3353	11.8089
METAL PRODUCTS, MACHINERY	3,931	0.0008	0.0264	-0.2010	-0.0117	0.0014	0.0143	0.1996	-0.0802	10.2239
MINING	898	-0.0014	0.0316	-0.2026	-0.0164	-0.0020	0.0127	0.1559	-0.0523	8.1405
NON-METAL MINER- AL PRODUCTS	3,931	0.0006	0.0220	-0.1979	-0.0091	0.0016	0.0116	0.2018	-0.4020	11.7950
REIT	3,931	0.0004	0.0267	-0.2545	-0.0117	0.0013	0.0139	0.2314	-0.3074	10.8713
SERVICES	3,931	0.0005	0.0242	-0.2066	-0.0109	0.0010	0.0122	0.2721	0.0553	13.8563
TECHNOLOGY	3,931	0.0005	0.0273	-0.2421	-0.0116	0.0014	0.0141	0.1977	-0.2557	11.1731
TELECOMMUNICA- TION	3,931	0.0006	0.0307	-0.2170	-0.0140	0.0002	0.0147	0.3031	0.3854	11.8415
TEXTILE, LEATHER	3,931	0.0004	0.0245	-0.2376	-0.0094	0.0015	0.0127	0.2705	-0.6651	15.0762
TOURISM	3,931	0.0004	0.0324	-0.1853	-0.0132	-0.0002	0.0141	0.3771	0.4986	13.6314
TRANSPORTATION	3,931	0.0007	0.0287	-0.1903	-0.0137	0.0011	0.0153	0.2262	-0.0532	8.3173
WHOLESALE AND RETAIL TRADE	3,931	0.0007	0.0251	-0.2022	-0.0110	0.0008	0.0129	0.2701	0.0724	13.4044
WOOD, PAPER, PRINTING	3,931	0.0005	0.0263	-0.2730	-0.0115	0.0007	0.0138	0.2390	-0.2512	11.6829

Panel C. Other Investments

	Obs	Mean	St. Dev.	Min	25th	Median	75th	Max	Skew	Kurtosis
USD	3,931	0.0005	0.0126	-0.1500	-0.0045	0.0000	0.0042	0.4544	12.7319	452.5759
EURO	3,931	0.0005	0.0127	-0.1487	-0.0043	0.0000	0.0044	0.4474	11.8618	412.7654
GOLD	3,931	0.0005	0.0113	-0.0966	-0.0048	0.0004	0.0063	0.0711	-0.3107	8.1907
STANDARD & POOR'S 500	3,931	0.0002	0.0123	-0.0903	-0.0048	0.0003	0.0056	0.1158	-0.0099	12.3956

Investigating a reduced sample period that begins from January 2015 may provide more insight in terms of comparing the index performances and understanding the more recent equity market trends. This analysis is presented in Table 2. The only positive mean returns belong to Stars and Main indices; however, this observation is an artifact of their shorter sample period. Looking at BIST 100/50/30/ All Shares indices and their capped versions, one can observe that their mean daily returns have been -5 to -6 basis points with standard deviations between 1.81% and 1.90%. The minimum daily returns are from -8.69% to -9.14% and the maximum daily returns are from 9.44% to 9.67%. The skewness statistics of these major equity indices fall within the band between -1 and 0; however, the kurtosis statistics all exceed 6 which again indicates the increased probability of extreme outcomes. Another important observation is that the mean daily return of All Shares-100 index has been only -1 basis points which hints at the idea that smaller stocks have generated better returns than larger stocks in the recent sample period. Among the other broad equity indices, the worst return generator has been the SME Industrial index with a mean daily return of -12 basis points. This index also has the most

negative skewness (-2.02), highest kurtosis (19.63) and the most negative daily return (-14.21%). Next, the attention is turned to the sector-specific indices. Panel B of Table 1 presents the descriptive statistics for these indices starting from January 2001. The time-series for most of these indices extend back to the beginning of the sample period, thus, they are on an equal footing with the exception of Construction, Mining and Brokerage Houses indices. These three indices are excluded from the discussion of this panel. Basic Metal and Metal Products, Machinery indices have the highest average daily returns with 10 and 8 basis points, respectively. Seven other sectors follow with mean returns of 7 basis points. The lowest average returns belong to Information Technology and Electricity indices with 2 basis points. The standard deviations fall within a band between 2.20% and 3.24%. The most negative (positive) daily return is observed for the leasing and factoring (tourism) sector and is equal to -31.31% (37.71%). The sector index return distributions are fairly symmetric with skewness statistics whose absolute values are all less than 1; however, they are also leptokurtic with the highest (lowest) kurtosis value observed for the textile and leather (transportation) sector.

TABLE 2. Descriptive Statistics for Borsa Istanbul Indices (2015/01 – 2016/08)

Panel A. Broad Indices

	Obs	Mean	St. Dev.	Min	25th	Median	75th	Max	Skew	Kurtosis
100 INDEX	421	-0.0006	0.0185	-0.0914	-0.0115	0.0002	0.0101	0.0958	-0.2931	6.5542
100 CAPPED INDEX	421	-0.0006	0.0185	-0.0913	-0.0115	0.0002	0.0101	0.0958	-0.2931	6.5659
100-30 INDEX	421	-0.0005	0.0174	-0.1114	-0.0091	0.0012	0.0090	0.0914	-0.7725	9.7081
30 INDEX	421	-0.0006	0.0190	-0.0877	-0.0126	0.0002	0.0106	0.0967	-0.2167	6.0473
30 CAPPED INDEX	421	-0.0006	0.0188	-0.0869	-0.0122	0.0004	0.0106	0.0960	-0.2224	6.0732
50 INDEX	421	-0.0006	0.0188	-0.0907	-0.0121	0.0002	0.0104	0.0965	-0.2461	6.2998
ALL SHARES INDEX	421	-0.0005	0.0181	-0.0912	-0.0110	0.0003	0.0099	0.0944	-0.3527	6.9240
ALL SHARES-100 INDEX	421	-0.0001	0.0144	-0.1075	-0.0061	0.0011	0.0070	0.0768	-1.4185	14.8979
DIVIDEND 25 INDEX	421	0.0000	0.0172	-0.0816	-0.0100	0.0009	0.0100	0.0755	-0.3752	5.5322
DIVIDEND INDEX	421	-0.0004	0.0188	-0.0897	-0.0117	0.0004	0.0105	0.0978	-0.2260	6.2724
INVESTMENT TRUSTS INDEX	421	-0.0003	0.0138	-0.0924	-0.0074	0.0003	0.0073	0.0684	-0.8725	10.5458
MAIN INDEX	191	0.0004	0.0160	-0.1087	-0.0054	0.0016	0.0075	0.0542	-1.9387	15.1013
PUBLIC OFFERING INDEX	421	-0.0002	0.0163	-0.1055	-0.0085	-0.0003	0.0101	0.0671	-1.1386	10.2112
SME INDUSTRIAL INDEX	421	-0.0012	0.0170	-0.1421	-0.0085	0.0001	0.0085	0.0825	-2.0152	19.6341
STARS INDEX	191	0.0002	0.0178	-0.0889	-0.0087	0.0008	0.0107	0.0433	-0.7571	6.1777
SUSTAINABILITY INDEX	421	-0.0005	0.0189	-0.0887	-0.0121	0.0009	0.0102	0.0937	-0.1980	5.7309

