NEW INDUSTRY CLASSIFICATION METHODOLOGY IMPACT ON CRSP US SECTOR INDEXES

Abstract

The paper compares performance of CRSP Sector Indexes using FTSE Industry Classification Benchmark (ICB®) to CRSP US Sector Indexes using enhanced FTSE Industry Classification Benchmark (EICB) based on backtested data for the past 11 years. The paper further explores impact of the new industry classification methodology, enhanced FTSE Industry Classification Benchmark (EICB), on specific CRSP Sector Indexes – Real Estate, Telecommunications, Consumer Discretionary and Consumer Staples.

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SUMMARY

CRSP developed the set of Sector Indexes in order to highlight industry segment-specific characteristics of all companies included in the CRSP US Total Market Index. Prior to June 2020 ranking, CRSP Sector Indexes used FTSE Industry Classification Benchmark (ICB®) to assign companies to the appropriate sector index.[1] After June 2020 ranking, CRSP Sector Indexes will adopt the enhanced FTSE Industry Classification Benchmark (EICB).[2]

In this paper we examine the impact of the change in industry classification methodology on the CRSP Sector Indexes using backtested results (refer to Appendix A for more details on data methodology).

The paper is divided into 5 sections:

- Section I gives an overview of the transition of ICB-based CRSP Sector Indexes to its EICB-based successors. The section establishes the successor/counterparty pairing between ICB and EICB-based CRSP Sector Indexes.
- Section II examines the weight reallocation between ICB and EICB-based sectors within the CRSP US Total Market Index as of December 2019, and for the past 11 years.
- Section III compares ICB to EICB-based CRSP Sector Indexes using the 11-year backtest. We examine how closely EICB-based CRSP Sector Indexes replicate their ICB-based predecessors using correlation, tracking and regression analysis. The goal is to see if the industry classification changes cause CRSP Sector Indexes based on new methodology to behave significantly different from sector indexes based on the previous industry classification methodology.
- Section IV focuses on impact of EICB methodology on specific CRSP Sector Indexes: 1) differences between CRSP Real Estate and Financials indexes; 2) impact of IRS 25/50 rule on CRSP Telecommunications index; 3) impact on intra-industry correlations for CRSP Consumer Discretionary and Consumer Staples indexes
- Section V summarizes our findings

[1] FTSE Industry Classification Benchmark (ICB®) is a product of FTSE International Limited and has been licensed for use

[2] FTSE Russell Press Release, "FTSE Russell announces enhancements to its Industry Classification Benchmark (ICB) following Market Consultation," September 6, 2017, https://www.ftserussell.com/press/ftse-russell-announces-enhancements-its-industry-classification-benchmark-icb-following

I. BACKGROUND

CRSP developed the set of Sector Indexes in order to highlight industry segment-specific characteristics of all companies included in the CRSP US Total Market Index.

Prior to June 2020 ranking, CRSP offered 10 sector indexes based on FTSE Industry Classification Benchmark (ICB®) codes, 2 indexes based on ICB subsector code, CRSP US REIT and Small Cap ex-REIT indexes (see Table 1). For each index there are two versions – Total Return and Price Return index versions.[3]

Table 1 – CRSP Sector Indexes prior to June 2020 Ranking

Category	ICB Industry	CRSP Ticker	CRSP Index Name	ICB Code Range	Inception Date
Industry-based	Technology	CRSPITT CRSPIT1	CRSP US Technology Index (TR) CRSP US Technology Index (PR)	9000-9999	2/1/2012
	Telecom	CRSPTET CRSPTE1	CRSP US Telecom Index (TR) CRSP US Telecom Index (PR)	6000-6999	2/1/2012
	Health Care	CRSPHCT CRSPHC1	CRSP US Health Care Index (TR) CRSP US Health Care Index (PR)	4000-4999	2/1/2012
	Financials	CRSPFNT CRSPFN1	CRSP US Financials Index (TR) CRSP US Financials Index (PR)	8000-8999	2/1/2012
	Consumer Services	CRSPCST CRSPCS1	CRSP US Consumer Services Index (TR) CRSP US Consumer Services Index (PR)	5000-5999	2/1/2012
	Consumer Goods	CRSPCGT CRSPCG1	CRSP US Consumer Goods Index (TR) CRSP US Consumer Goods Index (PR)	3000-3999	2/1/2012
	Industrials	CRSPIDT CRSPID1	CRSP US Industrials Index (TR) CRSP US Industrials Index (PR)	2000-2999	2/1/2012
	Materials	CRSPMTT CRSPMT1	CRSP US Materials Index (TR) CRSP US Materials Index (PR)	1000-1999	2/1/2012
	Oil & Gas	CRSPENT CRSPEN1	CRSP US Oil and Gas Index (TR) CRSP US Oil & Gas Index (PR)	0100-0999	2/1/2012
	Utilities	CRSPUTT CRSPUT1	CRSP US Utilities Index (TR) CRSP US Utilities Index (PR)	7000-7999	2/1/2012
Sector-based	REITs	CRSPRET CRSPRE1	CRSP US REIT Index (TR) CRSP US REIT Index (PR)	8671-8675,8677 minus Timber REITs	4/1/2011
Specialty	Small Cap ex-REITs	CRSPSXT CRSPSX1	CRSP US Small Cap ex-REIT Index (TR) CRSP US Small Cap ex-REIT Index (PR)	all but 8671-8677	2/1/2012 9/10/2012

Note: CRSP Sector Indexes, prior to June 2020 rankings, use ICB methodology prior to 2017 announced enhancements[4]; TR in the index name indicates total return index version; PR in the index name indicates price-only return index version

On September 6, 2017, FTSE announced the enhancements to FTSE Industry Classification Benchmark.[4]

[3] For the methodology difference between Price and Total Return indexes, please refer to our CRSP US Equity Indexes Methodology Guide

[4] FTSE Russell Press Release, "FTSE Russell announces enhancements to its Industry Classification Benchmark (ICB) following Market Consultation," September 6, 2017, https://www.ftserussell.com/press/ftse-russell-announces-enhancements-its-industry-classification-benchmark-icb-following

The enhanced FTSE Industry Classification Benchmark (EICB) incorporates significant restructuring.[5] This is why starting with June 5, 2020 ranking, CRSP Sector Indexes will adopt enhanced FTSE Industry Classification Benchmark (EICB) methodology.

The Table 2 shows the pairing of new EICB-based CRSP Sector Indexes to their predecessors, ICB-based CRSP Sector Indexes. For more details on the CRSP sector indexes changes, please see CRSP April 28, 2020 announcement.[6]

