Analysis of SRI vs Russell 3000 datasets and viability of portfolio optimization based on KLD Score Quantiles

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1. ABSTRACT

There has been a significant amount of researched conducted on the performance of Socially Responsible Investing (SRI) since the 1990s. Some of the largest funds in the world are based on SRI principles, such as the Government Pension Fund of Norway; other large funds include Vanguard ESG U.S. Stock ETF, and Calvert Equity Fund. In 2021 nearly one-third of all equity assets are managed in some form of SRI fund.

Research presented in CFRM 509 exhibited conclusions that SRI portfolios perform very similar to major indexes, such as the MSCI World Index in terms of performance and risk. The results, indicate similar performance to the MSCI index, but with an average of 30 basis extra points of cost annually.

The research focus of this document, it is to evaluate if there is a relation between the KLD scoring ranked of a company and his risk-adjusted performance; essentially to answer the question: Is there a relation between the total KLD score of a company and its performance? Additionally, this paper investigates the performance of SRI based portfolios during down market periods.

2. PROJECT OBJECTIVES

1. Evaluate performance of KLD ranked companies versus Russell 3000

   The main purpose of this objective is validating results from the references provided in the course, but most importantly to serve as the primary source of validation for the software developed for the project to conduct the analysis.

2. Relative Performance of KLD ranked companies

   One question not addressed by the researched papers reviewed during class is: Is there a statistically significant relationship between the KLD score of a company and its risk-adjusted performance? Understanding such relationship can provide additional guidance to SRI portfolio managers in the formation of new optimum SRI based portfolios, which not only perform similar to the Russell 3000, but provide additional alpha.

3. Performance of SRI ranked companies versus Russell 3000 in down market periods

   Another open question raised by research and the book ethics in finance by Boatright, it is the viability of SRI Mutual Funds during market down periods. A critique of current SRI research, it is that most of the analysis has been conducted during market bull years, except for the period of 2007 to 2010.

3. METHODOLOGY

The process to perform the objectives defined for the project are:

1. Leverage the following datasets:

    - us_r3000_ranked_model_reg_ftp.csv
    - 2021.04.28 FinalData - KLD Normalized Scores (1991-2018).csv

    - The first dataset provides monthly data for the Russell 3000 consisting of future forecast returns and a variety of factor data.
    - Second dataset has annual KLD scores for a set of companies; this information is leveraged for all three objectives of this report.

2. Process and merge datasets

    - Remove all records that do not have monthly returns defined, total KLD score, and the identifier to join the datasets.
    - An SRI set is created by merging both datasets, this corresponds to all companies in the Russell 3000 that have KLD scores associated with them each year.
    - KLD scores are annually reported, therefore it is possible that a company in the index might not have a KLD score in the past but started a sometime in the future; this scenario occurred in 2004 where there was large increase in the number of companies added to the KLD dataset.
    - Another data issue is that companies could be dropped out of the KLD dataset for any given year, or no longer in the Russell 3000, both options must be considered when merging the datasets, and merge in such a way as to maximize the number of companies with KLD scores each year.

3. Analytics

    - The period selected for analytics is 1997-2018. This is the period that overlaps both datasets and provides 22-years of monthly data.
    - To derived average monthly, annual, etc. metrics per dataset, it was necessary to assume that the companies represented in the Russell 3000 datasets are equally weighted. This is an incorrect assumption, the Russell 3000 index is cap-weighted, but this information was not available in the

original datasets (the means to derive was later provided, but too close to the project due date to include).
    - For the research conducted in this report, no having capitalization weighted metrics should not impact the results, especially in the analysis of relative comparison of the SRI and Russell 3000 datasets, and within each quantile.
    - The effect of no using capitalization to weight the results, it is that validation with the standard Russell 3000 index will be different. However, the overall pattern of the index, down periods, it is expected to be similar.
- Group companies each year in the SRI dataset based on their KLD score (the merged dataset as defined in step 2) above)
- Derived quantiles per year based on the KLD total scores for each year. Assigned the corresponding quantile to each company each year. The quantile assigned might vary per year.
- The number of quantiles was selected to be ten. The reason for this number is that it provides many companies in each quantile, about 250 per quantile after 2004, but only about 25 from 1997-2003. The reason for the lower numbers in the earlier period is that there were fewer companies ranked in the KLD database.
- Calculate a variety of metrics per month, per year, and overall, for the SRI dataset, as well as for the Russell-3000 index.
- The metrics derived included returns, standard deviation, sharpe ratio, drawdown, CAGR, sortino ratio, etc. for each period defined. Many metrics are calculated per dataset and per monthly and annual periods.
- For some important metrics such as max. drawdown, other key performance information is derived and maintain per dataset. Such as top 10 drawdown periods, length to recovery, top performing days, top-down days, etc. The goal deriving these analytics is to provide a comprehensive view of the performance of the SRI and Russell 3000 datasets relative to each other, and relative within the KLD quantiles assigned.
- Calculate metrics per quantile, month, year, and overall, in the SRI dataset. The same metrics and stats as defined in the previous bullet are also calculated and maintain in an in-memory database for analysis and visuals.
- Determine annual and monthly counts of companies in each dataset

4. Analysis

- This step consists of aggregating and summarizing metrics derived in step 3), in tabular form for each of the objectives in the project.
- Performance metrics are summarized per month, year, and overall results per dataset. In addition, per quantile summary data is generated.
- Summary data for down periods and statistics are generated per month, year and overall, per dataset.
- Statistical analysis is conducted to validate results are statistically significant per dataset, and per quantile.
    - T-Test, and Non-Parametric T-Tests are utilized

5. Dashboards/Visuals

Custom visuals were created to derive further insights into the analysis carried in step 4, as well as for validation of the datasets. The following dashboards were generated to conduct the analysis:

- SRI and Russell 3000
    - Summary Performance Dashboards
    - Detail Datasets tear sheets for deep review of the performance of the SRI dataset benchmark against the Russell 3000
    - Companies per dataset overtime
    - Returns, Sharpe Ratios, Standard Deviation, etc.
- SRI Quantiles
    - Annual Metrics
        - Returns, Cumulative, Sharpe Ratio, etc.
    - Summary Metrics (1997-2018)
    - Comparison of top performing quantiles versus complete SRI dataset
- Down Market Periods
    - Distribution or returns, standard deviations, and Sharpe Ratios
    - Drawdowns
- Distributional Analysis of Selected Finance Metrics
    - SRI and R-3000 Monthly Returns
    - SRI and R-3000 Monthly Returns Standard Deviation
    - SRI and R-3000 Monthly Sharpe-Ratios
    - SRI Quantiles Monthly Return
    - SRI Quantiles Monthly Sharpe-Ratios
    - SRI Quantiles Monthly Return's Standard Deviations

6. Implementation

- All modeling and analysis were conducted in Python
- The following Python libraries were selected for analysis, due to their wide usage in the Financial Industry and ability to manage large datasets, and to perform complex SQL-like queries
  - pandas, numpy, matplotlib, seaborn, statistics, jupyter-notebook
- For replication purposes, Jupyter-Notebook was selected
  - Jupyter Notebooks provides the means to share research with others, and the means to re-create all analysis conducted in the project.
  - For transparency all code developed to perform the project is self-contained in the notebook, and no in external python files.
- The project Jupyter Notebook can be loaded in any browser and reviewed without requiring any software installation.
  - To re-create the results, a Python 3.5 environment or later, and the libraries detailed earlier must be installed.
  - The notebook is included as a reference in its own file, as well as PDF version of it to assist the reader in the review process.
- The implementation in the Jupyter Notebook is self-documented.