Panel A. Broad Indices

	Obs	Mean	St. Dev.	Min	25th	Median	75th	Max	Skew	Kurtosis
BANKING	421	-0.0007	0.0235	-0.1093	-0.0140	0.0004	0.0129	0.1370	0.0286	6.8383
BASIC METAL	421	-0.0002	0.0209	-0.0744	-0.0119	0.0005	0.0117	0.0683	-0.0538	3.8006
BROKERAGE HOUSES	421	-0.0005	0.0185	-0.0872	-0.0115	-0.0001	0.0104	0.0950	-0.2407	6.3775
CHEMISTRY, PETRO- LEUM, PLASTIC	421	0.0001	0.0171	-0.0732	-0.0093	0.0007	0.0104	0.0634	-0.2792	4.6283
CONSTRUCTION	421	-0.0003	0.0185	-0.0874	-0.0095	0.0000	0.0100	0.0599	-0.3141	4.9043
ELECTRICITY	421	-0.0005	0.0214	-0.1495	-0.0105	0.0000	0.0097	0.1154	-0.8478	11.5933
FINANCIALS	421	-0.0006	0.0207	-0.1008	-0.0126	0.0007	0.0112	0.1166	-0.1626	7.0631
FOOD, BEVERAGE	421	-0.0007	0.0188	-0.1138	-0.0115	-0.0003	0.0096	0.0756	-0.4902	6.7032
HOLDING AND IN- VESTMENT	421	-0.0004	0.0179	-0.0890	-0.0103	0.0004	0.0103	0.0748	-0.4213	5.5739
INDUSTRIALS	421	-0.0002	0.0163	-0.0806	-0.0096	0.0004	0.0088	0.0710	-0.4495	5.8769
INFORMATION TECH- NOLOGY	421	0.0005	0.0216	-0.1467	-0.0105	0.0011	0.0123	0.1036	-0.6804	10.2674
INSURANCE	421	-0.0001	0.0125	-0.0573	-0.0074	-0.0002	0.0072	0.0635	-0.1032	5.7302
LEASING, FACTORING	421	0.0003	0.0179	-0.1006	-0.0093	0.0006	0.0091	0.1035	-0.0017	8.5362
METAL PRODUCTS, MACHINERY	421	0.0002	0.0182	-0.0870	-0.0104	0.0010	0.0109	0.0855	-0.2587	5.6391
MINING	421	-0.0005	0.0356	-0.2026	-0.0186	-0.0002	0.0169	0.1559	0.0332	8.4393
NATIONAL SERVICES	421	-0.0008	0.0166	-0.0842	-0.0104	0.0002	0.0088	0.0736	-0.6075	6.3641
NON-METAL MINER- AL PRODUCTS	421	-0.0006	0.0173	-0.1075	-0.0094	0.0007	0.0087	0.0895	-0.7291	9.2828
REIT	421	0.0000	0.0200	-0.1187	-0.0111	0.0011	0.0107	0.1316	-0.2263	11.3166
TECHNOLOGY	421	0.0006	0.0195	-0.1314	-0.0090	0.0001	0.0111	0.1033	-0.7097	11.0123
TELECOMMUNICATION	421	-0.0009	0.0191	-0.0747	-0.0112	-0.0009	0.0107	0.0609	-0.2779	3.9768
TEXTILE, LEATHER	421	-0.0002	0.0194	-0.1218	-0.0090	0.0005	0.0108	0.0869	-1.0526	9.7185
TOURISM	421	-0.0006	0.0220	-0.1344	-0.0096	-0.0009	0.0102	0.0985	-0.4840	10.5441
TRANSPORTATION	421	-0.0017	0.0224	-0.1392	-0.0142	-0.0007	0.0111	0.1044	-0.5753	7.7353
WHOLESALE AND RETAIL TRADE	421	-0.0004	0.0179	-0.0819	-0.0091	-0.0003	0.0102	0.0698	-0.4233	5.4007
WOOD, PAPER, PRINTING	421	-0.0004	0.0175	-0.0997	-0.0089	0.0001	0.0097	0.0632	-0.6829	7.5509

Panel C. Other Investments

	Obs	Mean	St. Dev.	Min	25th	Median	75th	Max	Skew	Kurtosis
USD	421	0.0005	0.0075	-0.0298	-0.0045	0.0000	0.0051	0.0349	0.3325	4.6648
EURO	421	0.0004	0.0084	-0.0308	-0.0040	0.0003	0.0045	0.0438	0.2756	5.8126
GOLD	421	0.0004	0.0094	-0.0258	-0.0054	-0.0001	0.0056	0.0473	0.6201	5.4996
STANDARD & POOR'S 500	421	0.0002	0.0094	-0.0394	-0.0043	0.0000	0.0049	0.0390	-0.2561	4.9227

Panel B of Table 2 presents descriptive statistics for the sector indices for the sample period from January 2015. All sector indices have complete data for this more recent time frame. Technology and Information Technology have the highest average daily returns with 6 and 5 basis points, respectively. The only other three industries with positive mean returns are leasing and factoring, metal products and machinery, and chemistry, petroleum and plastic. The five worst performing sectors during the recent period have been food and beverage, banking, national services, telecommunication and transportation sectors in descending order with mean returns between -7 and -17 basis points. The standard deviations of returns for all indices lie between 1.25% and 3.56% which is a wider band compared to that of the full sample period. The most negative and positive daily returns both belong to the mining industry with -20.26% and 15.59%, respectively. The absolute values of the skewness statistics are again all less than 1 with the exception of the textile and leather industry. The kurtosis statistics are generally lower compared to the full sample period with the highest (lowest) kurtosis value belonging to the electricity (basic metal) industry.

Finally, Panel C of Tables 1 and 2 present descriptive statistics for US dollar, euro, gold and S&P 500 index for the full and reduced sample periods. For the full sample period, USD and euro have mean daily returns of 5 basis points, just below those of the major broad BIST indices. On the other hand, the standard deviations for these currency returns are less than half of those of the major broad BIST indices. The minimum daily return for USD has been -15.00% and the maximum has been 45.44%. The analogous figures are -14.87% and 44.74% for euro, respectively. Both series exhibit large positive skewness with statistics exceeding 10 and high leptokurtosis with statistics exceeding 400, a result which is not unexpected due to the likelihood of extreme currency movements. Such large fluctuations in currency values are associated with the financial crisis of Turkey in 2001 and the global credit crisis of 2008. Gold has the same mean return with the two currency series; however, its distribution is more well-behaved with milder higher-order moments. S&P 500 index also has a well-behaved distribution, but its average daily return of 2 basis points falls short compared to the other

investments. For the more recent sample period, the mean returns of all four investment alternatives have been very close to those in the full sample period. It is worth pointing out that all major broad BIST indices have negative returns during this recent time frame whereas US dollar, euro, gold and S&P 500 index were able to compensate their investors with positive returns. The standard deviations of the four indices are between 0.75% and 0.94%, again less than half of those of major broad BIST indices. The skewness and kurtosis statistics indicate that the four indices had distributions closer to the normality assumption compared to the full sample period.

This section of the report presented various return characteristics for a wide variety of BIST equity indices and alternative investments. However, a high average return by itself does not justify an investment's value. Market participants are concerned about both the risk and the return of their investments and particularly how much return they are earning per unit of risk they assume. To answer this question, the next section of the report compares all previously mentioned indices based on alternative reward-to-risk metrics.

4. REWARD-TO-RISK METRICS

4.1 Full Sample Period

When one focuses on the Sharpe ratio rankings in Panel A of Table 3, the best performing sectors reveal themselves to be industrials, basic metal, metal products and machinery, non-metal mineral products, and wholesale and retail trade. The average monthly Sharpe ratios vary between 0.0477 and 0.0540 for this group. To put things into perspective, one can interpret these numbers by stating that Industrials index generated a 5.40% excess return per unit of standard deviation during the full sample period. The five sectors that are located at the bottom of the rankings are wood, paper and printing, information technology, brokerage houses, electricity and tourism with average Sharpe ratios between 0.0147 and 0.0275. This goes on to show that there is a large heterogeneity of Sharpe ratios between industries with the best performing sector having an average Sharpe ratio about four times as high as that of the worst performing sector. This heterogeneity seems to be mostly driven by the mean returns due to the relative uniformity of the sector-index volatilities in Table 1. Two indices with the highest mean returns (Basic Metal and Metal Products, Machinery) continue to stay on the top after adjusting for risk as measured by standard deviation and two indices with the lowest mean returns (Information Technology and Electricity) stay put at the bottom of the rankings. The minimum monthly Sharpe ratios vary between -0.2717 (transportation) and -0.1386 (food and beverage) whereas the maximum monthly Sharpe ratios vary between 0.2333 (telecommunications) and 0.4447 (textile and leather, basic metal).

Looking next at the major broad equity indices, All Shares/100/50 and 30 indices have average Sharpe ratios of 0.0429, 0.0414, 0.0401 and 0.0393, respectively. Although these values are close, a point can be made that the mean Sharpe ratios mildly drop as the index focuses on a sample of larger stocks. Gold fares well with these broad BIST indices with its Sharpe ratio of 0.0429 and S&P 500 ranks close

with its Sharpe ratio of 0.0364. Although the mean return of S&P 500 index was low in Table 1, it also had a small standard deviation which boosts up its volatility-adjusted performance. On the other hand, although US dollar and euro had mean returns close to the broad BIST indices in Table 1, their Sharpe ratios of 0.0253 and 0.0158 cannot match up with those of the major BIST equity indices which highlights the importance of risk-adjustment.