Table 2 – Transition from ICB-based to EICB-based CRSP Sector Indexes

CRSP Sector Indexes Prior June 2020 (follow ICB)					CRSP Sector Indexes Post June 2020 (follow EICB)				
Category	Industry	CRSP Ticker	CRSP Index Name	ICB Code Range	Industry	CRSP Ticker	CRSP Index Name	EICB Code Range	Category
Industry-based	Technology	CRSPITT CRSPIT1	CRSP US Technology Index (TR) CRSP US Technology Index (PR)	9000-9999	Technology	CRSPITT CRSPIT1	CRSP US Technology Index (TR) CRSP US Technology Index (PR)	10000000- 14999999	Industry-based
	Telecom	CRSPTET CRSPTE1	CRSP US Telecom Index (TR) CRSP US Telecom Index (PR)	6000-6999	Telecommunications	CRSPTET CRSPTE1	CRSP US Telecommunications Index (TR) CRSP US Telecommunications Index (PR)	15000000- 19999999	
	Health Care	CRSPHCT CRSPHC1	CRSP US Health Care Index (TR) CRSP US Health Care Index (PR)	4000-4999	Health Care	CRSPHCT CRSPHC1	CRSP US Health Care Index (TR) CRSP US Health Care Index (PR)	20000000- 29999999	
	Financials	CRSPFNT CRSPFN1	CRSP US Financials Index (TR) CRSP US Financials Index (PR)	8000-8999	Financials	CRSPFNT CRSPFN1	CRSP US Financials Index (TR) CRSP US Financials Index (PR)	30000000- 34999999	
	Consumer Services	CRSPCST CRSPCS1	CRSP US Consumer Services Index (TR) CRSP US Consumer Services Index (PR)	5000-5999	Consumer Discretionary	CRSPCDT CRSPCD1	CRSP US Consumer Discretionary Index (TR) CRSP US Consumer Discretionary Index (PR)	40000000- 44999999	
	Consumer Goods	CRSPCGT CRSPCG1	CRSP US Consumer Goods Index (TR) CRSP US Consumer Goods Index (PR)	3000-3999	Consumer Staples	CRSPCST CRSPCS1	CRSP US Consumer Staples Index (TR) CRSP US Consumer Staples Index (PR)	45000000- 49999999	
	Industrials	CRSPIDT CRSPID1	CRSP US Industrials Index (TR) CRSP US Industrials Index (PR)	2000-2999	Industrials	CRSPIDT CRSPID1	CRSP US Industrials Index (TR) CRSP US Industrials Index (PR)	50000000- 54999999	
	Materials	CRSPMTT CRSPMT1	CRSP US Materials Index (TR) CRSP US Materials Index (PR)	1000-1999	Basic Materials	CRSPMTT CRSPMT1	CRSP US Basic Materials Index (TR) CRSP US Basic Materials (PR)	55000000- 59999999	
	Oil & Gas	CRSPENT CRSPEN1	CRSP US Oil and Gas Index (TR) CRSP US Oil & Gas Index (PR)	0100-0999	Energy	CRSPENT CRSPEN1	CRSP US Energy Index (TR) CRSP US Energy Index (PR)	60000000- 64999999	
	Utilities	CRSPUTT CRSPUT1	CRSP US Utilities Index (TR) CRSP US Utilities Index (PR)	7000-7999	Utilities	CRSPUTT CRSPUT1	CRSP US Utilities Index (TR) CRSP US Utilities Index (PR)	65000000- 69999999	
Sector-based	REITs	CRSPRET CRSPRE1	CRSP US REIT Index (TR) CRSP US REIT Index (PR)	8671-8675,8677 minus Timber REITs	Real Estate	CRSPRET CRSPRE1	CRSP US Real Estate Index (TR) CRSP US Real Estate Index (PR)	35000000- 39999999	
Specialty	Small Cap ex-REITs	CRSPSXT CRSPSX1	CRSP US Small Cap ex-REIT Index (TR) CRSP US Small Cap ex-REIT Index (PR)	all but 8671-8677	Small Cap ex-Real Estate	CRSPSXT CRSPSX1	CRSP US Small Cap ex-Real Estate Index (TR) CRSP US Small Cap ex-Real Estate Index (PR)	all but 35000000- 39999999	Specialty

Note: Red text indicates changes to the naming convention and tickers for the new EICB-based CRSP Sector Indexes; TR in the index name indicates total return index version; PR in the index name indicates price-only return index version

[5] For an overview of changes please refer to FTSE Russell website at https://www.ftserussell.com/data/industry-classification-benchmark-icb

[6] The public notice can be found here on the CRSP website at http://www.crsp.org/files/Enhanced_ICB_Notice.pdf

II. CRSP US TOTAL MARKET INDEX SECTOR ALLOCATIONS WEIGHT DIFFERENCES

It may be of interest to investors to assess how much risk and performance in the market can be attributed to a particular sector. As such, it would helpful to understand how much weight each sector contributes to CRSP US Total Market Index.

To compute sector weight within CRSP US Total Market Index we use security membership in CRSP Sector Indexes. That is, we sum up the weights of all securities within CRSP US Total Market that belong to CRSP Technology Index to determine the weight of Technology sector within Total Market Index.[7] This process can be repeated for each CRSP sector index, and for both methodologies (EICB and ICB).

Table 3 displays the differences between sector weights based on EICB and ICB methodologies within CRSP US Total Market Index as of December 31, 2019. The sectors are paired based on the Table 2 assignments to compare the differences between the two methodologies. Table 3 shows that one of the major weight reallocations occurs for Telecommunications sector. The weight of Telecommunications is doubled under the EICB methodology. Other significant changes are the reduction of the combined weight of Financial and Real Estate sectors as compared to ICB-based Financials sector,[8] and reduction of Consumer Staples sector weight compared to Consumer Goods sector.

Table 3 – CRSP US Total Market Index Sector Allocation (December 31, 2019)

ICB-based Sectors		Delta	EICB-based Sectors	
Name	Weight	(EICB - ICB)	Weight	Name
Technology	21.8%	-0.6%	21.2%	Technology
Telecom	1.9%	2.2%	4.1%	Telecommunications
Health Care	13.0%	0.5%	13.6%	Health Care
Financials	19.5%	-2.1%	13.2%	Financials
			4.1%	Real Estate
Consumer Services	13.3%	0.7%	13.9%	Consumer Discretionary
Consumer Goods	7.9%	-1.9%	6.0%	Consumer Staples
Industrials	13.2%	0.9%	14.1%	Industrials
Materials	2.2%	0.0%	2.2%	Basic Materials
Oil & Gas	4.1%	0.0%	4.1%	Energy
Utilities	3.2%	0.3%	3.5%	Utilities

Note: Data is for backtested CRSP US Total Market Index as of December 31, 2019; sector weights are computed based on securities' membership in CRSP sector indexes; float-adjusted market capitalization is used to determine security weight in CRSP Total Market Index; ICB-based Financials sector is compared to the sum of EICB-based Financials and Real Estate sectors

To better understand how the weight is redistributed between old and new sectors we look at Table 4 that shows weight contribution of each ICB-based sector to EICB-based sector. For example, Table 4 makes it clear that most of the weight

[7] For an illustrative example, please refer to Appendix B. Note, float-adjusted market capitalization is used to determine security weight in CRSP Total Market Index

[8] Given that ICB-based Financial sector includes REITs, which represent majority of the EICB-based Real Estate sector, we compare the ICB-based Financials sector weight to the sum of EICB-based Financials and Real Estate sectors weights

increase for EICB-based Telecommunications sector comes from reassigning ~1.1% of Total Market weight from ICB-based Technology and Consumer Services sectors.

Table 4 also reveals that almost ~35% of the weight (2.8% out of 7.9%) of ICB-based Consumer Goods sector is reassigned to EICB-based Consumer Discretionary sector. In addition, we can also see that the new EICB-based Real Estate sector is primarily made-up of companies coming from ICB-based Financials (4.0% out of 4.1%).

Table 4 – ICB and EICB-based Sector Weights Allocations in CRSP US Total Market Index

		ICB-based Sector Allocation										
		Technology	Telecom	Health Care	Financials	Consumer Services	Consumer Goods	Industrials	Materials	Oil & Gas	Utilities	EICB-based Sector Total
EICB-based Sector Allocation	Technology	20.7%				0.1%		0.5%				**21.2%**
	Telecommunications	1.1%	1.9%			1.1%		0.0%				**4.1%**
	Health Care	0.0%		13.0%	0.0%	0.1%	0.0%	0.4%	0.0%			**13.6%**
	Financials	0.0%			13.0%	0.0%		0.2%				**13.2%**
	Real Estate	0.0%			4.0%			0.1%		0.0%		**4.1%**
	Consumer Discretionary	0.0%			0.0%	11.1%	2.8%	0.0%				**13.9%**
	Consumer Staples			0.0%		0.9%	5.1%					**6.0%**
	Industrials				2.4%	0.0%	0.0%	11.4%	0.2%	0.0%		**14.1%**
	Basic Materials						0.0%	0.2%	2.0%	0.0%		**2.2%**
	Energy	0.0%				0.0%	0.0%	0.0%	0.0%	4.1%	0.0%	**4.1%**
	Utilities							0.3%			3.2%	**3.5%**
	ICB-based Sector Total	**21.8%**	**1.9%**	**13.0%**	**19.5%**	**13.3%**	**7.9%**	**13.2%**	**2.2%**	**4.1%**	**3.2%**	**100.0%**

Note: Data is for backtested CRSP US Total Market Index as of December 31, 2019; sector weights are computed based on securities' membership in CRSP sector indexes; float-adjusted market capitalization is used to determine security weight in CRSP Total Market Index

While Table 4 reveals many adjustments to companies' assignments, we can see that most EICB-based sectors' weights originate from the corresponding ICB-based sectors. As such, we can expect that the behavior of the CRSP Sector Indexes based on EICB methodology should resemble closely the behavior of their ICB-based predecessors, provided these sector weight changes hold throughout the history of the backtest.