7. Validation

- T-Test
- Non-Parametric T-Test

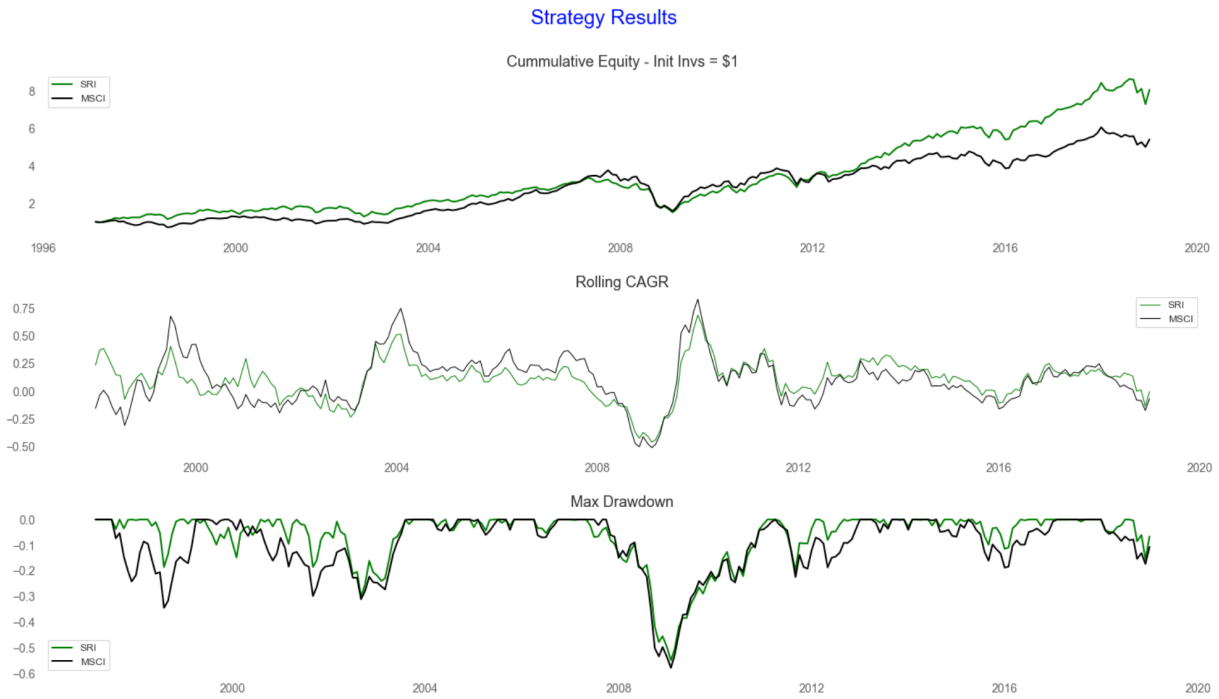
4. EMPIRICAL RESULTS

The results of the analysis executed for each of the project goals follows. For each objective, the principal financial charts are presented and categorized, including tabular data. Following the dashboards, the key insights derived from the analysis, are highlighted for each objective.

Objective 1: Evaluate performance of KLD ranked companies versus Russell 3000

Summary Comparison

Basic set of metric comparisons for the SRI and R-3000 index. The green line is the SRI dataset, the color was selected in the spirit of the data. From this data, we can observe visually the SRI set is outperforming his benchmark in cumulative returns, CAGR, and about the same or better for maximum drawdown.



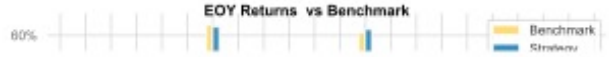
Detail Comparison

Comprehensive tear-sheet-report comparing the SRI dataset using the Russell-3000 as the benchmark.

SRI Strategy vs R-3000 Tearsheet

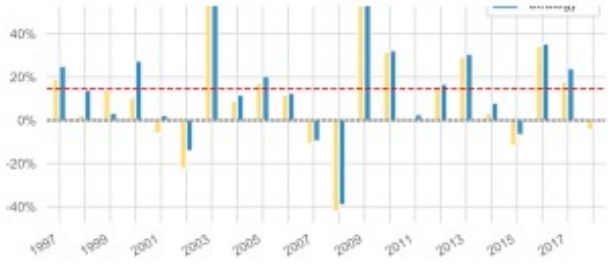
31 Jan, 1997 - 31 Dec, 2018

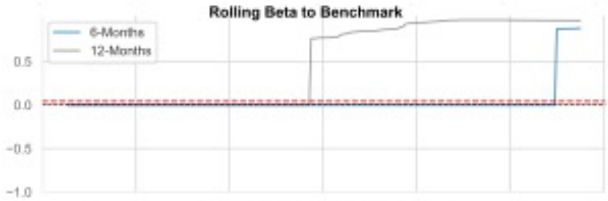
Generated by Gustavo Zambrana (v. 0.0.34)

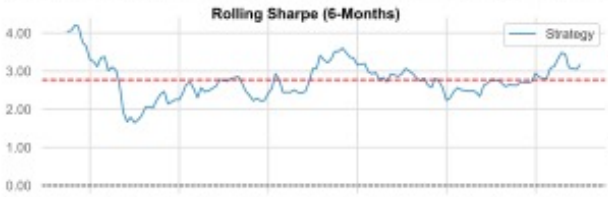


Key Performance Metrics

Metric	Strategy	Benchmark
Risk-Free Rate	0.0%	0.0%
Time in Market	100.0%	100.0%
Cumulative Return	1,193.52%	495.46%
CAGR%	12.38%	8.48%
Sharpe	3.28	2.29
Sortino	5.11	3.42
Sortino/√2	3.61	2.42
Max Drawdown	-54.81%	-57.93%
Longest DD Days	1035	1279
Volatility (ann.)	86.14%	94.31%
R^2	0.92	0.92
Calmar	0.23	0.15
Skew	-0.35	-0.31
Kurtosis	1.97	1.69
Expected Daily %	0.97%	0.68%
Expected Monthly %	0.97%	0.68%
Expected Yearly %	12.34%	8.45%
Kelly Criterion	27.91%	16.31%
Risk of Ruin	0.0%	0.0%
Daily Value-at-Risk	-7.8%	-8.92%
Expected Shortfall (cVaR)	-7.8%	-8.92%
Gain/Pain Ratio	0.72	0.46
Gain/Pain (1M)	0.72	0.46
Payoff Ratio	0.94	0.81
Profit Factor	1.72	1.46
Common Sense Ratio	1.94	1.53
CPC Index	1.05	0.74
Tail Ratio	1.12	1.05



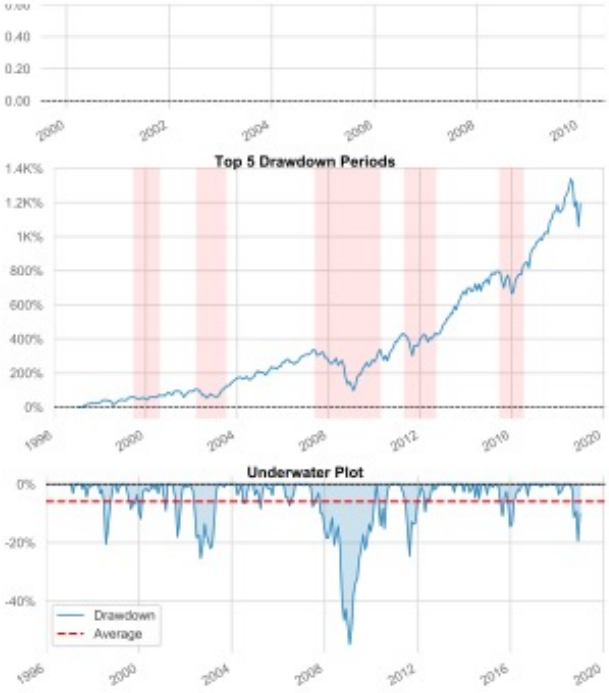




Metric	Strategy	Benchmark
Outlier Win Ratio	3.13	2.97
Outlier Loss Ratio	2.99	2.7
MTD	11.61%	11.36%
3M	1.4%	-0.94%
6M	-6.15%	-9.43%
YTD	0.64%	-4.42%
1Y	0.64%	-4.42%
3Y (ann.)	15.65%	10.98%
5Y (ann.)	10.6%	6.27%
10Y (ann.)	17.82%	14.82%
All-time (ann.)	12.38%	8.48%
Best Day	23.3%	24.01%
Worst Day	-22.06%	-22.77%
Best Month	23.3%	24.01%
Worst Month	-22.06%	-22.77%
Best Year	63.88%	64.77%
Worst Year	-39.07%	-42.28%
Avg. Drawdown	-8.52%	-9.94%
Avg. Drawdown Days	151	201
Recovery Factor	21.78	8.55
Ulcer Index	1.08	1.02
Avg. Up Month	4.35%	4.37%
Avg. Down Month	-4.65%	-5.38%
Win Days %	65.15%	62.5%
Win Month %	65.15%	62.5%
Win Quarter %	68.18%	62.5%
Win Year %	81.82%	72.73%
Beta	0.88	-
Alpha	0.94	-