TABLE 3. Reward-to-Risk Ratios (2001/01 – 2016/08)

Panel A. Sharpe Ratios

	Mean	Median	Minimum	Maximum	Obs
ALL SHARES-100 INDEX	0.0557	0.0372	-0.1771	0.4407	88
INDUSTRIALS	0.0540	0.0512	-0.1847	0.3942	184
BASIC METAL	0.0532	0.0532	-0.1595	0.3577	184
METAL PRODUCTS, MACHINERY	0.0525	0.0584	-0.2109	0.4447	184
100-30 INDEX	0.0514	0.0294	-0.1967	0.4425	88
NON-METAL MINERAL PRODUCTS	0.0486	0.0516	-0.2090	0.3676	184
WHOLESALE AND RETAIL TRADE	0.0477	0.0528	-0.2016	0.3453	184
CHEMISTRY, PETROLEUM, PLASTIC	0.0467	0.0366	-0.2033	0.3506	184
TECHNOLOGY	0.0445	0.0365	-0.2203	0.4118	184
INSURANCE	0.0435	0.0404	-0.2544	0.3270	184
ALL SHARES INDEX	0.0429	0.0445	-0.1977	0.3789	184
GOLD	0.0429	0.0423	-0.1862	0.2601	184
DIVIDEND 25 INDEX	0.0428	0.0183	-0.1378	0.2667	58
FOOD, BEVERAGE	0.0424	0.0446	-0.1386	0.3317	184
NATIONAL SERVICES	0.0416	0.0391	-0.2154	0.3191	184
100 INDEX	0.0414	0.0432	-0.1976	0.3699	184
TEXTILE, LEATHER	0.0409	0.0337	-0.1695	0.4447	184
50 INDEX	0.0401	0.0392	-0.1906	0.3628	184
30 INDEX	0.0393	0.0409	-0.1905	0.3525	184
FINANCIALS	0.0369	0.0415	-0.1833	0.3670	184
STANDARD & POOR'S 500	0.0364	0.0314	-0.1466	0.2241	184
LEASING, FACTORING	0.0364	0.0318	-0.2299	0.3822	184
INVESTMENT TRUSTS INDEX	0.0363	0.0303	-0.1955	0.3513	184
BANKING	0.0361	0.0431	-0.2052	0.3458	184
HOLDING AND INVESTMENT	0.0356	0.0331	-0.2068	0.4150	184
TRANSPORTATION	0.0352	0.0248	-0.2717	0.4027	184
REIT	0.0316	0.0279	-0.2346	0.3743	184
TELECOMMUNICATION	0.0291	0.0237	-0.1992	0.2333	184
WOOD, PAPER, PRINTING	0.0275	0.0243	-0.2206	0.2366	184
INFORMATION TECHNOLOGY	0.0270	0.0311	-0.2203	0.3849	184
BROKERAGE HOUSES	0.0269	0.0112	-0.2069	0.3690	104
DIVIDEND INDEX	0.0266	0.0032	-0.1361	0.2742	58
PUBLIC OFFERING INDEX	0.0260	0.0260	-0.1873	0.1652	72
EURO	0.0253	0.0294	-0.2395	0.2313	184
USD	0.0158	0.0117	-0.2742	0.2507	184
ELECTRICITY	0.0156	0.0160	-0.2207	0.3114	184
TOURISM	0.0147	0.0080	-0.2245	0.3010	184
30 CAPPED INDEX	0.0132	-0.0081	-0.0950	0.2110	29
100 CAPPED INDEX	0.0126	-0.0081	-0.0994	0.2139	29
CONSTRUCTION	-0.0021	-0.0078	-0.1054	0.1109	39
SUSTAINABILITY INDEX	-0.0098	-0.0253	-0.0860	0.1504	18
MINING	-0.0389	-0.0654	-0.2413	0.1722	39
SME INDUSTRIAL INDEX	-0.0556	-0.0536	-0.1700	0.0499	29

Panel B. Semi-Sharpe Ratios

	Mean	Median	Minimum	Maximum	Obs
BASIC METAL	0.0933	0.0836	-0.2596	0.7640	184
METAL PRODUCTS, MACHINERY	0.0897	0.0829	-0.3149	0.8869	184
ALL SHARES-100 INDEX	0.0841	0.0490	-0.1969	0.8783	88
INDUSTRIALS	0.0817	0.0702	-0.2873	0.7997	184
WHOLESALE AND RETAIL TRADE	0.0810	0.0837	-0.3484	0.6098	184
100-30 INDEX	0.0793	0.0378	-0.2287	0.8055	88
INSURANCE	0.0765	0.0570	-0.2908	0.5337	184
TECHNOLOGY	0.0759	0.0573	-0.3395	0.7634	184
CHEMISTRY, PETROLEUM, PLASTIC	0.0757	0.0529	-0.3242	0.6760	184
NON-METAL MINERAL PRODUCTS	0.0751	0.0716	-0.2627	0.7314	184
LEASING, FACTORING	0.0736	0.0505	-0.2719	0.8542	184
TRANSPORTATION	0.0727	0.0331	-0.3128	0.8629	184
ALL SHARES INDEX	0.0726	0.0680	-0.2489	0.7791	184
FOOD, BEVERAGE	0.0713	0.0650	-0.2249	0.7786	184
100 INDEX	0.0711	0.0652	-0.2513	0.7523	184
DIVIDEND 25 INDEX	0.0709	0.0246	-0.2222	0.4792	58
50 INDEX	0.0703	0.0615	-0.2499	0.7346	184
NATIONAL SERVICES	0.0700	0.0604	-0.3068	0.6614	184
30 INDEX	0.0696	0.0638	-0.2574	0.7030	184
GOLD	0.0689	0.0592	-0.2097	0.5236	184
BANKING	0.0679	0.0640	-0.3199	0.6579	184
FINANCIALS	0.0678	0.0606	-0.2888	0.7191	184
INVESTMENT TRUSTS INDEX	0.0660	0.0472	-0.3262	0.7270	184
HOLDING AND INVESTMENT	0.0642	0.0485	-0.2762	0.7840	184
TEXTILE, LEATHER	0.0623	0.0423	-0.2119	0.6651	184
REIT	0.0573	0.0407	-0.3422	0.6427	184
WOOD, PAPER, PRINTING	0.0562	0.0385	-0.2666	0.4465	184
TELECOMMUNICATION	0.0557	0.0374	-0.2720	0.5114	184
STANDARD & POOR'S 500	0.0536	0.0497	-0.2525	0.3579	184
INFORMATION TECHNOLOGY	0.0526	0.0425	-0.3440	0.7940	184
BROKERAGE HOUSES	0.0489	0.0151	-0.3140	0.7242	104
DIVIDEND INDEX	0.0484	0.0041	-0.2259	0.4953	58
EURO	0.0481	0.0431	-0.3874	0.4440	184
PUBLIC OFFERING INDEX	0.0420	0.0348	-0.2347	0.3010	72
ELECTRICITY	0.0371	0.0254	-0.3124	0.5524	184
USD	0.0329	0.0200	-0.4853	0.4744	184
TOURISM	0.0318	0.0145	-0.3070	0.5574	184
30 CAPPED INDEX	0.0264	-0.0098	-0.1477	0.3515	29
100 CAPPED INDEX	0.0246	-0.0128	-0.1392	0.3406	29
CONSTRUCTION	-0.0002	-0.0101	-0.1405	0.1885	39
SUSTAINABILITY INDEX	-0.0139	-0.0336	-0.1429	0.2388	18
MINING	-0.0437	-0.0963	-0.3246	0.3060	39
SME INDUSTRIAL INDEX	-0.0726	-0.0600	-0.2705	0.0667	29