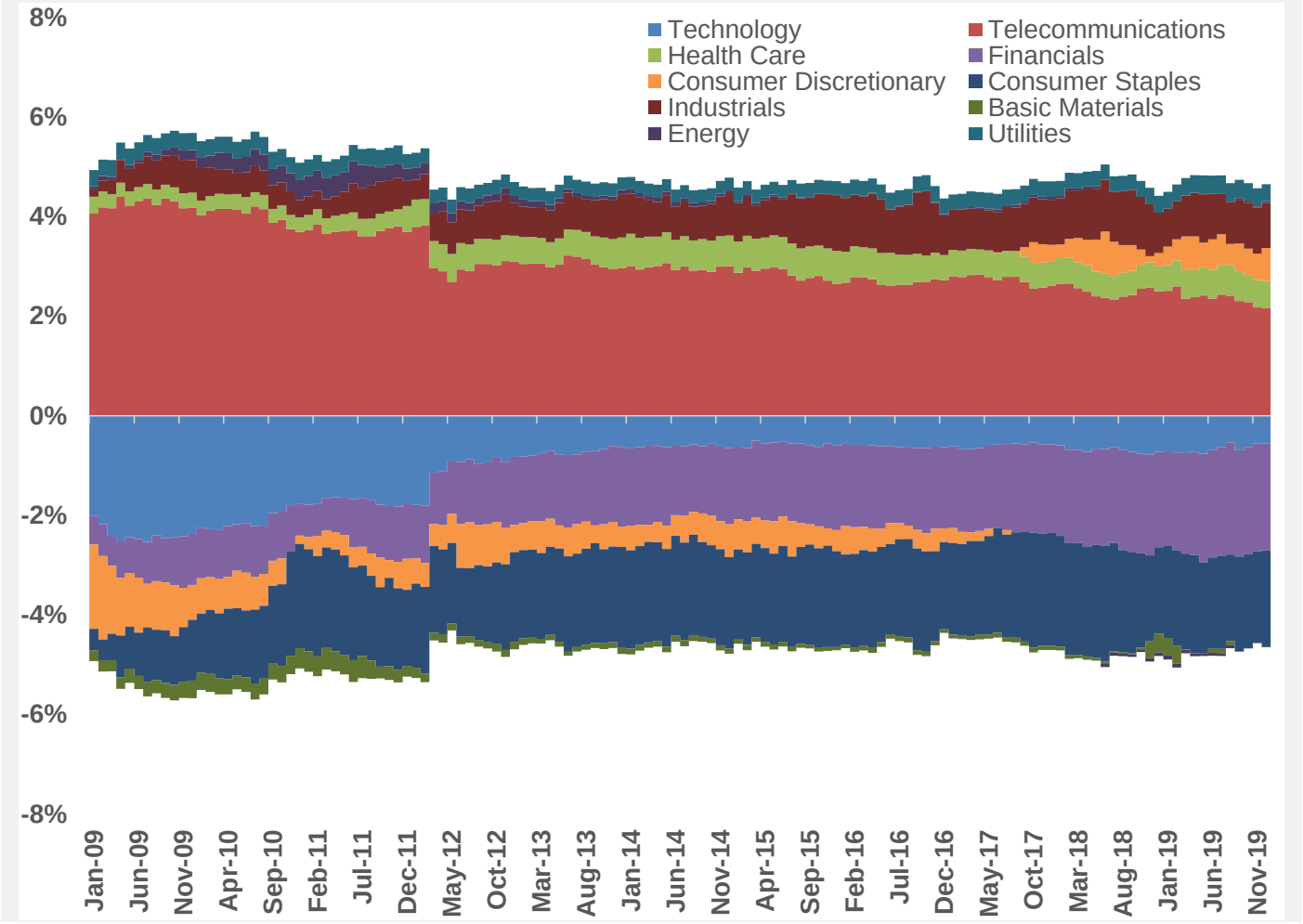
This is indeed what we discover when we analyze the weight differences historically. Figure 1 depicts the historical sector weight differences within CRSP US Total Market Index for the past 11 years. For easier representation, Figure 1 uses the EICB-based sector names. However, we maintain the same matching of EICB-based sectors with corresponding ICB-based sectors as described in Table 3. Figure 1 also uses the same methodology for computing sector differences as Table 3. Therefore, if a bar is below 0% it indicates that EICB-based sector weight in CRSP US Total Market Index is lower than the corresponding ICB-based sector weight. If the bar is above 0%, then it is vice-versa.

In general, Figure 1 confirms that the trends identified in Table 3, based on point-in-time data, hold true from January 2009 through December 2019:

- A major increase in weight for EICB-based Telecommunications sector holds throughout the 11-year history
- A decline in combined weight of EICB-based Financials and Real Estate sectors, while smaller in 2009, is present through the entire history
- A decline in EICB-based Consumer Staples sector weight relative to ICB-based Consumer Goods sector appears to be almost unchanged from 2010 to 2019

Unlike Table 3, Figure 1 reveals that an increase in EICB-based Consumer Discretionary sector weight over ICB-based Consumer Services sector is more of a recent phenomenon. However, we would not expect the difference to seriously impact index behavior, given that the delta between the two is relatively small.

Figure 1 – CRSP US Total Market Historical Sector Allocation Weight Differences
(January 2009 – December 2019)



Note: Data is for backtested CRSP US Total Market Index; sector weights are computed based on securities' membership in CRSP sector indexes; float-adjusted market capitalization is used to determine security weight in CRSP Total Market Index; EICB-based sector names are used for labels, maintaining the same matching of EICB-based sectors with corresponding ICB-based sectors as in Table 3; ICB-based Financials sector is compared to the sum of EICB-based Financials and Real Estate sectors

The next sections analyzes how these differences contribute to the difference in performance of the CRSP Sector indexes following ICB and EICB methodologies.