EOY Returns vs Benchmark

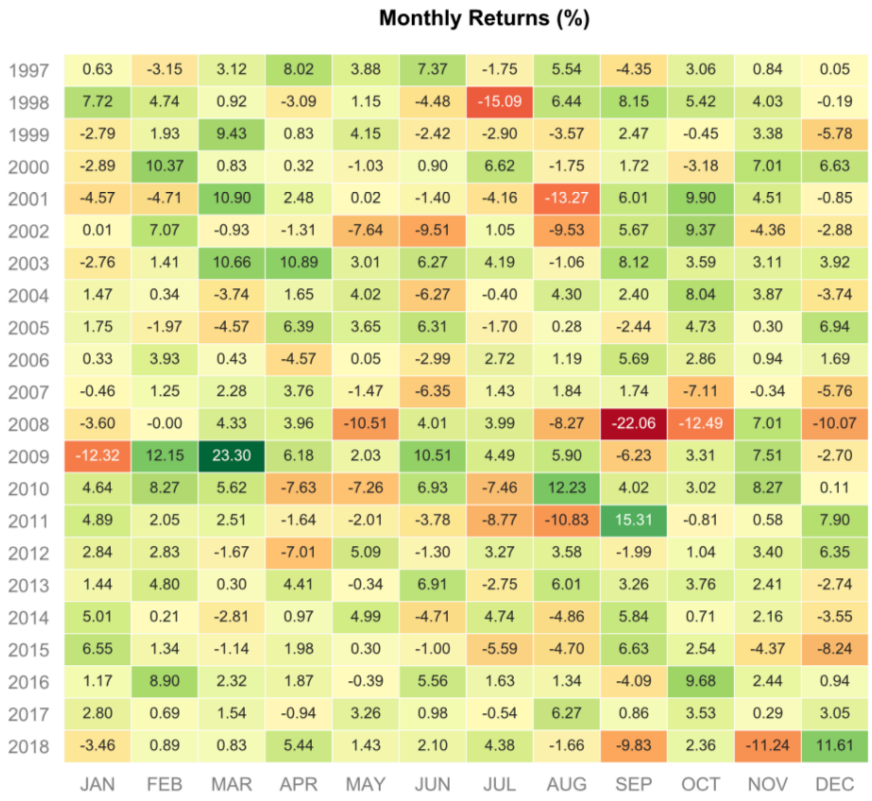
Year	Benchmark	Strategy	Multiplier	Won
1997	18.98%	24.86%	1.31	+
1998	2.42%	14.08%	5.83	+

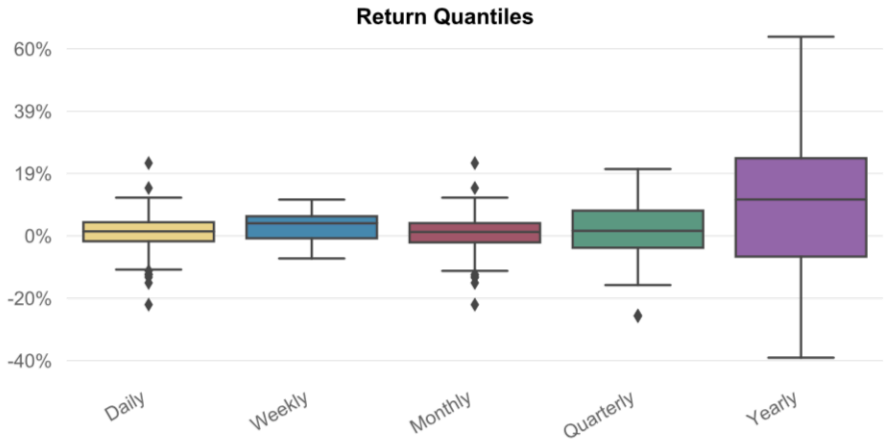


Year	Benchmark	Strategy	Multiplier	Won
1999	13.98%	3.36%	0.24	-
2000	10.32%	27.43%	2.66	+
2001	-6.25%	2.29%	-0.37	+
2002	-22.39%	-14.13%	0.63	+
2003	64.77%	63.88%	0.99	-
2004	8.93%	11.64%	1.30	+
2005	16.98%	20.56%	1.21	+
2006	11.85%	12.50%	1.05	+
2007	-10.97%	-9.53%	0.87	+
2008	-42.28%	-39.07%	0.92	+
2009	61.31%	62.77%	1.02	+
2010	31.62%	32.22%	1.02	+
2011	1.06%	2.75%	2.59	+
2012	15.15%	16.83%	1.11	+
2013	29.20%	30.49%	1.04	+
2014	3.48%	8.14%	2.34	+
2015	-11.46%	-6.68%	0.58	+
2016	34.37%	35.29%	1.03	+
2017	17.83%	23.86%	1.34	+
2018	-4.42%	0.64%	-0.14	+

Worst 10 Drawdowns

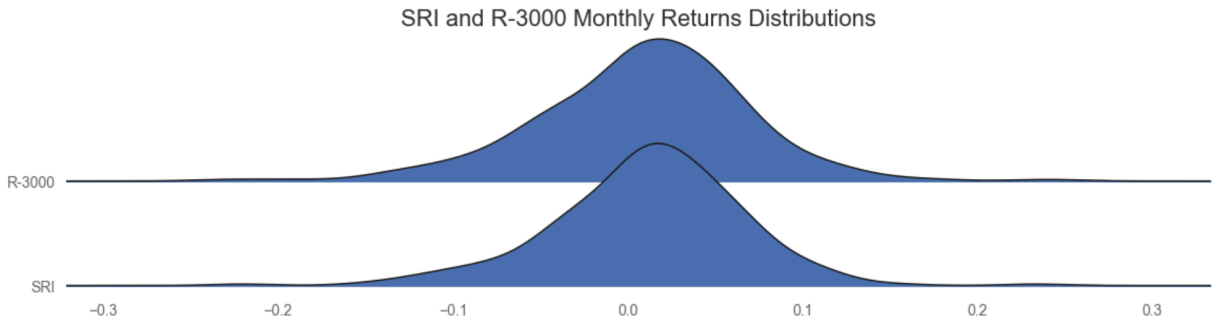
Started	Recovered	Drawdown	Days
2007-05-31	2010-03-31	-54.81%	1035
2002-03-29	2003-06-30	-25.30%	458
2011-04-29	2012-08-31	-24.56%	490
1998-04-30	1998-11-30	-20.49%	214
2018-08-31	2018-12-31	-19.44%	122
2001-06-29	2002-02-28	-18.04%	244
2010-04-30	2010-10-29	-15.23%	182
2015-06-30	2016-06-30	-14.53%	366
1999-06-30	2000-07-31	-11.85%	397
2001-01-31	2001-03-30	-9.06%	58





Distributions

The distributions of the monthly returns, as well as the standard deviation of the monthly returns give us additional indication visually, that the SRI dataset distributions are not as spread, the difference is very noticeable when comparing side by side.