Panel C. Return-to-VaR Ratios

	Mean	Median	Minimum	Maximum	Obs
BASIC METAL	0.0209	0.0184	-0.0660	0.1509	184
100-30 INDEX	0.0206	0.0089	-0.0535	0.2403	88
METAL PRODUCTS, MACHINERY	0.0203	0.0176	-0.0764	0.2481	184
ALL SHARES-100 INDEX	0.0194	0.0103	-0.0366	0.2135	88
TECHNOLOGY	0.0191	0.0122	-0.0839	0.1990	184
INDUSTRIALS	0.0190	0.0144	-0.0743	0.2170	184
WHOLESALE AND RETAIL TRADE	0.0189	0.0175	-0.0860	0.1425	184
INSURANCE	0.0184	0.0128	-0.0587	0.1335	184
DIVIDEND 25 INDEX	0.0181	0.0051	-0.0499	0.1362	58
TRANSPORTATION	0.0181	0.0078	-0.0646	0.2298	184
CHEMISTRY, PETROLEUM, PLASTIC	0.0180	0.0120	-0.0747	0.1622	184
NON-METAL MINERAL PRODUCTS	0.0177	0.0148	-0.0609	0.2011	184
ALL SHARES INDEX	0.0174	0.0138	-0.0545	0.2041	184
LEASING, FACTORING	0.0173	0.0100	-0.0581	0.1959	184
100 INDEX	0.0172	0.0138	-0.0541	0.1999	184
FOOD, BEVERAGE	0.0172	0.0135	-0.0548	0.2071	184
50 INDEX	0.0169	0.0140	-0.0533	0.1939	184
GOLD	0.0169	0.0134	-0.0565	0.1354	184
30 INDEX	0.0168	0.0134	-0.0536	0.1851	184
BANKING	0.0165	0.0143	-0.0659	0.1885	184
FINANCIALS	0.0164	0.0130	-0.0599	0.2002	184
NATIONAL SERVICES	0.0163	0.0127	-0.0701	0.1540	184
INVESTMENT TRUSTS INDEX	0.0157	0.0087	-0.0733	0.1830	184
HOLDING AND INVESTMENT	0.0146	0.0102	-0.0615	0.2319	184
TEXTILE, LEATHER	0.0139	0.0085	-0.0512	0.1598	184
WOOD, PAPER, PRINTING	0.0139	0.0080	-0.0584	0.1175	184
REIT	0.0137	0.0089	-0.0750	0.1810	184
INFORMATION TECHNOLOGY	0.0135	0.0077	-0.0854	0.2067	184
TELECOMMUNICATION	0.0133	0.0079	-0.0528	0.1143	184
STANDARD & POOR'S 500	0.0131	0.0116	-0.0608	0.0958	184
BROKERAGE HOUSES	0.0127	0.0033	-0.0901	0.2086	104
DIVIDEND INDEX	0.0121	0.0008	-0.0536	0.1307	58
EURO	0.0110	0.0099	-0.0939	0.1128	184
PUBLIC OFFERING INDEX	0.0093	0.0067	-0.0465	0.0764	72
ELECTRICITY	0.0089	0.0055	-0.0785	0.1489	184
USD	0.0089	0.0044	-0.1119	0.1424	184
TOURISM	0.0078	0.0028	-0.0713	0.1155	184
30 CAPPED INDEX	0.0068	-0.0019	-0.0363	0.0781	29
100 CAPPED INDEX	0.0063	-0.0031	-0.0344	0.0742	29
CONSTRUCTION	0.0008	-0.0020	-0.0276	0.0455	39
SUSTAINABILITY INDEX	-0.0019	-0.0066	-0.0344	0.0560	18
MINING	-0.0078	-0.0171	-0.0754	0.0724	39
SME INDUSTRIAL INDEX	-0.0148	-0.0125	-0.0647	0.0154	29

Panel D. Return-to-Parametric VaR Ratios

	Mean	Median	Minimum	Maximum	Obs
BASIC METAL	0.0247	0.0216	-0.0734	0.1927	184
GOLD	0.0241	0.0154	-0.0560	0.5963	183
METAL PRODUCTS, MACHINERY	0.0239	0.0195	-0.0787	0.2503	184
ALL SHARES-100 INDEX	0.0231	0.0114	-0.0469	0.2594	88
100-30 INDEX	0.0226	0.0096	-0.0520	0.2419	88
INDUSTRIALS	0.0223	0.0169	-0.0746	0.2317	184
WHOLESALE AND RETAIL TRADE	0.0222	0.0212	-0.0852	0.1830	184
LEASING, FACTORING	0.0221	0.0123	-0.0660	0.2589	184
INSURANCE	0.0217	0.0143	-0.0638	0.1548	184
TECHNOLOGY	0.0215	0.0146	-0.0855	0.2079	184
NON-METAL MINERAL PRODUCTS	0.0211	0.0186	-0.0628	0.2111	184
TRANSPORTATION	0.0209	0.0088	-0.0779	0.2561	184
CHEMISTRY, PETROLEUM, PLASTIC	0.0208	0.0140	-0.0800	0.1886	184
ALL SHARES INDEX	0.0201	0.0158	-0.0605	0.2215	184
DIVIDEND 25 INDEX	0.0198	0.0064	-0.0538	0.1363	58
100 INDEX	0.0197	0.0152	-0.0623	0.2158	184
50 INDEX	0.0194	0.0150	-0.0620	0.2109	184
30 INDEX	0.0193	0.0151	-0.0618	0.2043	184
BANKING	0.0193	0.0167	-0.0767	0.1990	184
FOOD, BEVERAGE	0.0192	0.0164	-0.0582	0.1919	184
FINANCIALS	0.0191	0.0150	-0.0695	0.2121	184
NATIONAL SERVICES	0.0190	0.0150	-0.0769	0.1738	184
INVESTMENT TRUSTS INDEX	0.0186	0.0114	-0.0782	0.2009	184
HOLDING AND INVESTMENT	0.0176	0.0116	-0.0679	0.2294	184
TEXTILE, LEATHER	0.0172	0.0094	-0.0530	0.2019	184
WOOD, PAPER, PRINTING	0.0163	0.0097	-0.0659	0.1260	184
REIT	0.0163	0.0102	-0.0827	0.2093	184
INFORMATION TECHNOLOGY	0.0158	0.0091	-0.0863	0.2130	184
TELECOMMUNICATION	0.0155	0.0093	-0.0644	0.1467	184
STANDARD & POOR'S 500	0.0152	0.0121	-0.0717	0.1029	184
BROKERAGE HOUSES	0.0143	0.0037	-0.0813	0.2124	104
EURO	0.0136	0.0108	-0.1001	0.1417	182
DIVIDEND INDEX	0.0134	0.0010	-0.0566	0.1344	58
PUBLIC OFFERING INDEX	0.0113	0.0083	-0.0560	0.0811	72
ELECTRICITY	0.0111	0.0066	-0.0805	0.1559	184
TOURISM	0.0108	0.0034	-0.0779	0.1570	184
USD	0.0093	0.0050	-0.1323	0.1329	182
30 CAPPED INDEX	0.0077	-0.0023	-0.0377	0.0920	29
100 CAPPED INDEX	0.0072	-0.0035	-0.0361	0.0896	29
CONSTRUCTION	0.0005	-0.0024	-0.0313	0.0511	39
SUSTAINABILITY INDEX	-0.0027	-0.0081	-0.0361	0.0657	18
MINING	-0.0090	-0.0218	-0.0776	0.0824	39
SME INDUSTRIAL INDEX	-0.0167	-0.0139	-0.0711	0.0181	29

The rankings of semi-Sharpe ratios, which only take those returns below zero when calculating risk, are presented in Panel B of Table 3. These rankings are similar to the Sharpe ratio rankings. Insurance replaces Non-Metal Mineral Products in the top five whereas Telecommunication replaces Wood, Paper and Printing in the bottom five. The average semi-Sharpe ratio of the best performing sector (basic metals) is equal to 0.0933 and about three times as high as the average semi-Sharpe ratio of the worst performing sector (tourism) which is equal to 0.0318. The semi-Sharpe ratios of the broad BIST indices are again close to one another with values declining from 0.0726 for the All Shares index to 0.0696 for the BIST 30 index. Gold continues to stay close to these equity indices with its semi-Sharpe ratio of 0.0689; however, this time, S&P 500 index slips down in the rankings with its semi-standard deviation adjusted performance of 0.0536. Euro and US dollar are only able to beat two and one sector indices with mean semi-Sharpe values equal to 0.0481 and 0.0329, respectively.

In Panel C of Table 3, average return-to-VaR ratios are calculated to capture downside risk at the left-tail of the index return distributions. Technology index sneaks into the top five whereas the bottom five group consists of the same sectors as in the semi-Sharpe ratio rankings. Again, the average return-to-VaR ratio of the best performing sector (basic metals) is equal to 0.0209 and about three times as high as the average return-to-VaR ratio of the worst performing sector (tourism) which is equal to 0.0078. The aforementioned trends for the major BIST indices persist with values declining from 0.0174 for the All Shares index to 0.0168 for the BIST 30 index. Gold ranks similar to the broad equity indices with its return-to-VaR ratio of 0.0169; however, S&P 500 index, euro and US dollar rank at the bottom with return-to-VaR ratios between 0.089 and 0.0131. These results are expected since especially euro and US dollar have very large skewness and kurtosis statistics which do not help their value-at-risk metrics. Although many patterns in this panel are similar to those for semi-Sharpe ratios, there are also some differences such as Dividend 25 index climbing up the rankings.