III. COMPARING ICB AND EICB-BASED CRSP SECTOR INDEXES

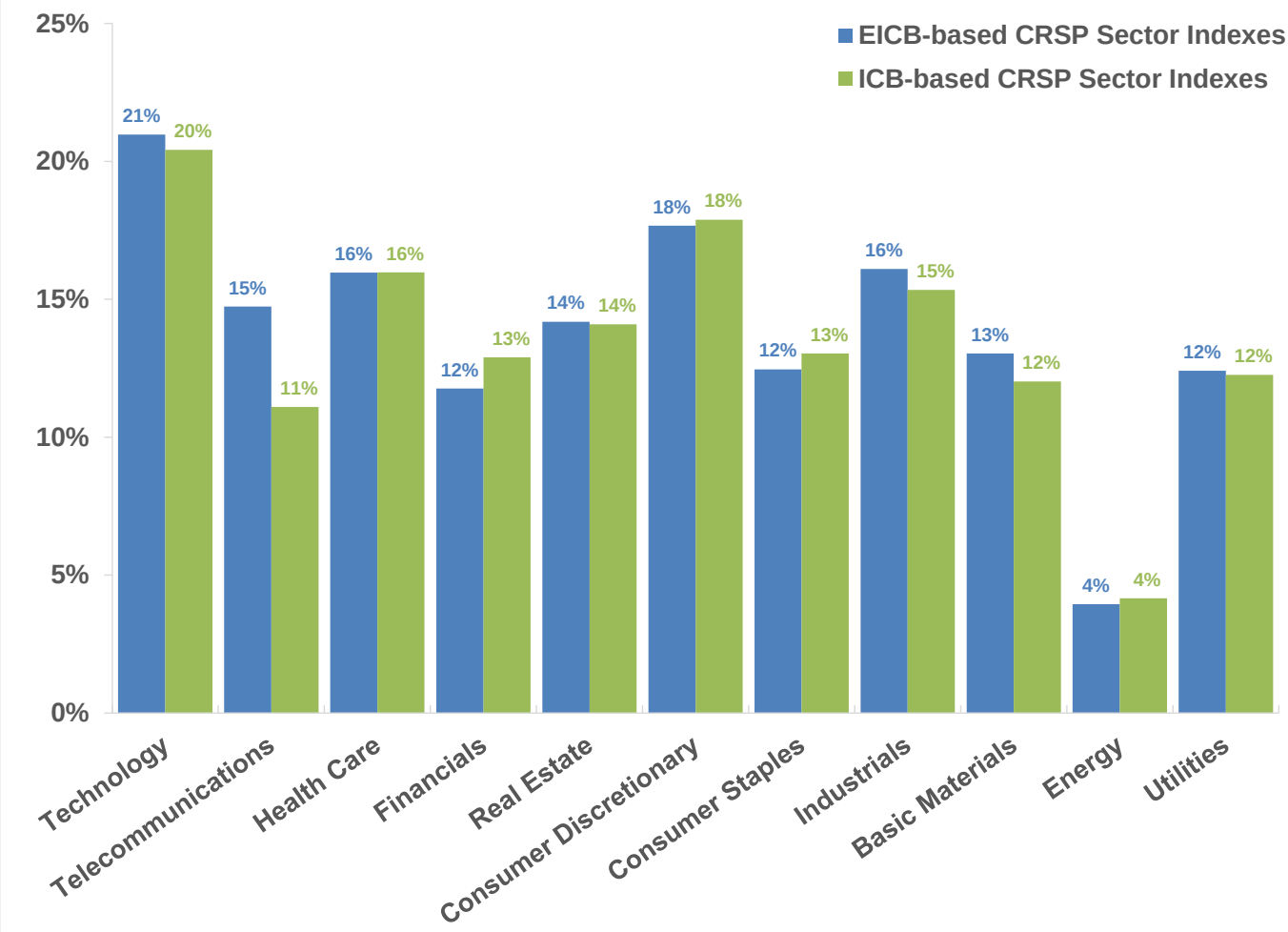
Our goal for comparing EICB-based CRSP Sector Indexes to their predecessors, ICB-based sector indexes, is to ascertain if the reallocations we observed in Section II cause divergence in sector index performances. To analyze if the EICB-based CRSP Sector Indexes are similar or not to their ICB-based predecessors, as outlined in Table 2, we will perform the following comparisons:

1. Performance and Risk
2. Correlation and Tracking
3. Factor Exposure

1. Performance and Risk

A simple comparison between the two sets of indexes would be to look at the differences in annualized returns based on the available 11-year period, January 2009 through December 2019. If the indexes are similar, we would expect that their annualized returns should be similar as well.

Figure 2 – Annualized Returns for Constrained CRSP Sector Indexes (1/1/2009 – 12/31/2019)

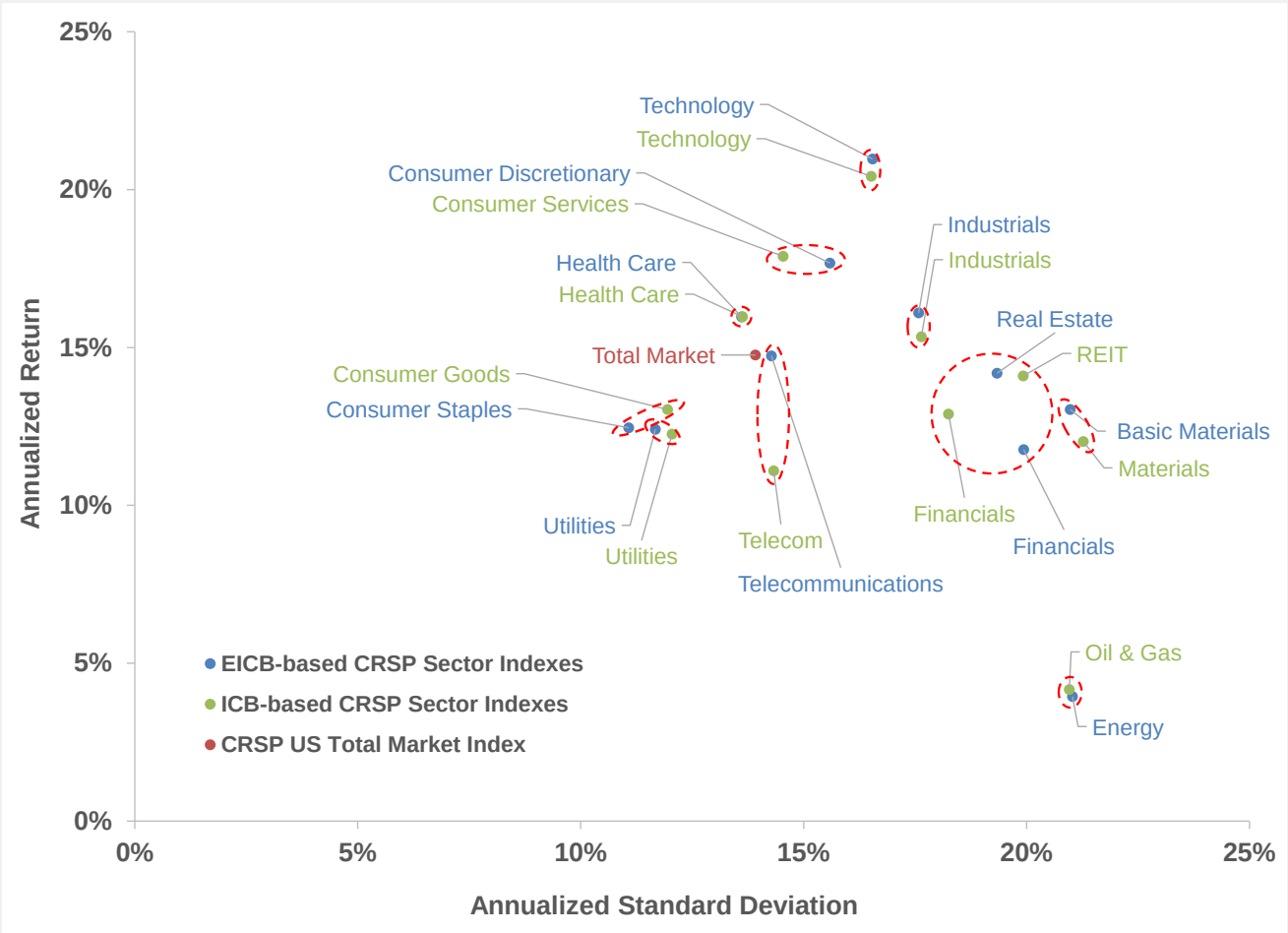


Note: Annualized return computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; EICB-based CRSP Sector Indexes names are used for the labels; pairings between EICB and ICB-based CRSP Sector Indexes are the same as in Table 2; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

Since some sector indexes may have to be constrained to comply with IRS Regulated Investment Company rules, we focus our analysis on constrained sector indexes[9], as these are the ones that would be used by an index fund available to an investor.

Figure 2 highlights that, as can be expected based on our analysis in Section I, the greatest difference in annualized returns between EICB and ICB-based CRSP Sector Indexes occurs for the Telecommunications Index. The chart also highlights contribution of Real Estate companies to the ICB-based CRSP Financials Index performance – without Real Estate companies, EICB-based Financials index underperforms ICB-based Financials index in the past 11 years.[10] As the next step, Figure 3 charts sector indexes annualized return against their risk, represented by standard deviation of the returns, to better understand the index performance.

Figure 3 – Constrained CRSP Sector Indexes Annualized Returns and Standard Deviation



Note: Annualized returns and annualized standard deviation are computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

[9] For more details on CRSP methodology of constraining CRSP Sector Indexes in order to comply with IRS Regulated Investment Company rules refer to CRSP US Equity Indexes Methodology Guide

[10] For more information about REITs performance, see our REITs analysis (http://crsp.org/files/CRSP-REITs_For_the_Past_20_Years_and_Beyond.pdf)

Figure 3 shows how close to each other are EICB and ICB-based CRSP Sector Indexes when evaluated on both dimensions, the annualized return and annualized standard deviation. Again, we note that the major difference in risk-return characteristics between CRSP Sector Indexes based on two methodologies occurs for Telecommunications Index. Figure 3 further highlights the difference in risk-return profile between EICB-based CRSP Real Estate and Financials indexes, bolstering the reason for the new Real Estate industry creation.