Annual Summary of Key Financial Metrics

Note: the table created has MSCI, but it is the Russell 3000 equally weighted index derived

Year	SRI_Ret	MSCI_Ret	SRI_Std	MSCI_Std	SRI_SR	MSCI_SR	SRI_Cumm_Ret	MSCI_Cumm_Ret	SRI_Max_Year_Drawdown	MSCI_Max_Year_Drawdown
1997	0.248645	0.189751	0.093102	0.126805	2.670668	1.496408	1.248645	1.189751	-0.043484	-0.040970
1998	0.140844	0.024162	0.123846	0.164626	1.137248	0.146768	1.424510	1.218498	-0.204905	-0.285391
1999	0.033610	0.139772	0.121431	0.177764	0.276784	0.786279	1.472388	1.388810	-0.092216	-0.155624
2000	0.274333	0.103224	0.156865	0.242970	1.748848	0.424841	1.876312	1.532168	-0.118458	-0.197105
2001	0.022890	-0.062481	0.151998	0.201552	0.150594	-0.309999	1.919261	1.436436	-0.180423	-0.257913
2002	-0.141273	-0.223910	0.131537	0.178214	-1.074012	-1.256412	1.648122	1.114804	-0.252975	-0.339109
2003	0.638826	0.647728	0.121493	0.136401	5.258131	4.748696	2.700984	1.836893	-0.220169	-0.305901
2004	0.116365	0.089263	0.102796	0.108076	1.132003	0.825926	3.015286	2.000859	-0.066382	-0.070081
2005	0.205606	0.169778	0.098649	0.107664	2.084226	1.576922	3.635246	2.340560	-0.083711	-0.106495
2006	0.124989	0.118496	0.091953	0.097804	1.359268	1.211569	4.089611	2.617908	-0.073788	-0.073842
2007	-0.095345	-0.109679	0.110586	0.114338	-0.862176	-0.959247	3.699688	2.330779	-0.154133	-0.162121
2008	-0.390672	-0.422794	0.181665	0.188175	-2.150509	-2.246809	2.254325	1.345340	-0.484589	-0.516371
2009	0.627667	0.613057	0.191741	0.202741	3.273513	3.023838	3.669291	2.170109	-0.548084	-0.579298
2010	0.322217	0.316240	0.118012	0.127273	2.730374	2.484746	4.851598	2.856385	-0.152287	-0.215077
2011	0.027523	0.010615	0.120538	0.129131	0.228337	0.082204	4.985129	2.886705	-0.245574	-0.253242
2012	0.168324	0.151531	0.097484	0.107845	1.726688	1.405075	5.824244	3.324130	-0.094470	-0.112498
2013	0.304947	0.292000	0.093842	0.106863	3.249560	2.732471	7.600329	4.294776	-0.027479	-0.031944
2014	0.081360	0.034805	0.097269	0.111023	0.836444	0.313497	8.218691	4.444257	-0.050484	-0.063759
2015	-0.066754	-0.114566	0.107533	0.127550	-0.620776	-0.898203	7.670064	3.935098	-0.145259	-0.178096
2016	0.352915	0.343687	0.105783	0.135137	3.336228	2.543244	10.376944	5.287539	-0.135233	-0.176425
2017	0.238602	0.178273	0.093634	0.120992	2.548234	1.473426	12.852907	6.230162	-0.009404	-0.020025
2018	0.006400	-0.044238	0.114809	0.129260	0.055748	-0.342241	12.935170	5.954551	-0.194379	-0.215379

Insights derived:

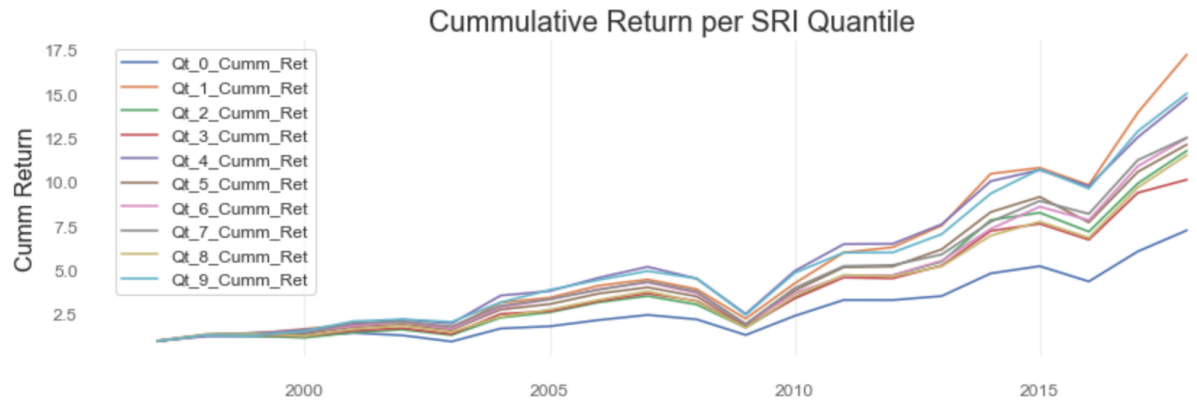
i.	The SRI dataset outperforms the Russell 3000 equally weighted index in all metrics
ii.	The max. drawdown performance for the SRI dataset is equal or better through the entire analyzed period
iii.	The standard distribution of the returns for the SRI is considerably narrower, with much less fatter tails
iv.	The cumulative results inclusive of risk are superior for the SRI dataset

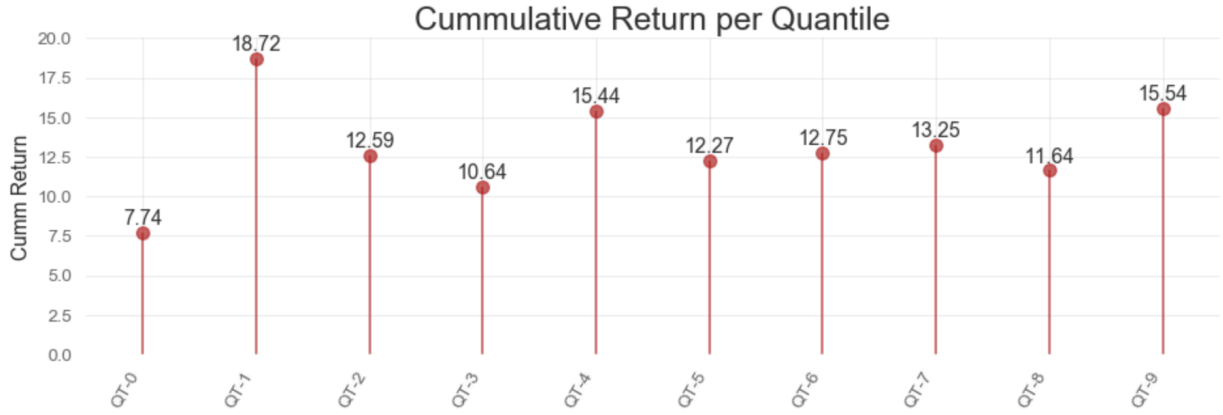
Objective 2: Relative Performance of KLD ranked companies

Metric and charts for comparisons of the entire SRI set of ranked companies against SRI KLD Ranked quantiles of the same dataset. The objective of the following analysis is to determine if there is different behavior observed per quantile and infer if higher ranking quantiles outperform lower ranked ones or infer other patterns in the data.

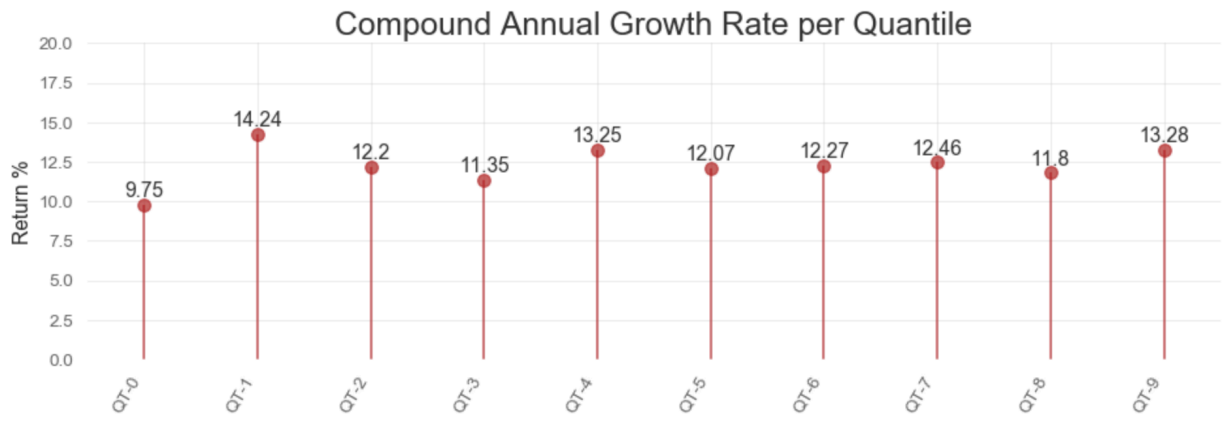
Cumulative Return per SRI Quantile

Observed the top performing quantiles are: 1, 4, and 9. Quantiles are grouped in ten buckets, from 0 to 9.