Finally, Panel D of Table 3 focuses on return-to-parametric VaR ratio rankings. Since the non-parametric and parametric versions of value-at-risk

are highly correlated, one does not expect a large scale change in the reward-to-risk rankings compared to Panel C of Table 3. The top five and bottom five sectors stay the same with the exception of leasing and factoring finding its place among the top group. The range for the mean return-to-PVaR ratios is between 0.0108 (tourism) and 0.0247 (basic metal). The major BIST indices fall within this range with return-to-PVaR ratios between 0.0193 (BIST 30 index) and 0.0201 (All Shares index). S&P 500 index and euro continue to be ranked towards the bottom. With its return-to-PVaR ratio of 0.093, there is no single equity index that US dollar can outperform. One final point to highlight is that Gold can be spotted at the second row of this panel with its return-to-PVaR ratio of 0.0241 which is only behind Basic Metals index.

4.2 Recent Sample Period

The average reward-to-risk metrics for each BIST equity index and alternative investments for the sample period between January 2015 and August 2016 are presented in Table 4. For this recent time frame, all of the indices have 20 months of data available (except Sustainability index which has two observations missing) and are eligible to be compared on an equal footing.

Panel A of Table 4 presents the mean, median, minimum and maximum Sharpe ratios for all investments. The five sector indices that have the highest average Sharpe ratios are Technology, Information Technology, Chemistry, Petroleum and Plastic, Metal Products and Machinery, and Leasing and Factoring. Average Sharpe ratios vary between 0.0259 and 0.0556 for these indices. Looking back to Panel B of Table 2, these are also the only indices that have positive mean returns during the recent sample period. Similarly, the five sector indices with the lowest average Sharpe ratios are among the indices with the lowest mean returns. These indices are Wood, Paper and Printing, Services, Telecommunication, Food and Beverage, and Transportation whose Sharpe ratios vary between -0.0468 and -0.0240. The minimum monthly Sharpe ratios vary between -0.2413 (mining) and -0.0619 (technology) whereas the maximum monthly Sharpe ratios vary between 0.0959 (construction) and 0.2448 (leasing and factoring). 16 out of 25 sector indices under scrutiny have negative

mean Sharpe ratios. In other words, most of the sector indices caused capital losses for their investors after adjusting for risk. This observation also holds true for the broad BIST All Shares/100/50/30 indices and their capped versions whose Sharpe ratios fall within the interval between -0.0129 and -0.0110. An investor who invests in an index fund which tracks BIST 100 index lost 1.25% per unit standard deviation each month on a before-fee basis. The analogous figure is -5.81% for SME Industrial index. On the other hand, two broad indices stand out with positive risk-adjusted performances which are Dividend 25 and All Shares-100 indices with Sharpe values of 0.0151 and 0.0146, respectively. This result indicates that smaller stocks and stocks with higher dividend yields had better reward-to-risk ratios during the recent sample period.

Finally, US dollar, euro, gold and S&P 500 index enjoyed better performances compared to the full sample period relative to BIST equity indices. US dollar dominates all other investments with its mean Sharpe ratio of 0.0654 and euro is only behind two sector indices with its mean Sharpe ratio of 0.0320. Gold and S&P 500 index also have higher average Sharpe ratios compared to all broad BIST equity indices. These results are again expected since these alternative investments had positive mean returns as the local currency lost a significant amount of its value during the sample period and relatively well-behaved distributions with lower volatilities compared to the equity indices.

TABLE 4. Reward-to-Risk Ratios (2015/01 – 2016/08)**Panel A. Sharpe Ratios**

	Mean	Median	Minimum	Maximum	Obs
USD	0.0654	0.0552	-0.0649	0.2169	20
TECHNOLOGY	0.0556	0.0409	-0.0619	0.1711	20
INFORMATION TECHNOLOGY	0.0473	0.0491	-0.1135	0.1622	20
EURO	0.0320	0.0321	-0.0680	0.1536	20
CHEMISTRY, PETROLEUM, PLASTIC	0.0290	0.0181	-0.0824	0.1379	20
METAL PRODUCTS, MACHINERY	0.0288	0.0174	-0.0973	0.1541	20
GOLD	0.0261	0.0133	-0.0650	0.1672	20
LEASING, FACTORING	0.0259	-0.0031	-0.1569	0.2448	20
STANDARD & POOR'S 500	0.0253	0.0134	-0.0656	0.1522	20
REIT	0.0157	0.0113	-0.1024	0.1442	20
DIVIDEND 25 INDEX	0.0151	0.0103	-0.0718	0.1564	20
ALL SHARES-100 INDEX	0.0146	0.0100	-0.0751	0.1676	20
TEXTILE, LEATHER	0.0061	0.0154	-0.1329	0.1802	20
INDUSTRIALS	0.0022	-0.0103	-0.0896	0.1725	20
INSURANCE	0.0010	-0.0006	-0.1260	0.1531	20
PUBLIC OFFERING INDEX	0.0004	-0.0231	-0.0981	0.1312	20
WHOLESALE AND RETAIL TRADE	-0.0039	-0.0061	-0.1037	0.1176	20
DIVIDEND INDEX	-0.0062	-0.0151	-0.0977	0.1554	20
NON-METAL MINERAL PRODUCTS	-0.0068	-0.0070	-0.1827	0.1600	20
ELECTRICITY	-0.0072	-0.0118	-0.1193	0.1609	20
HOLDING AND INVESTMENT	-0.0082	-0.0177	-0.0946	0.1679	20
MINING	-0.0095	-0.0195	-0.2413	0.1722	20
SUSTAINABILITY INDEX	-0.0098	-0.0253	-0.0860	0.1504	18
BASIC METAL	-0.0101	-0.0428	-0.1338	0.1909	20
ALL SHARES INDEX	-0.0110	-0.0129	-0.0982	0.1516	20
CONSTRUCTION	-0.0112	-0.0100	-0.1054	0.0959	20
30 INDEX	-0.0117	-0.0146	-0.0955	0.1453	20
30 CAPPED INDEX	-0.0117	-0.0144	-0.0950	0.1450	20
FINANCIALS	-0.0124	-0.0177	-0.1063	0.1430	20
100 INDEX	-0.0125	-0.0156	-0.0994	0.1497	20
100 CAPPED INDEX	-0.0125	-0.0156	-0.0994	0.1497	20
50 INDEX	-0.0129	-0.0151	-0.0975	0.1480	20
BROKERAGE HOUSES	-0.0149	-0.0259	-0.0984	0.1451	20
100-30 INDEX	-0.0150	-0.0286	-0.1251	0.1614	20
INVESTMENT TRUSTS INDEX	-0.0152	-0.0331	-0.0940	0.1096	20
BANKING	-0.0164	-0.0211	-0.1089	0.1244	20
TOURISM	-0.0179	-0.0201	-0.1058	0.1010	20
WOOD, PAPER, PRINTING	-0.0240	-0.0061	-0.1662	0.1018	20
NATIONAL SERVICES	-0.0246	-0.0301	-0.1150	0.1193	20
TELECOMMUNICATION	-0.0249	-0.0364	-0.1163	0.1206	20
FOOD, BEVERAGE	-0.0299	-0.0318	-0.1049	0.1121	20
TRANSPORTATION	-0.0468	-0.0508	-0.1618	0.1089	20
SME INDUSTRIAL INDEX	-0.0581	-0.0557	-0.1700	0.0499	20