Figure 3 also highlights another change. Note that EICB-based CRSP Consumer Staples Index has lower annualized standard deviation compared to its predecessor ICB-based CRSP Consumer Goods Index. At the same time, EICB-based CRSP Consumer Discretionary Index has higher standard deviation compared to its predecessor ICB-based CRSP Consumer Services Index. The result of these changes is that the gap in risk-return profile between Consumer Staples and Discretionary indexes is wider under EICB methodology than under ICB methodology. This change is not inconsistent with the enhanced ICB stated views that "Consumer Staples companies provide essential everyday products and services, whose sales are typically not impacted by the economic environment. Their stocks offer defensive qualities and tend to be less volatile, even when markets are risk averse … By contrast, sales and profits of Consumer Discretionary companies tend to ebb and flow with the economic cycle, and the stocks typically perform more in line with market growth expectations and risk appetites."[11]

2. Correlation and Tracking

To further compare "similarity" of CRSP sector indexes based on EICB and ICB methodologies, we can use correlation and tracking measures. There are several metrics that we can use for tracking, but neither metric alone is perfect. This is why we will use all three metrics together to compare EICB and ICB counterparty CRSP Sector Indexes.

		Tracking	
	A. Correlation	B. Tracking Error	C. **Slope (β)** Coefficient
Formula	$\rho_{r_{EICB},r_{ICB}} = \frac{Cov(r_{EICB},r_{ICB})}{\sqrt{Var(r_{EICB})Var(r_{ICB})}}$	$\sqrt{Var(r_{EICB} - r_{ICB})}$	$r_{EICB} = \alpha + \beta r_{ICB} + \varepsilon$ $\beta = \rho_{r_{EICB},r_{ICB}} \frac{\sqrt{Var(r_{EICB})}}{\sqrt{Var(r_{ICB})}}$
Definitions	r_{EICB} – EICB-based CRSP Sector Indexes monthly returns r_{ICB} – ICB-based CRSP Sector Indexes monthly returns		
Pros	Helps ascertain whether the relationship is linear	Helps ascertain month-to-month deviations	Helps ascertain if relationship is one-to-one over time period
Cons	Does not differentiate between different slopes, i.e. if the relationship is 1-to-1 or 1-to-2	Does not account for the drift, a consistent under- or over-performance of one index relative to the other	Does not account for how large are variations from the trend line
"Good Metric"	Close to 1	Close to 0	Close to 1

[11] FTSE Russell Research, "Industry Classification Benchmark (ICB) reclassification, Expanded and improved," December 2019, https://www.ftserussell.com/research/industry-classification-benchmark-icb-reclassification

Putting the above measures all together, we would expect that a pair of EICB and ICB-based CRSP Sector Indexes are "similar" if their correlation is close to 1, tracking error is close to 0, and the regression slope is close to 1.[12]

A. Correlation

Table 5 displays correlation between constrained EICB and ICB-based CRSP Sector Indexes. To help compare the correlation coefficients, the table uses red font to indicate the strongest correlation between a particular EICB-based sector index and all ICB-based sector indexes; the table uses light-green color to highlight the strongest correlation between a particular ICB-based sector index and all EICB-based sector indexes.

As indicated by red font in the Table 5, the strongest correlations for EICB-based CRSP Sector Indexes are with ICB-based predecessor sector indexes as defined in Table 2. At the same time, the strongest correlation for ICB-based CRSP Sector Indexes is with EICB-based successor sector indexes as indicated with light-green color highlights. As an example, looking across the row for EICB-based CRSP Health Care Index we see that it has the highest correlation with ICB-based CRSP Health Care Index among all ICB-based sector indexes; and vice-versa, looking along the column for ICB-based CRSP Health Care Index we see that it has the highest correlation with its successor, EICB-based CRSP Health Care Index among all EICB-based sector indexes.

Looking across the diagonal of the table, we also note that Telecommunications/ Telecom indexes have the lowest correlation out of all counterparty pairings, as could be anticipated given the major reallocation that EICB-based Telecommunications sector undergone based on data from Table 4. The rest of the correlations, however, are very high and close to ideal metric of 1.

Table 5 – Correlation between EICB and ICB-based Constrained CRSP Sector Indexes

		ICB-based CRSP Sector Indexes										
		Technology	Telecom	Health Care	Financials	REIT	Consumer Services	Consumer Goods	Industrials	Materials	Oil & Gas	Utilities
EICB-based CRSP Sector Indexes	Technology	**1.00**	0.57	0.63	0.73	0.53	0.82	0.73	0.81	0.77	0.61	0.29
	Telecommunications	0.77	**0.89**	0.64	0.78	0.67	0.86	0.83	0.84	0.78	0.67	0.44
	Health Care	0.63	0.55	**1.00**	0.68	0.49	0.74	0.70	0.73	0.64	0.53	0.40
	Financials	0.71	0.55	0.65	**0.98**	0.60	0.80	0.73	0.87	0.78	0.66	0.23
	Real Estate	0.57	0.61	0.52	0.76	**1.00**	0.70	0.71	0.74	0.63	0.50	0.59
	Consumer Discretionary	0.84	0.65	0.70	0.85	0.66	**0.99**	0.84	0.90	0.82	0.65	0.30
	Consumer Staples	0.57	0.68	0.66	0.64	0.61	0.72	**0.94**	0.67	0.58	0.51	0.62
	Industrials	0.82	0.67	0.71	0.91	0.71	0.90	0.83	**1.00**	0.88	0.75	0.36
	Basic Materials	0.78	0.66	0.65	0.81	0.60	0.80	0.76	0.89	**1.00**	0.79	0.26
	Energy	0.60	0.58	0.52	0.67	0.46	0.65	0.64	0.75	0.80	**1.00**	0.27
	Utilities	0.32	0.51	0.43	0.37	0.61	0.37	0.58	0.41	0.29	0.31	**1.00**

Note: Computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

B. Tracking Error

Tracking error helps ascertain the spread of the monthly returns deviations between the two sets of indexes. The larger the deviation, the less likely that the two indexes would exhibit "similar" behavior in performance and risk metrics. Note,

[12] We would also expect that regression intercept (α) is close to 0 and not statistically significant, implying that 0% return for one index yields 0% for its counterparty

that tracking error measures deviations over monthly periods, whereas our performance and risk metrics looked over the entire 11 year period. As such, tracking error gives us an additional information on the index "similarity."

Tracking error is not a perfect metric as it would not indicate a presence of a drift, i.e. a systematic over- or under-performance over long periods of time. That is a low tracking error could be a problem, if one index consistently under- or over-performs the other, as the cumulative gap between the two indexes would grow over time. To address this issue, we will examine regression coefficients, including intercept, in the next section in addition to the risk-return profile in Figure 3.

Similarly to correlation, the Table 6 uses red font to indicate the lowest tracking error between a particular EICB-based sector index and all ICB-based sector indexes; the table uses light-green color to highlight the lowest tracking error between a particular ICB-based sector index and all EICB-based sector indexes.

As in the case of correlation, Table 6 shows that the lowest tracking error is between EICB-based CRSP Sector Indexes and their ICB-based predecessor sector indexes, both from the perspective of EICB-based sector indexes (red font) and from the perspective of ICB-based sector indexes (light-green highlight). Similar to correlation, EICB-based Telecommunications and ICB-based Telecom indexes have the highest tracking error among all counterparty pairings (i.e. diagonal values), while other values are very close to the ideal metric of 0.