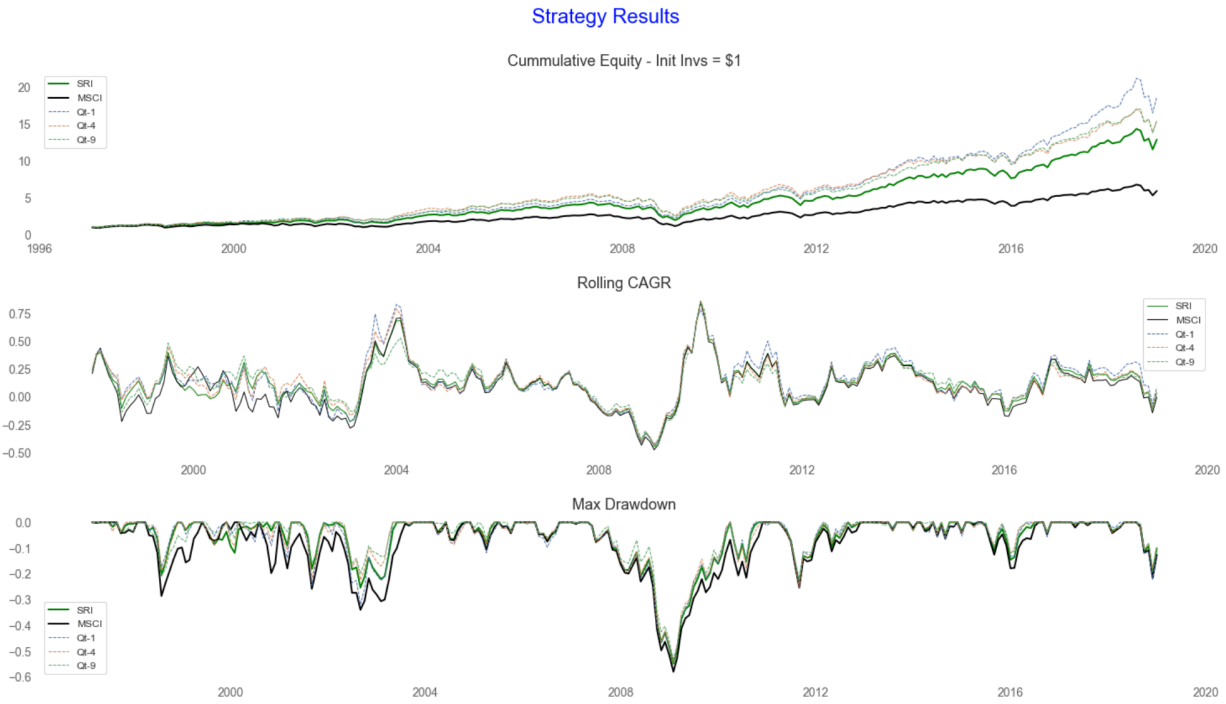


Compound Annual Growth Rate (CAGR) per SRI Quantile



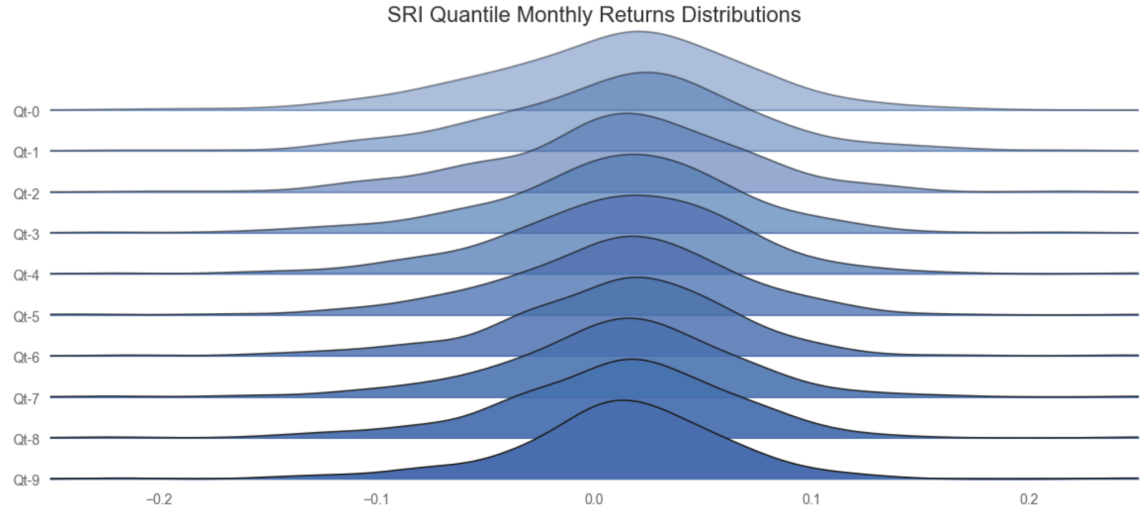
Summary Comparison of Top Performing SRI Quantiles vs SRI set

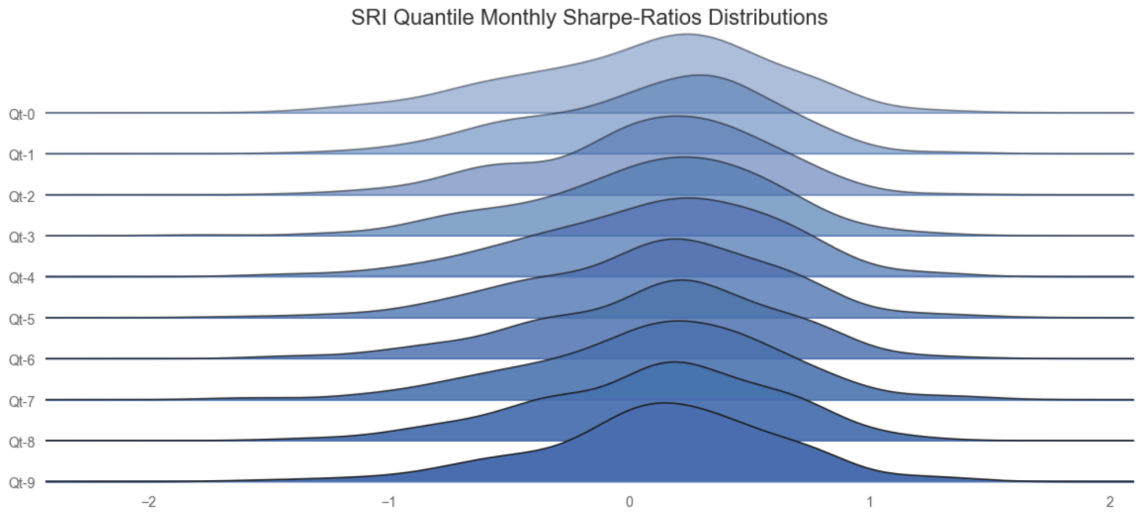
Top performing SRI (1, 4, and 9) against the entire SRI dataset and Russell 3000.