Panel B. Semi-Sharpe Ratios

	Mean	Median	Minimum	Maximum	Obs
USD	0.1296	0.1047	-0.1048	0.4093	20
TECHNOLOGY	0.0955	0.0763	-0.0664	0.3512	20
INFORMATION TECHNOLOGY	0.0847	0.0840	-0.1246	0.3158	20
EURO	0.0573	0.0444	-0.0926	0.2808	20
METAL PRODUCTS, MACHINERY	0.0542	0.0233	-0.1144	0.2680	20
GOLD	0.0541	0.0195	-0.1070	0.3029	20
LEASING, FACTORING	0.0499	-0.0054	-0.1892	0.4194	20
CHEMISTRY, PETROLEUM, PLASTIC	0.0447	0.0257	-0.0959	0.2155	20
STANDARD & POOR'S 500	0.0354	0.0212	-0.0846	0.2031	20
REIT	0.0296	0.0162	-0.1281	0.2397	20
ALL SHARES-100 INDEX	0.0261	0.0106	-0.0769	0.2447	20
DIVIDEND 25 INDEX	0.0238	0.0130	-0.1137	0.2592	20
TEXTILE, LEATHER	0.0195	0.0203	-0.1832	0.2629	20
INSURANCE	0.0151	0.0019	-0.1630	0.2867	20
INDUSTRIALS	0.0076	-0.0163	-0.1113	0.2731	20
WHOLESALE AND RETAIL TRADE	0.0051	-0.0078	-0.1282	0.2362	20
MINING	0.0011	-0.0276	-0.2886	0.3060	20
ELECTRICITY	-0.0006	-0.0134	-0.1545	0.2799	20
BASIC METAL	-0.0016	-0.0655	-0.1872	0.3732	20
PUBLIC OFFERING INDEX	-0.0031	-0.0341	-0.1252	0.1891	20
NON-METAL MINERAL PRODUCTS	-0.0043	-0.0109	-0.2088	0.2252	20
DIVIDEND INDEX	-0.0060	-0.0195	-0.1281	0.2562	20
HOLDING AND INVESTMENT	-0.0090	-0.0259	-0.1464	0.2867	20
ALL SHARES INDEX	-0.0125	-0.0180	-0.1355	0.2393	20
INVESTMENT TRUSTS INDEX	-0.0131	-0.0349	-0.1362	0.1930	20
SUSTAINABILITY INDEX	-0.0139	-0.0336	-0.1429	0.2388	18
30 INDEX	-0.0147	-0.0218	-0.1467	0.2343	20
30 CAPPED INDEX	-0.0147	-0.0217	-0.1477	0.2341	20
CONSTRUCTION	-0.0149	-0.0152	-0.1405	0.1433	20
100 INDEX	-0.0152	-0.0227	-0.1379	0.2362	20
100-30 INDEX	-0.0154	-0.0365	-0.1468	0.2410	20
100 CAPPED INDEX	-0.0154	-0.0226	-0.1392	0.2362	20
50 INDEX	-0.0163	-0.0224	-0.1443	0.2361	20
FINANCIALS	-0.0173	-0.0247	-0.1435	0.2287	20
TOURISM	-0.0192	-0.0258	-0.1829	0.2017	20
BROKERAGE HOUSES	-0.0192	-0.0352	-0.1293	0.2292	20
BANKING	-0.0248	-0.0323	-0.1525	0.1936	20
WOOD, PAPER, PRINTING	-0.0264	-0.0086	-0.2538	0.1688	20
NATIONAL SERVICES	-0.0280	-0.0397	-0.1709	0.2007	20
TELECOMMUNICATION	-0.0341	-0.0515	-0.1705	0.2098	20
FOOD, BEVERAGE	-0.0401	-0.0432	-0.1845	0.1945	20
TRANSPORTATION	-0.0589	-0.0709	-0.1892	0.2139	20
SME INDUSTRIAL INDEX	-0.0744	-0.0616	-0.2705	0.0667	20

Panel C. Return-to-VaR Ratios

	Mean	Median	Minimum	Maximum	Obs
USD	0.0337	0.0201	-0.0166	0.1148	20
TECHNOLOGY	0.0241	0.0148	-0.0110	0.0911	20
INFORMATION TECHNOLOGY	0.0198	0.0175	-0.0227	0.0694	20
GOLD	0.0142	0.0045	-0.0244	0.0825	20
METAL PRODUCTS, MACHINERY	0.0125	0.0051	-0.0205	0.0605	20
EURO	0.0124	0.0110	-0.0207	0.0602	20
LEASING, FACTORING	0.0117	-0.0014	-0.0292	0.0914	20
CHEMISTRY, PETROLEUM, PLASTIC	0.0096	0.0056	-0.0191	0.0452	20
STANDARD & POOR'S 500	0.0080	0.0060	-0.0188	0.0376	20
REIT	0.0072	0.0034	-0.0211	0.0478	20
DIVIDEND 25 INDEX	0.0064	0.0027	-0.0241	0.0740	20
ALL SHARES-100 INDEX	0.0063	0.0019	-0.0172	0.0575	20
TEXTILE, LEATHER	0.0060	0.0042	-0.0364	0.0662	20
INSURANCE	0.0057	0.0009	-0.0361	0.0649	20
MINING	0.0039	-0.0051	-0.0484	0.0724	20
WHOLESALE AND RETAIL TRADE	0.0026	-0.0017	-0.0252	0.0600	20
INDUSTRIALS	0.0024	-0.0031	-0.0246	0.0717	20
ELECTRICITY	0.0017	-0.0025	-0.0275	0.0718	20
NON-METAL MINERAL PRODUCTS	0.0011	-0.0024	-0.0401	0.0586	20
DIVIDEND INDEX	0.0000	-0.0036	-0.0303	0.0625	20
BASIC METAL	-0.0007	-0.0166	-0.0418	0.0923	20
INVESTMENT TRUSTS INDEX	-0.0012	-0.0063	-0.0331	0.0567	20
HOLDING AND INVESTMENT	-0.0013	-0.0050	-0.0318	0.0735	20
ALL SHARES INDEX	-0.0015	-0.0035	-0.0335	0.0574	20
PUBLIC OFFERING INDEX	-0.0017	-0.0062	-0.0314	0.0421	20
SUSTAINABILITY INDEX	-0.0019	-0.0066	-0.0344	0.0560	18
30 CAPPED INDEX	-0.0020	-0.0042	-0.0363	0.0573	20
30 INDEX	-0.0020	-0.0043	-0.0365	0.0570	20
100 INDEX	-0.0021	-0.0044	-0.0344	0.0570	20
100 CAPPED INDEX	-0.0021	-0.0044	-0.0344	0.0570	20
TOURISM	-0.0021	-0.0048	-0.0402	0.0544	20
100-30 INDEX	-0.0022	-0.0066	-0.0327	0.0565	20
FINANCIALS	-0.0023	-0.0057	-0.0348	0.0532	20
50 INDEX	-0.0024	-0.0044	-0.0357	0.0570	20
CONSTRUCTION	-0.0025	-0.0038	-0.0237	0.0287	20
BROKERAGE HOUSES	-0.0030	-0.0069	-0.0298	0.0550	20
BANKING	-0.0041	-0.0060	-0.0372	0.0423	20
WOOD, PAPER, PRINTING	-0.0048	-0.0020	-0.0584	0.0340	20
NATIONAL SERVICES	-0.0052	-0.0073	-0.0367	0.0491	20
TELECOMMUNICATION	-0.0067	-0.0106	-0.0408	0.0600	20
FOOD, BEVERAGE	-0.0074	-0.0087	-0.0350	0.0529	20
TRANSPORTATION	-0.0117	-0.0154	-0.0517	0.0489	20
SME INDUSTRIAL INDEX	-0.0148	-0.0122	-0.0647	0.0154	20

Panel D. Return-to-Parametric VaR Ratios

	Mean	Median	Minimum	Maximum	Obs
USD	0.0350	0.0257	-0.0230	0.1113	20
TECHNOLOGY	0.0266	0.0186	-0.0135	0.1038	20
INFORMATION TECHNOLOGY	0.0236	0.0217	-0.0269	0.0872	20
LEASING, FACTORING	0.0159	-0.0013	-0.0357	0.1187	20
GOLD	0.0159	0.0052	-0.0281	0.0869	20
EURO	0.0148	0.0119	-0.0236	0.0747	20
METAL PRODUCTS, MACHINERY	0.0144	0.0058	-0.0266	0.0723	20
CHEMISTRY, PETROLEUM, PLASTIC	0.0115	0.0067	-0.0240	0.0540	20
STANDARD & POOR'S 500	0.0095	0.0060	-0.0210	0.0499	20
REIT	0.0088	0.0038	-0.0269	0.0635	20
ALL SHARES-100 INDEX	0.0074	0.0024	-0.0177	0.0671	20
DIVIDEND 25 INDEX	0.0070	0.0034	-0.0278	0.0746	20
TEXTILE, LEATHER	0.0060	0.0053	-0.0467	0.0727	20
INSURANCE	0.0047	0.0007	-0.0428	0.0748	20
MINING	0.0033	-0.0059	-0.0603	0.0824	20
INDUSTRIALS	0.0025	-0.0039	-0.0278	0.0759	20
WHOLESALE AND RETAIL TRADE	0.0022	-0.0020	-0.0315	0.0657	20
ELECTRICITY	0.0019	-0.0031	-0.0349	0.0834	20
NON-METAL MINERAL PRODUCTS	0.0012	-0.0027	-0.0424	0.0644	20
BASIC METAL	-0.0002	-0.0177	-0.0475	0.0997	20
DIVIDEND INDEX	-0.0005	-0.0047	-0.0312	0.0710	20
PUBLIC OFFERING INDEX	-0.0007	-0.0078	-0.0332	0.0490	20
HOLDING AND INVESTMENT	-0.0016	-0.0065	-0.0371	0.0802	20
INVESTMENT TRUSTS INDEX	-0.0019	-0.0079	-0.0360	0.0522	20
ALL SHARES INDEX	-0.0023	-0.0043	-0.0354	0.0661	20
SUSTAINABILITY INDEX	-0.0027	-0.0081	-0.0361	0.0657	18
100-30 INDEX	-0.0027	-0.0081	-0.0356	0.0668	20
30 CAPPED INDEX	-0.0029	-0.0052	-0.0377	0.0646	20
30 INDEX	-0.0029	-0.0052	-0.0379	0.0646	20
100 INDEX	-0.0030	-0.0055	-0.0362	0.0656	20
100 CAPPED INDEX	-0.0030	-0.0054	-0.0361	0.0656	20
TOURISM	-0.0031	-0.0061	-0.0466	0.0575	20
CONSTRUCTION	-0.0033	-0.0041	-0.0300	0.0360	20
50 INDEX	-0.0033	-0.0054	-0.0372	0.0654	20
FINANCIALS	-0.0033	-0.0062	-0.0359	0.0625	20
BROKERAGE HOUSES	-0.0040	-0.0083	-0.0323	0.0625	20
BANKING	-0.0054	-0.0080	-0.0382	0.0524	20
WOOD, PAPER, PRINTING	-0.0059	-0.0023	-0.0659	0.0446	20
NATIONAL SERVICES	-0.0065	-0.0094	-0.0445	0.0536	20
TELECOMMUNICATION	-0.0085	-0.0131	-0.0448	0.0563	20
FOOD, BEVERAGE	-0.0090	-0.0103	-0.0432	0.0543	20
TRANSPORTATION	-0.0133	-0.0177	-0.0483	0.0570	20
SME INDUSTRIAL INDEX	-0.0169	-0.0134	-0.0711	0.0181	20