Table 6 – Annualized Tracking Error between EICB and ICB-based Constrained CRSP Sector Indexes

EICB-based CRSP Sector Indexes	ICB-based CRSP Sector Indexes: Technology	Telecom	Health Care	Financials	REIT	Consumer Services	Consumer Goods	Industrials	Materials	Oil & Gas	Utilities
Technology	**1%**	14%	13%	13%	18%	9%	11%	11%	14%	17%	17%
Telecommunications	11%	**7%**	12%	12%	15%	8%	8%	10%	13%	16%	14%
Health Care	13%	13%	**0%**	13%	18%	10%	10%	12%	16%	18%	14%
Financials	14%	17%	15%	**4%**	18%	12%	14%	10%	14%	17%	21%
Real Estate	17%	16%	17%	13%	**2%**	14%	14%	13%	18%	20%	16%
Consumer Discretionary	9%	13%	11%	10%	15%	**3%**	9%	8%	12%	16%	17%
Consumer Staples	14%	11%	10%	14%	16%	10%	**4%**	13%	17%	18%	10%
Industrials	10%	13%	12%	8%	15%	8%	10%	**1%**	10%	14%	17%
Basic Materials	13%	16%	16%	12%	18%	13%	14%	9%	**2%**	13%	21%
Energy	17%	17%	18%	16%	21%	16%	16%	14%	13%	**1%**	21%
Utilities	17%	13%	14%	18%	16%	15%	11%	17%	21%	21%	**1%**

Note: Computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

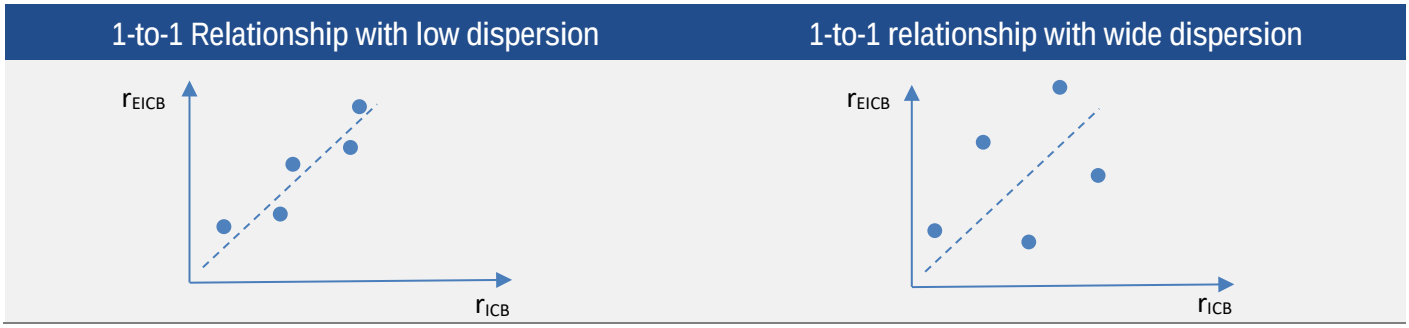
C. Regression Coefficient

The goal of analyzing the slope coefficient from the regression below is to confirm that the relationship between the counterparty sector indexes, i.e. EICB-based Telecommunications and ICB-based Telecom indexes, is close to 1-to-1:

$$r_{EICB} = \alpha + \beta r_{ICB} + \varepsilon$$

The slope coefficient (β) that is close to 1 would indicate that 1% monthly change in ICB-based sector index on average corresponds to 1% monthly change for EICB-based sector index. The 1-to-1 relationship between the two indexes would imply that from the investment performance perspective, there is no difference between investing in EICB-based or ICB-based sector, and therefore the two indexes could be called "similar."

It is important to note that, just like the other metrics, the regression slope coefficient is not a perfect metric of "similarity" on a stand-alone basis. Specifically, regression slope on its own doesn't account for potentially high dispersion around the trend line, as seen from the examples below.



To mitigate this, we can take a look at standard errors of the coefficients and R^2, as well as, at correlation and tracking error metrics from the earlier analyses.

Table 7 displays linear regression slope coefficients (β) for constrained EICB-based sector indexes monthly returns vs. constrained ICB-based sector indexes monthly returns over the period from January 2009 through December 2019. To help compare the slope coefficients, the table uses red font to indicate a slope that is closest to 1 between a particular EICB-based sector index and all ICB-based sector indexes; the table uses light-green color to highlight a slope closest to 1 between a particular ICB-based sector index and all EICB-based sector indexes pairings.

Most of the coefficients for the regression slopes between counterparty sector indexes are closest to 1, as indicated by the alignment of red font and light-green background along the diagonal. However, there are exceptions such as Telecommunications/Telecom, Financials, Consumer Staples/Consumer Goods and Basic Materials/Materials indexes.

Table 7 – Regression Slope Coefficients (β)

		ICB-based CRSP Sector Indexes										
		Technology	Telecom	Health Care	Financials	REIT	Consumer Services	Consumer Goods	Industrials	Materials	Oil & Gas	Utilities
EICB-based CRSP Sector Indexes	Technology	1.00	0.66	0.76	0.67	0.44	0.94	1.01	0.76	0.60	0.48	0.40
	Telecommunications	0.67	0.89	0.67	0.61	0.48	0.84	0.99	0.68	0.53	0.46	0.52
	Health Care	0.52	0.52	1.00	0.50	0.33	0.69	0.80	0.56	0.41	0.34	0.45
	Financials	0.86	0.76	0.95	1.07	0.60	1.10	1.22	0.99	0.73	0.63	0.38
	Real Estate	0.67	0.82	0.74	0.80	0.97	0.93	1.15	0.81	0.57	0.46	0.94
	Consumer Discretionary	0.79	0.71	0.80	0.72	0.51	1.06	1.10	0.80	0.60	0.49	0.39
	Consumer Staples	0.38	0.52	0.54	0.39	0.34	0.55	0.87	0.42	0.30	0.27	0.57
	Industrials	0.87	0.82	0.92	0.88	0.62	1.09	1.22	0.99	0.73	0.63	0.52
	Basic Materials	0.99	0.97	1.00	0.93	0.63	1.16	1.33	1.06	0.98	0.80	0.44
	Energy	0.77	0.85	0.80	0.77	0.49	0.94	1.13	0.90	0.80	1.00	0.48
	Utilities	0.22	0.42	0.37	0.23	0.36	0.30	0.57	0.27	0.16	0.17	0.97

Note: Computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; the return series for constrained sector indexes is used; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

It is worth noting that Telecommunications/Telecom and Financials indexes counterparty pairings also happen to align with the major changes in EICB methodology as we have seen from Table 4, and, therefore, it is not surprising that the EICB-based sector index and its predecessor ICB-based sector index may not have slope that is closest to 1. To further explore regression results implications about similarity between EICB and ICB-based sector indexes, we investigate standard errors of slope coefficients and regression intercepts (α). The analysis is described in Appendix C.

3. Factor exposure

The exposure to the risk factors is the last comparison that we perform. While there are multiple factor definitions, we chose the Fama-French 3-factor model plus the Momentum factor for this analysis. We chose these 4 factors because they are well defined and studied, both, within academia and among practitioners.

Factors	Simplified Interpretation[13]	Interpreting Coefficients Sign[13]
Market (MKT)	Impact of broad market on the index returns	A positive coefficient indicates that broad market moves are positively correlated with the index moves
Size (SMB)	Impact associated with capitalization size, i.e. "small cap" risk	A positive coefficient indicates exposure to "small-cap stocks"; negative coefficient indicates exposure to "large-cap" stocks
Value (HML)	Impact associated with "value style"	A positive coefficient may indicate exposure to "value style"; negative coefficient implies exposure to "growth style"
Momentum (Mom)	Impact of the Momentum risk	A positive coefficient indicates that index returns are positively correlated with momentum; a negative coefficient indicates that index returns are negatively correlated with momentum

To determine factor exposure, we run a regression analysis over the longest time period, January 2009 through December 2019, using monthly returns:

$$CRSP\ Sector\ Index\ Returns = \alpha + \beta_{MKT}MKT + \beta_{SMB}SMB + \beta_{HML}HML + \beta_{Mom}Mom + \varepsilon$$