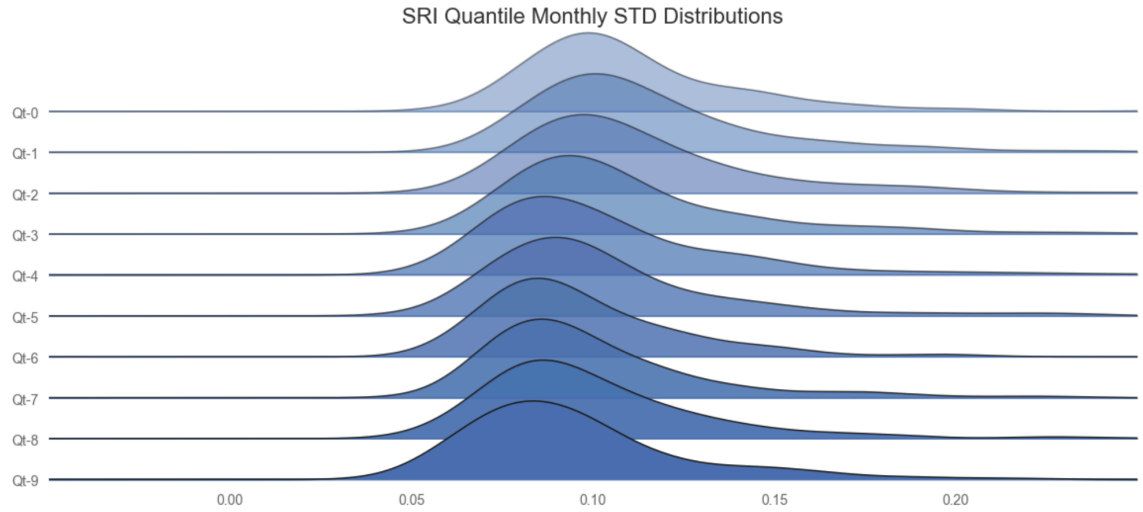


Distributions

The following set of distribution charts reveal an interesting patter, the spread of the distributions for monthly returns, standard deviation of the returns, sharpe ratios, decreases as the SRI ranked quantile increase. The risk is decreasing the higher the KLD quantile score is.







Annual Summary of Key Metrics

	Quantile_rank	qt_CAGR	qt_cum_fut_ret	qt_Overall_Std	qt_Overall_SR	qr_labels
0	0	0.097488	7.740976	0.102465	0.951427	Qt-0
1	1	0.142447	18.723857	0.132002	1.079132	Qt-1
2	2	0.122004	12.585592	0.109462	1.114580	Qt-2
3	3	0.113465	10.638664	0.099899	1.135802	Qt-3
4	4	0.132477	15.439879	0.103525	1.279657	Qt-4
5	5	0.120712	12.270562	0.115412	1.045916	Qt-5
6	6	0.122676	12.752504	0.121424	1.010306	Qt-6
7	7	0.124612	13.245175	0.104974	1.187069	Qt-7
8	8	0.118046	11.644353	0.091265	1.293441	Qt-8
9	9	0.132824	15.544494	0.117156	1.133738	Qt-9

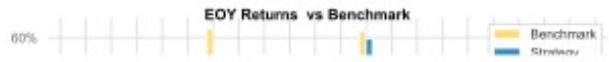
Detailed Comparison of SRI Top Ranked Quantile versus SRI universe

Comprehensive tear-sheet-report comparing the SRI dataset top ranked-quantile versus the SRI complete dataset use as a benchmark.

SRI Top Ranked KLD Quantile Strategy vs SRI Tearsheet 31 Jan,

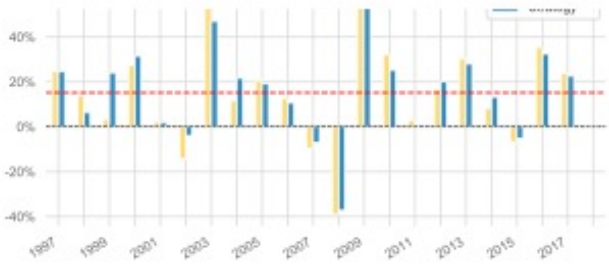
1997 - 31 Dec, 2018

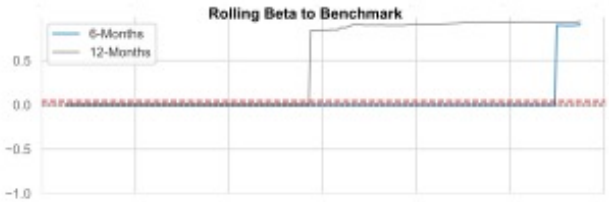
Generated by Gustavo Zambrana (v. 0.0.34)



Key Performance Metrics

Metric	Strategy	Benchmark
Risk-Free Rate	0.0%	0.0%
Time in Market	100.0%	100.0%
Cumulative Return	1,454.45%	1,193.52%
CAGR%	13.33%	12.38%
Sharpe	3.68	3.28
Sortino	5.77	5.11
Sortino/√2	4.08	3.61
Max Drawdown	-53.82%	-54.81%
Longest DD Days	1247	1035
Volatility (ann.)	80.43%	86.14%
R^2	0.94	0.94
Calmar	0.25	0.23
Skew	-0.37	-0.35
Kurtosis	3.17	1.97
Expected Daily %	1.04%	0.97%
Expected Monthly %	1.04%	0.97%
Expected Yearly %	13.28%	12.34%
Kelly Criterion	30.69%	25.06%
Risk of Ruin	0.0%	0.0%
Daily Value-at-Risk	-7.16%	-7.8%
Expected Shortfall (cVaR)	-7.16%	-7.8%
Gain/Pain Ratio	0.88	0.72
Gain/Pain (1M)	0.88	0.72
Payoff Ratio	0.93	0.87
Profit Factor	1.88	1.72
Common Sense Ratio	2.09	1.94





Metric	Strategy	Benchmark
CPC Index	1.16	0.97
Tail Ratio	1.11	1.12
Outlier Win Ratio	3.23	2.96
Outlier Loss Ratio	3.18	2.86
MTD	12.34%	11.61%
3M	1.6%	1.4%
6M	-5.67%	-6.15%
YTD	0.01%	0.64%
1Y	0.01%	0.64%
3Y (ann.)	14.31%	15.65%
5Y (ann.)	11.03%	10.6%
10Y (ann.)	17.04%	17.82%
All-time (ann.)	13.33%	12.38%
Best Day	24.55%	23.3%
Worst Day	-21.82%	-22.06%
Best Month	24.55%	23.3%
Worst Month	-21.82%	-22.06%
Best Year	59.55%	63.88%
Worst Year	-37.25%	-39.07%
Avg. Drawdown	-6.41%	-8.52%
Avg. Drawdown Days	120	151
Recovery Factor	27.02	21.78
Ulcer Index	1.1	1.08
Avg. Up Month	3.97%	4.26%
Avg. Down Month	-4.28%	-4.9%
Win Days %	66.67%	65.15%
Win Month %	66.67%	65.15%
Win Quarter %	71.59%	68.18%
Win Year %	77.27%	81.82%
Beta	0.91	-
Alpha	0.4	-

EOY Returns vs Benchmark

Year	Benchmark	Strategy	Multiplier	Won

Year	Benchmark	Strategy	Multiplier	Won
1997	24.86%	24.54%	0.99	-
1998	14.08%	6.30%	0.45	-
1999	3.36%	24.10%	7.17	+
2000	27.43%	31.51%	1.15	+
2001	2.29%	1.76%	0.77	-
2002	-14.13%	-3.90%	0.28	+
2003	63.88%	47.01%	0.74	-
2004	11.64%	21.65%	1.86	+
2005	20.56%	19.11%	0.93	-
2006	12.50%	10.65%	0.85	-
2007	-9.53%	-7.04%	0.74	+
2008	-39.07%	-37.25%	0.95	+
2009	62.77%	59.55%	0.95	-
2010	32.22%	25.22%	0.78	-
2011	2.75%	-0.08%	-0.03	-
2012	16.83%	20.03%	1.19	+
2013	30.49%	28.00%	0.92	-
2014	8.14%	13.29%	1.63	+
2015	-6.68%	-5.17%	0.77	+
2016	35.29%	32.46%	0.92	-
2017	23.86%	22.59%	0.95	-
2018	0.64%	0.01%	0.02	-