BIST equity indices have skewness statistics that fall into a narrow band in the recent sample period as observed in Panels A and B of Table 2. This fact causes the Sharpe ratio rankings and semi-Sharpe ratio rankings to be very similar. Panel B of Table 4 presents descriptive statistics for semi-Sharpe ratios for all investments. The five best-performing indices are the same with a couple of within-group order changes whereas even the descending order for the five worst-performing indices remains the same compared to the Sharpe ratio rankings. The highest (lowest) average semi-Sharpe ratio belongs to the technology (transportation) sector with a value of 0.0955 (-0.0589). The major broad equity indices again have negative reward-to-risk ratios when risk is adjusted using semi-standard deviation. Semi-Sharpe ratios for the BIST All Shares/100/50/30 indices vary from -0.0163 to -0.0125. All Shares-100 and Dividend 25 indices again have positive average risk-adjusted performances. US dollar, euro and gold are among the top ranks with semi-Sharpe ratios between 0.0541 and 0.1296. This is another indication that investors who invested in these instruments rather than broad equity indices enjoyed better risk-adjusted returns during the recent sample period.

All of these patterns pointed out for the Sharpe and semi-Sharpe ratios continue to hold when downside risk is calculated from the left-tail of the return distribution. It is possible that an investment with a higher mean return compared to another investment could also have a higher Sharpe ratio if the volatilities of the two investments are close, but suffer from lower reward-to-downside risk ratios if its higher-order moments are large and the investment is exposed to large losses. For the purposes of this analysis, there is not much differentiation in terms of skewness and kurtosis among BIST equity indices and other investments in the recent sample period. Thus, results from the return-to-VaR and return-to-parametric VaR analysis in Panels C and D of Table 4 turn out to be similar to the earlier Sharpe ratio and semi-Sharpe ratios analyses. However, it is worth pointing out that this similarity is specific to the sample period. As will be seen in the next section, standard deviations and Sharpe ratios behave erratically, thus, value-at-risk metrics produce more accurate pictures of risk during highly volatile periods.

4.3 Graphical Evidence

In the final part of this research report, several comparative figures are presented in order to understand the time-series evolution of performances of various key investments and the tendency of the performance metrics to move in tandem or in opposite directions is examined.

Figure 1. Sharpe Ratios and Return-to-VaR Ratios for BIST 100 Index

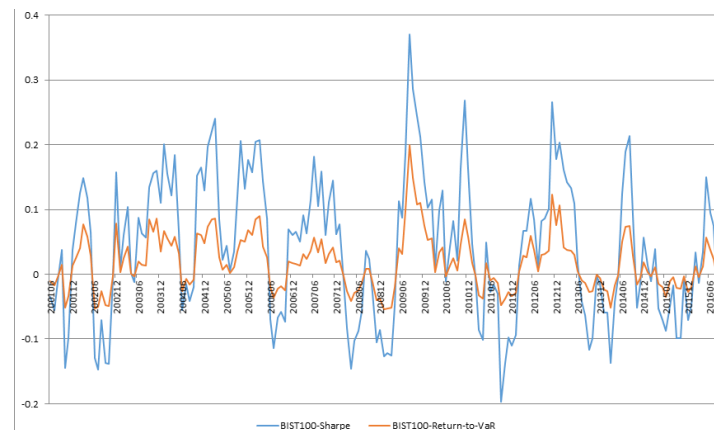


Figure 1 presents the historical record for the Sharpe and return-to-VaR ratios for the BIST 100 index. It can be seen that the Sharpe ratio for the index has been generally positive in the first half of the sample period with the exception of few temporary dips into the negative territory. Sharpe ratios experience a fall in 2008 with the global economic crisis, but quickly bounce back in the next year and reach their peak value. Another dip in 2011 which brings the Sharpe ratio of the BIST 100 index to its minimum value is again followed by a significant recovery in 2012 and the plot crosses the x-axis several times in the subsequent time frame until the end of the sample period. An important observation is that the return-to-VaR ratio also follows similar downtrend and uptrend patterns; however, it moves within a more conservative range compared to the erratic behavior of the Sharpe ratio. Since the return-to-VaR ratio is more well-behaved, the subsequent figures focus on this metric. Figure 2 compares the return-to-VaR and return-to-PVaR ratios for the BIST 100 index and reveals that the two metrics very closely track one another.

Figure 2. Return-to-VaR Ratios and Return-to-Parametric VaR Ratios for BIST 100 Index

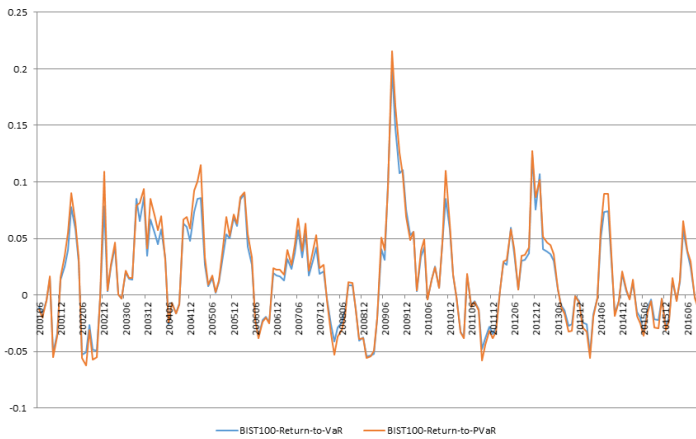


Figure 3 compares the return-to-VaR ratios for BIST 100 and Gold. There are two major observations to be noted. First, although there seems to be a certain amount of co-movement between the two series, Gold is lagging behind BIST 100. For example, BIST 100 reaches its peak value in the middle of 2009 whereas Gold reaches its peak value only several months later. Another way to interpret this relation is that gold reaches its peak while BIST 100 is experiencing a decline from its peak and equity market investors are turning to gold as a safe haven. Thus, despite the apparent co-movement in the two return-to-VaR ratios, the contemporaneous correlation coefficient is only 0.28. Second, the peaks and troughs of BIST 100 are larger in absolute value compared to those of Gold which oscillates in a narrower band.