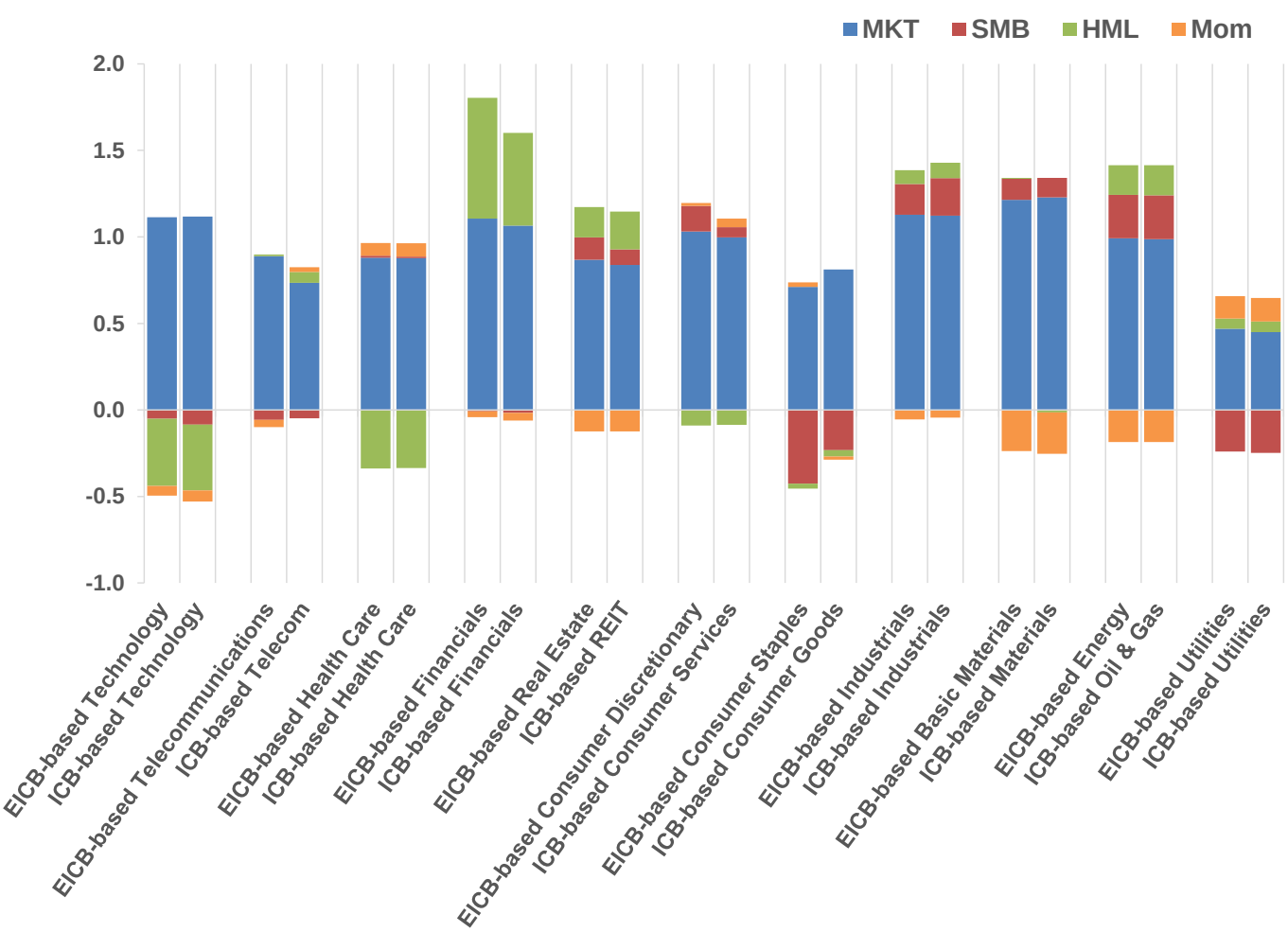
Figure 4 shows the slopes (β_{MKT}, β_{SMB}, β_{HML}, β_{Mom}) associated with the factors for each of the CRSP sector indexes. If the bar is above 0 then it indicates a positive slope, whereas if the bar is below it indicates a negative slope. The size of the bar indicates the value of the slope.

As can be seen from Figure 4, the exposure to factors is almost identical between EICB-based CRSP Sector Indexes and their ICB-based predecessors. The differences between factor exposures are not statistically significant for most of the counterparty pairings, as analyzed in Appendix D.[14] The statistically significant differences in factor exposure between EICB and ICB-based CRSP Sector Indexes occur for Telecommunications/Telecom, Financials, and Consumer Staples/Consumer Goods indexes. The factor exposure differences coincide with some of the major changes as observed in the initial analysis in Table 4, and the subsequent analysis of tracking and correlation.

[13] We use quotes for certain terms, such as "value style", "small-cap stocks", because those terms are not universally defined, and are dependent on factor constructions

[14] We use alpha of 10% and 2-sided hypothesis testing to ascertain whether the difference in factor exposure is statistically significant. More details, including statistical significance of factor exposure, are available in Appendix D

Figure 4 – Factor Exposure for EICB and ICB-based Constrained CRSP Sector Indexes



Note: Computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; Factors series returns are taken from Kenneth French website; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

While the differences between factor exposures align with some of the major changes, and therefore are not unexpected, it is worth highlighting some of the potential implications:

- EICB-based Telecommunications index has greater exposure to the MKT factor and almost no exposure to the HML factor when compared to ICB-based Telecom. This could be due to reduced weight of smaller companies within constrained EICB-based Telecommunications index compared to its predecessor, ICB-based Telecom. Further comparison of constrained Telecommunications/Telecom indexes is in Section IV.
- EICB-based Financials and Real Estate indexes exhibit different factor loadings, which may help to explain the different risk-return profiles we saw in Figure 3. This observation is another reason that bolsters the decision to create a separate Real Estate industry.
- The factor exposure difference between EICB-based Consumer Discretionary and Consumer Staples indexes has widened when compared to the difference in factor exposure between ICB-based Consumer Services and Consumer Goods. This is consistent with the growing gap between EICB-based Consumer Discretionary and Consumer Staples risk/return characteristics we observed earlier in Figure 3. Therefore, we can observe that EICB-based CRSP

Consumer Discretionary and Consumer Staples indexes performance is not inconsistent with the stated intent regarding these industries in ICB's documentation.[15]

Conclusion

When considering all three metrics together (performance, correlation/tracking and factor exposure), we can conclude that while the changes that were implemented within EICB framework have impacted the CRSP Sector Indexes' behavior relative to their ICB-based predecessors, overall, the EICB and their ICB predecessor CRSP Sector Indexes, as defined in Table 2, exhibit similar behavior based on the 11-year backtested history.

[15] FTSE Russell Research, "Industry Classification Benchmark (ICB) reclassification, Expanded and improved," December 2019, https://www.ftserussell.com/research/industry-classification-benchmark-icb-reclassification