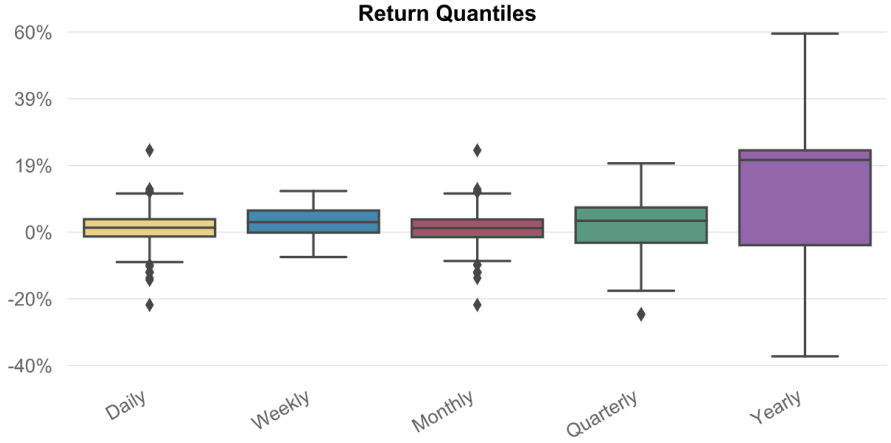
Worst 10 Drawdowns

Started	Recovered	Drawdown	Days
2007-05-31	2010-10-29	-53.82%	1247
2011-04-29	2012-02-29	-21.71%	306
1998-04-30	1999-03-31	-20.89%	335
2002-04-30	2003-04-30	-19.91%	365
2018-08-31	2018-12-31	-19.16%	122
2001-05-31	2001-11-30	-15.93%	183
2015-05-29	2016-04-29	-11.97%	336
2012-03-30	2012-08-31	-7.51%	154
1999-12-31	2000-02-29	-6.46%	60
2005-02-28	2005-05-31	-6.36%	92

Monthly Returns (%)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1997	0.49	-3.30	3.24	9.41	2.47	7.61	0.77	6.09	-3.28	0.19	0.99	-1.64
1998	7.89	4.92	0.42	-3.28	-1.33	-3.89	-13.75	3.78	7.49	2.38	5.07	-1.50
1999	-1.08	6.11	10.03	0.47	7.54	0.60	-2.54	-1.50	0.04	1.80	3.82	-2.60
2000	-3.96	12.03	1.16	0.13	-0.47	1.71	6.49	1.81	0.52	-1.60	8.55	2.41
2001	-1.76	-1.94	6.36	0.54	-1.32	0.22	-3.22	-12.16	3.85	8.63	5.99	-1.72
2002	1.81	6.57	0.71	-0.82	-7.36	-8.64	2.41	-6.84	5.43	7.72	-2.45	-0.87
2003	-1.30	0.09	8.26	8.66	2.76	2.63	3.25	-1.01	6.40	2.43	4.61	2.94
2004	2.93	0.27	-0.39	-0.14	5.66	-3.83	-0.45	3.65	1.72	10.02	2.98	-1.94
2005	3.27	-1.12	-5.30	5.22	3.57	5.40	0.02	0.73	-3.65	3.76	0.01	6.46
2006	-0.69	3.58	0.83	-4.34	0.44	-2.03	1.55	0.82	6.14	3.05	0.37	0.84
2007	-0.10	2.35	2.71	3.00	-1.48	-5.47	2.39	2.18	1.00	-6.80	1.25	-7.47
2008	-1.56	-0.54	5.71	4.62	-8.97	2.51	4.39	-7.66	-21.82	-11.99	3.81	-9.79
2009	-14.35	10.21	24.55	6.10	1.98	10.33	4.40	5.62	-4.07	4.29	6.87	-3.58
2010	5.07	5.88	4.00	-7.52	-5.64	5.62	-6.94	11.58	3.24	1.95	7.13	0.29
2011	3.75	0.36	2.05	-1.32	-1.66	-4.27	-7.74	-8.65	12.89	0.08	-0.17	6.49
2012	3.92	2.98	-0.85	-6.72	3.81	0.40	3.18	1.78	-1.14	1.31	3.38	7.01
2013	1.56	5.20	1.78	3.61	-1.36	6.37	-3.20	4.18	4.85	3.04	2.76	-3.29
2014	5.21	1.27	-0.44	1.77	3.67	-2.92	4.06	-4.35	5.02	1.84	1.61	-3.61
2015	6.50	0.59	-0.20	0.76	-0.78	0.58	-5.78	-3.98	6.91	2.84	-3.63	-7.99
2016	0.90	8.88	2.14	2.68	-1.42	5.79	1.36	1.08	-3.98	8.24	1.71	1.78
2017	1.79	0.25	1.40	-0.60	4.02	1.17	-0.14	5.65	0.40	3.71	0.34	2.75
2018	-3.16	0.79	0.83	4.16	1.17	2.23	3.87	-0.41	-10.25	2.78	-12.00	12.34

Return Quantiles



Insights derived:

i.	The SRI performance per quantile varies, best expected performant quantiles are in the lower and upper end, quantile two and nine
ii.	Quantiles two, five, and nine outperform the SRI average one
iii.	A key finding is that the distribution of returns and their standard deviation increases from quantile 0 to 9. The tails of the distributions become narrower
iv.	The top performing quantiles have superior CAGR and drawdown performance than the SRI average throughout the entire period. This indicates that superior performance can potentially be achieved without increasing risk in the downside
v.	Portfolio selections of SRI ranked companies with superior performance in terms of KLD Ranking can be achieved without sacrificing returns and/or increase risk

Objective 3: Performance of SRI companies versus Russell 3000 in down market periods

The number of down years, their corresponding annul return and standard deviations were extracted from the different datasets. The next three tables have the data for each dataset. It can be observed that the Russell 3000 had worst down years than the SRI in all years that overlap. Additionally, the SRI Top Ranked KLD quantile outperform the SRI universe in all down years this is consistent with similar behavior observed, top rank quantiles having less risk.

SRI Dataset down years 1997-2018

	Year	fut_ret_all_year	fut_std_all_year
0	2002	-0.141273	0.131537
1	2007	-0.095345	0.110586
2	2008	-0.390672	0.181665
3	2015	-0.066754	0.107533

Russell 3000 down years 1997-2018

	Year	fut_ret_all_year	fut_std_all_year
0	2001	-0.062481	0.201552
1	2002	-0.223910	0.178214
2	2007	-0.109679	0.114338
3	2008	-0.422794	0.188175
4	2015	-0.114566	0.127550
5	2018	-0.044238	0.129260

SRI Top KLD Quantile down years 1997-2018

	Year	Quantile_rank	qt_fut_ret_all_year	qt_fut_std_all_year
0	2002	9	-0.039021	0.114132
1	2007	9	-0.070434	0.109407
2	2008	9	-0.372545	0.177224
3	2011	9	-0.000819	0.099518
4	2015	9	-0.051663	0.097955

Monthly and Annual Summary Metrics

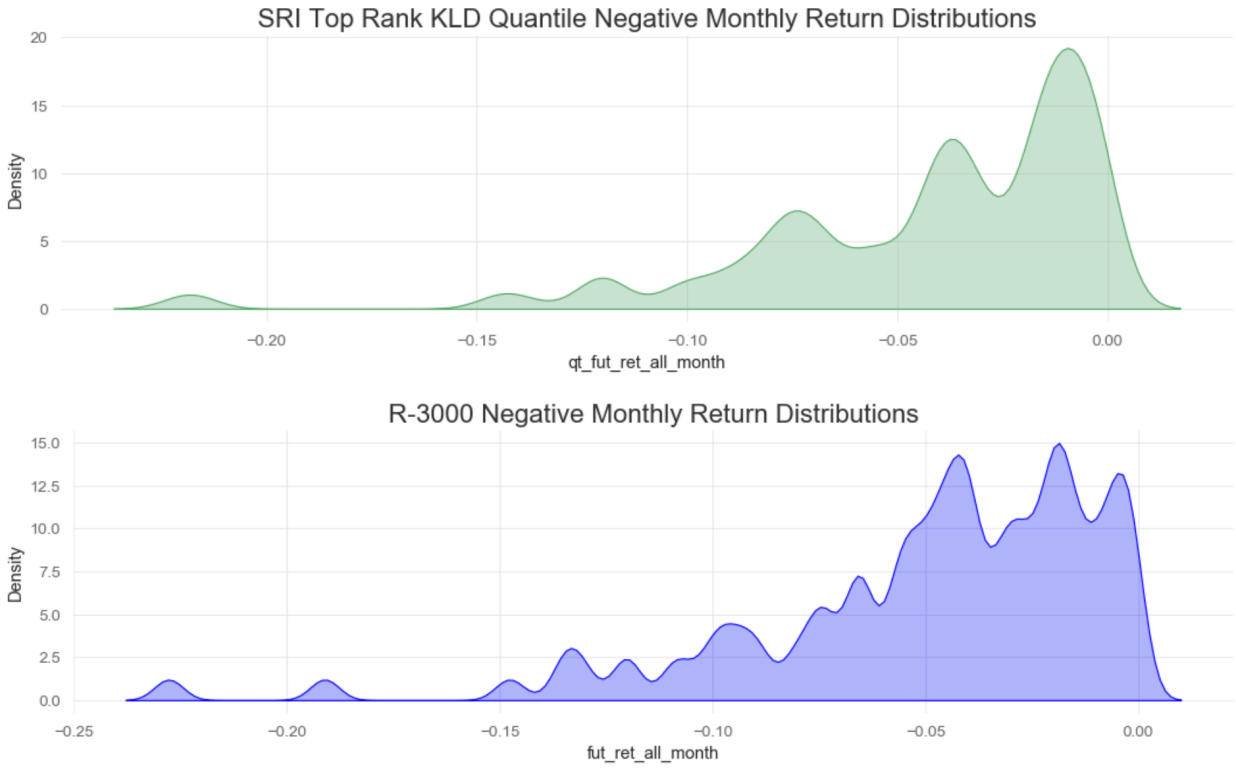
Another way to compare down periods, is by looking at the number down months in market for each of the datasets. Having more data points presents a better reflection of the performance in down markets. The same behavior observed in the annual data, is also present in the monthly data. The mean for the SRI Top quantile during down months is almost a full percent better than the Russell 3000.