Figure 3. Return-to-VaR Ratios for BIST 100 Index and Gold

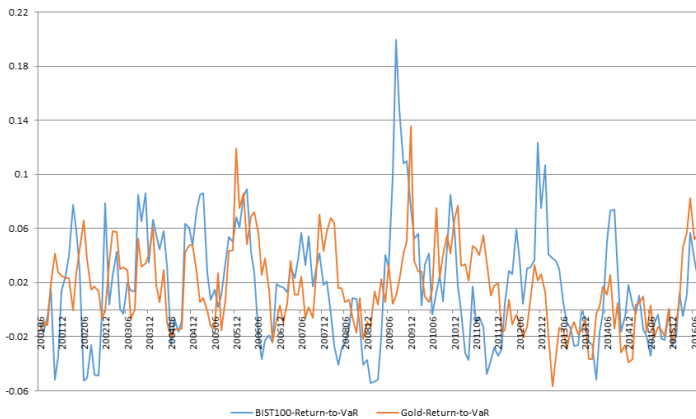


Figure 4. Return-to-VaR Ratios for BIST 100 Index and S&P 500 Index

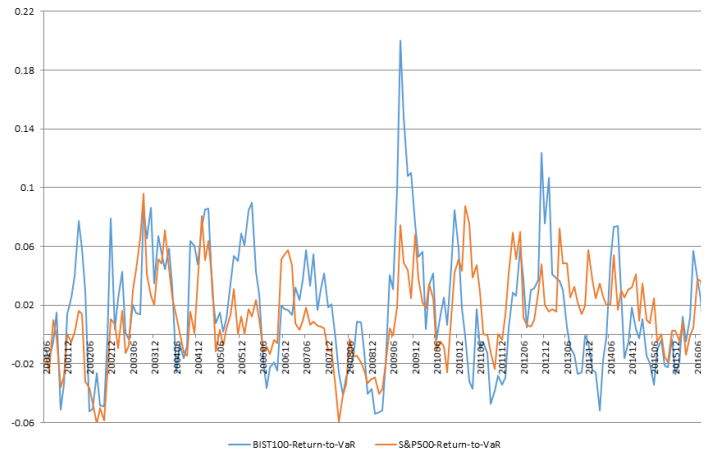


Figure 4 compares the return-to-VaR ratios for BIST 100 and S&P 500 indices. The contemporaneous correlation between these two series is higher at a value of 0.54. In other words, there is a tendency for these ratios to reach their highs and lows simultaneously. For example, as BIST 100 hits its peak performance in the middle of 2009, S&P 500 index also climbs to a local maximum. Similarly, as S&P 500 reaches its lowest values in the second half of 2002 or the first half 2008, BIST 100 also experiences sharp declines in its return-to-VaR ratio. Similar to Gold, the return-to-downside risk ratios for S&P 500 index move in a tighter band compared to those of BIST 100.

Figure 5. Return-to-VaR Ratios for BIST 100 Index and US Dollar

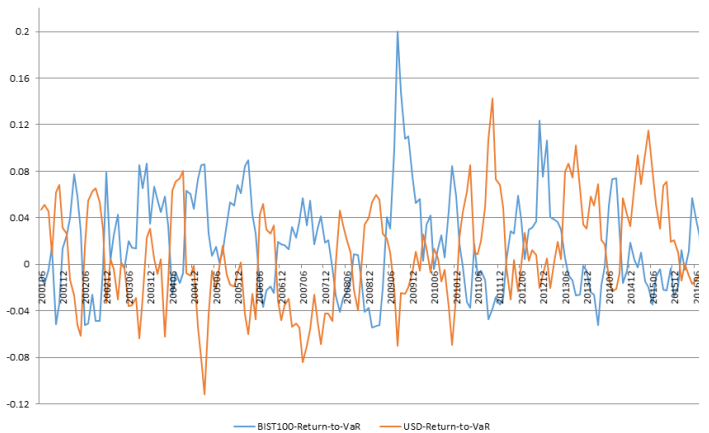


Figure 5 compares the return-to-VaR ratios for BIST 100 and US dollar. This picture looks different than the earlier ones as the two series have a tendency to move in opposite directions on average. The contemporaneous correlation between the two return-to-downside risk metrics is -0.70. To a certain extent

this strong negative correlation is expected as equity returns are measured in US dollars. The performance series for US dollar is as volatile as that of BIST100 and the drops in value are sharper for the US dollar in the first half of the sample. At these low points for the US dollar, the reward-to-VaR ratios for BIST 100 spike up and the distance between the two plots widens. The negative correlation between the two series persists in the second half of the sample; however, this time the low points of BIST 100 are more extreme and US dollar reaches higher peaks in the positive region. This graphical evidence makes the results in Tables 3 and 4 that US dollar (BIST 100) outperforms BIST 100 (US dollar) on a risk-adjusted basis in the recent (full) sample period more transparent.

5. CONCLUSION

This research report compares the risk-adjusted performances of various broad and sector-specific BIST equity indices and alternative investments such as US dollar, euro, gold and S&P 500 index. It is crucial to adjust for risk when evaluating investment performance since high realized returns may simply be the result of a high level of underlying risk. The analysis that extends back to 2001 and places special emphasis on the concept of downside risk reveals many results. To highlight some of these, first, most of the broad equity indices in the full sample period exhibited positive returns about 6 basis points per day, high standard deviations, mild skewness statistics and leptokurtosis. Currency investments had a mean return of 5 basis points per day with a lower standard deviation; however, their return distributions deviated from normality to a larger extent. Second, the broad equity indices had negative average returns in a more recent sample period that extends back to 2015. In this time frame, currency investments, gold and S&P 500 maintained their positive average returns and their distributions were more well-behaved. Third, over the full sample, both broad equity indices and most sector-specific indices outperformed the currency investments on a risk-adjusted basis. This result is important since currency investments had similar mean returns to equity investments, but their performances are poorer after taking their higher level of risk in the full sample period into account. Broad equity indices also outperformed S&P 500; however, gold established itself as an investment which is up to par with the equity market based on its reward-to-risk metrics. Fourth, this picture turns upside down in the recent sample period where the currency investments, gold and S&P 500 outperform all broad equity indices and most sector-specific indices after adjusting for risk.

APPENDIX

Hansen (1994) introduces a generalization of the Student t-distribution which accounts for skewness and excess kurtosis in the data. This skewed t (ST) density is given by:

$$f(z_t; \mu, \sigma, v, \lambda) = \begin{cases} bc \left(1 + \frac{1}{v-2} \left(\frac{bz_t + a}{1-\lambda}\right)^2\right)^{\frac{-v+1}{2}} & \text{if } z_t < -\frac{a}{b} \\ bc \left(1 + \frac{1}{v-2} \left(\frac{bz_t + a}{1+\lambda}\right)^2\right)^{\frac{-v+1}{2}} & \text{if } z_t \geq -\frac{a}{b} \end{cases}$$

where $z_t = \frac{R_t - \mu}{\sigma}$ is the standardized excess market return, and the constants a , b , and c are given by

$$a = 4\lambda c \left(\frac{v-2}{v-1}\right), b^2 = 1 + 3\lambda^2 - a^2, c = \frac{\Gamma\left(\frac{v+1}{2}\right)}{\sqrt{\pi(v-2)}\Gamma(v/2)}$$

Hansen (1994) shows that this density is defined for $2 < v < \infty$ and $-1 < \lambda < 1$. The density has a single mode at $-a/b$, which is of opposite sign with the parameter λ . Thus, if $\lambda > 0$, the mode of the density is to the left of zero and the variable is skewed to the right, and vice versa when $\lambda < 0$. Furthermore, if $\lambda = 0$, Hansen's distribution reduces to the traditional standardized t distribution. If $\lambda = 0$ and $v = \infty$, it reduces to a normal density. The parameters of the ST density are estimated by maximizing the log-likelihood function of $R_{i,t}$ with respect to the parameters μ , σ , v and λ :

$$\log L = n \ln b + n \ln \Gamma\left(\frac{v+1}{2}\right) - \frac{n}{2} \ln \pi - n \ln \Gamma(v-2) - n \ln \Gamma\left(\frac{v}{2}\right) - n \ln \sigma - \left(\frac{v+1}{2}\right) \sum_{t=1}^n \ln \left(1 + \frac{d_t^2}{v-2}\right)$$

where $d_t = (bz_t + a)/(1 - \lambda s)$ and s is a sign dummy taking the value of 1 if $bz_t + a < 0$ and $s = -1$ otherwise. Assuming that $R_t = f_{v,\lambda}(z)$ follows an ST density, parametric VaR is the solution to

$$\int_{-\infty}^{\Gamma_{ST}(\phi)} f_{v,\lambda}(z) dz = \phi$$

where $\Gamma_{ST}(\phi)$ is the VaR threshold based on the ST density with a loss probability of 1%. The above equation indicates that parametric VaR can be calculated by integrating the area under the

probability density function of the ST distribution. Specifically, to compute a quantile of a distribution, the Cornish-Fisher (1937) expansion is used which is a moment-based approximation motivated by the theory of estimating functions, saddle-point approximations, and Fourier-inversion. The advantage of this approximation is that it can be computed without any matrix decomposition. It is based on the cumulants, which are the power series coefficients of the cumulant generating function. According to the fourth-order Cornish-Fisher expansion, the lowest daily return can be specified as a nonlinear function of the mean, standard deviation, skewness, and kurtosis of the daily returns. Hence, by using rolling estimates of the first four moments of index return distributions, a parametric VaR measure is constructed.

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