Down Periods Summary Statistics

	Dataset	Num Down Years	Perc Down Years	Num Down Months	Perc Down Months	Mean-Ret Down Months	Std-Ret Down Months
0	SRI	4	0.181818	92	0.348485	-0.044679	0.038624
0	SRI-Top-Qt	5	0.227273	88	0.333333	-0.040088	0.039037
0	R-3000	6	0.272727	99	0.375000	-0.049519	0.041782

Distributions

Monthly distributions of negative monthly returns for Russell 3000 and SRI Top Rank KLD quantile. It can be clearly observed that the SRI top ranked quantile has a distribution more center to the right with higher peaks, and the left tail is less fat, this is in accordance with the statistics calculated.



Insights derived:

i.	The Russell 3000 had worst down years than the SRI dataset in all years that overlap
ii.	The SRI Top Ranked KLD quantile outperform the SRI universe in all down years
iii.	Monthly down months have the same pattern as down years, with the SRI Top Ranked KLD quantile outperforming.
iv.	The mean for the SRI Top quantile during down months is almost a full percent better than the Russell 3000

5. VALIDATION

T-Test

The T-Test is used to calculate how likely it is the mean of a strategy' returns greater than the mean of the benchmark returns. Two T-Tests were executed and summarized below; benchmark returns were risk adjusted against the strategy:

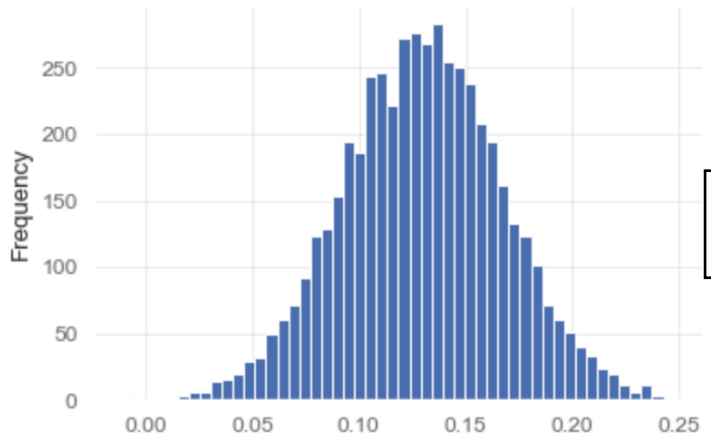
i. SRI vs. Russell 3000
ii. SRI Top Quantile vs. SRI

Experiment	T-Value	P-Value	Statistically Significant
SRI Returns vs. R-3000 Returns	3.41554	0.00073	✓
SRI Top Quantile vs. SRI	3.77940	0.00019	✓

Non-Parametric Monte Carlo T-Test

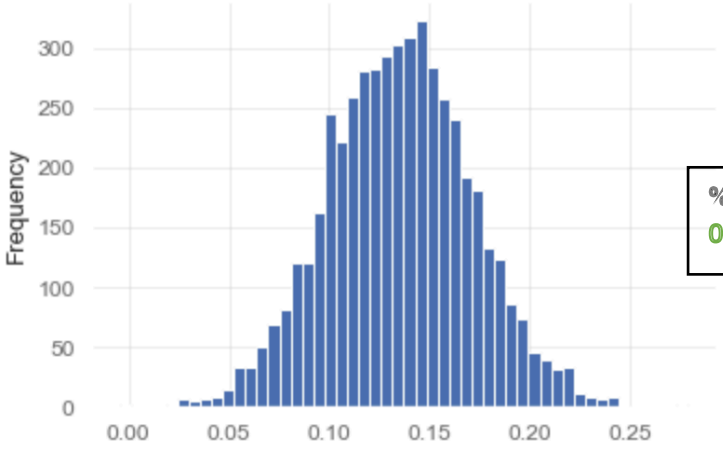
T-Tests make the assumption about the statistical distribution of returns. Assumptions that are normally violently violated when using financial data. To account for this potential bias on the T-Test results, Non-parametric T-Tests were conducted leveraging Monte Carlo technique.

SRI vs. Russell 3000



% Chance (SRI – R-3000) Return diff. is < 0 = 0.06 %

SRI Top Quantile vs. SRI



% Chance (SRI Top Qt. – SRI) Return diff. is < 0 =
0.02 %

Summary

The T-Test and Non-parametric T-Test both concluded the results to be statically significant. This proves what the empirical experiments conducted, and charts indicated, i.e.:

i. The difference in returns between the SRI data set and the risk-adjusted Russel 3000 datasets is statistically significant
ii. The difference in returns between the SRI Ranked Top Quantile in KLD Score and overall SRI dataset is statistically significant.

6. CONCLUSION

- SRI universe outperformed the Russell 3000 from 1997-2018 across all financial metrics, including risk reduction

Metric	SRI	Russell 3000
Cumulative Return	1193%	495%
CAGR	12.38%	8.48%
Sharpe	3.28	2.29
Sortino	5.11	3.42
Max Drawdown	-54.81%	-57.93%
Ave Drawdown	-8.52%	-9.94%

- The SRI Top Ranked KLD Quantile outperformed the SRI set

Metric	SRI Top KLD Qt.	SRI
Cumulative Return	1454%	1193%
CAGR	13.33%	12.38%
Sharpe	3.68	3.28
Sortino	5.77	5.11
Max Drawdown	-53.82%	-54.81%
Ave Drawdown	-6.41%	-8.51%

- Risked was observed to be reduced as the KLD quantile score increased

- Risked-adjusted performance based on sharpe ratio increases as the KLD quantile increases, except for quantile 4 (the 50th percentile)

- The SRI dataset outperformed the Russell 3000 during down periods

- The SRI Top Ranked KLD quantile outperformed the SRI dataset.

- The difference in returns between the SRI and Russell 3000, as well as the SRI Top Ranked KLD quantiles were found to be statistically significant
  - T-Test and Non-Parametric T-Tests validated the results

- The results in this research may have a company size bias, since none of the datasets were adjusted for market capitalization.

- The overall pattern of results should not change even when weighted by market capitalization, but needs to be confirmed

- Recommendations for future research based on the findings:

  - Incorporate the market capitalization dataset provided towards the end of the class
  - Determine the correlation between KLD quantile scoring and top performing factors, there may be a co-factor relationship between increased in performance and some financial factors
  - Investigate creation of optimum portfolios against the SRI Top KLK Ranked quantile, two approaches:
    i. Use the financial factor data to run robust regression models against the top performing KLD quantiles.

    ii. Create an un-supervised model to sub-group the companies in the top performing KLD quantiles using the financial factor data, and then implement an ensemble of Machine Learning classifiers to predict future returns.