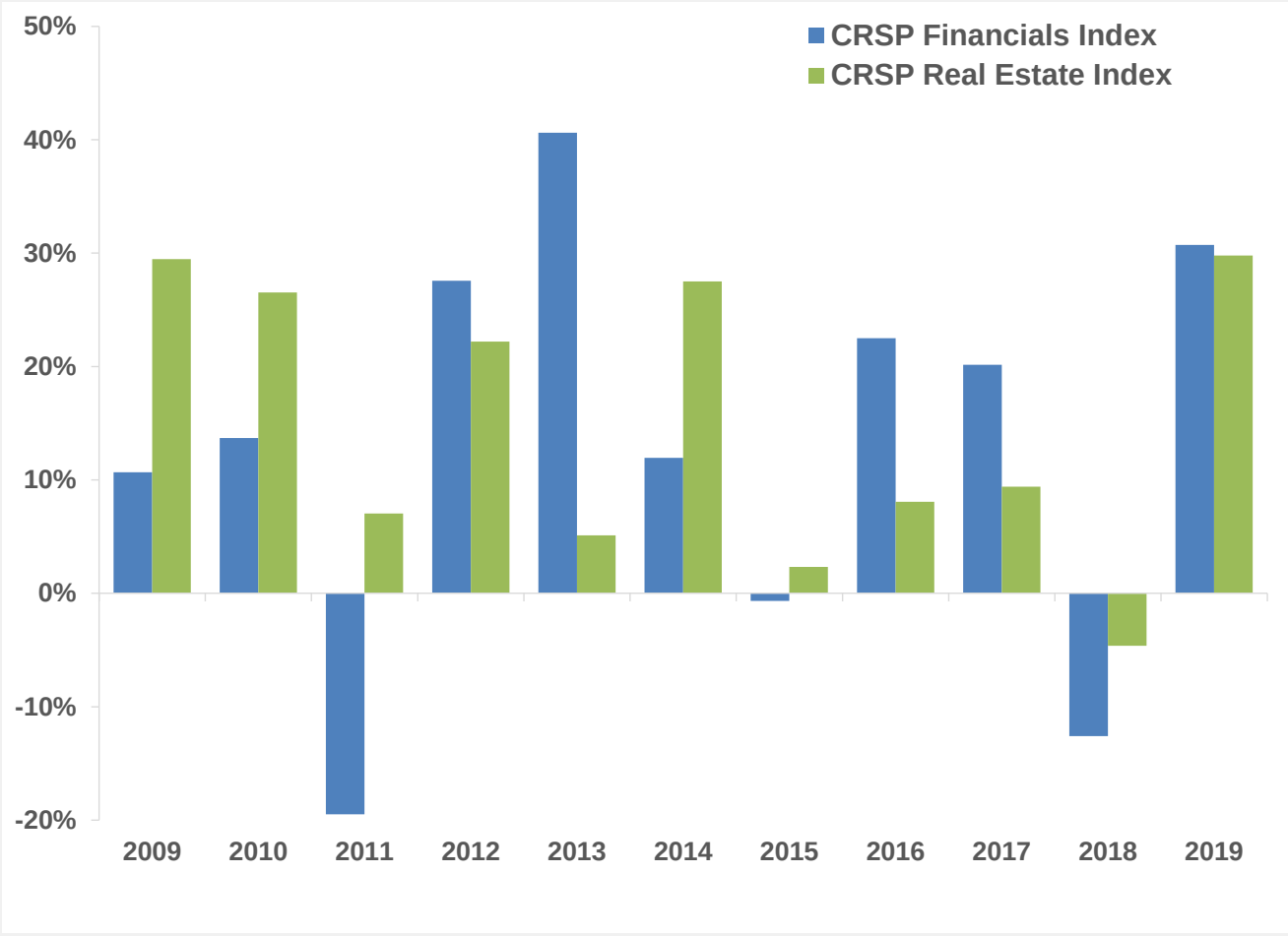
IV. SPECIFIC CRSP SECTOR INDEXES CHANGES IMPACT

Section III established that the EICB-based and their predecessor ICB-based CRSP Sector Indexes behave similar based on the 11-year backtested history, with notable exceptions. Section III also highlighted that Real Estate, Telecommunications and Consumer Discretionary/Staples indexes have greater difference from their ICB-based predecessors than other EICB-based CRSP Sector Indexes. As such, it would be useful to further understand how EICB changes impacted the behavior of CRSP Sector Indexes. Section IV focuses further on the analysis on these 3 indexes.

1. Real Estate Index

As we have seen in Section III, EICB-based CRSP Real Estate index was similar in its behavior to the ICB-based predecessor, CRSP REIT Index. The two indexes had similar risk-return profile, close to 1 correlation, low tracking error, and appeared to have on average 1-to-1 relationship between their monthly returns. However, because Real Estate became a separate industry under EICB methodology, the companies that were assigned to Real Estate were excluded from EICB-based CRSP Financials index.

Figure 5 – Annual Returns for EICB-based CRSP Financials and Real Estate Indexes



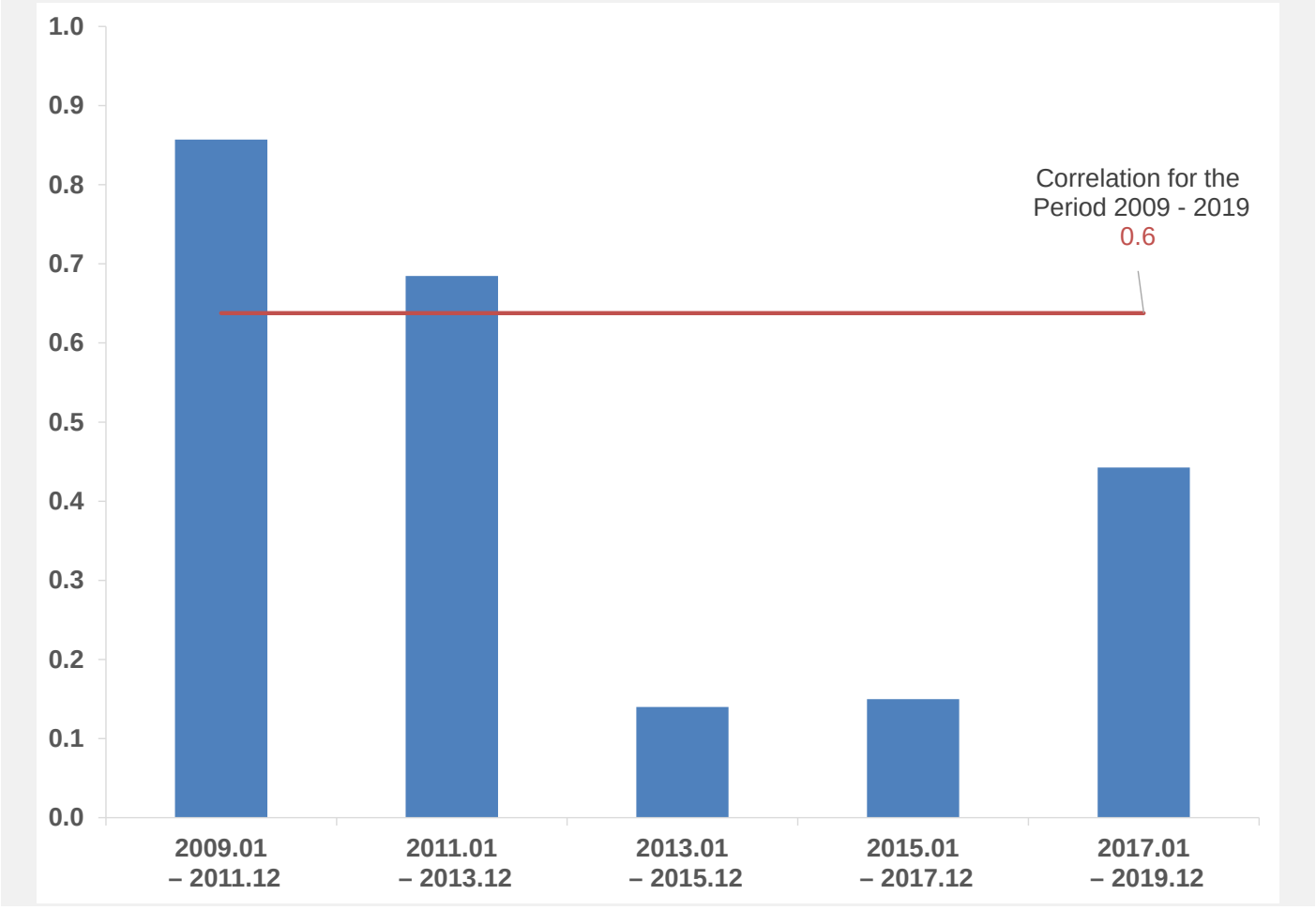
Note: Computed using monthly total return series

The change impacted EICB-based CRSP Financials Index, and, while it still resembled its ICB-based predecessor, we observed that the performance, correlation and tracking metrics were further from the ideal values compared to other counterparty indexes that did not undergo major changes.

As we examined the differences in risk-return profile and factors exposures between EICB-based CRSP Financials and Real Estate indexes, we noted that creation of a new Real Estate industry appeared to be justified. Because many of our analyses in Section III relied on the entire backtested period data, it is worth looking into shorter periods to ascertain whether the differences between EICB-based CRSP Financials and Real Estate indexes were caused by a specific time period or the differences are consistently present throughout the entire 11-year backtest period.

As Figure 5 shows, EICB-based Financials and Real Estate indexes had different annual returns for the past 11 years. Therefore, the return differences we saw in Figure 2 were not a result of one-off event, but consistent throughout 11 years. Figure 6, which shows 3-year rolling correlation between the two sectors, further highlights that differences between Financials and Real Estate indexes are present through the entire 11-year history.

Figure 6 – Rolling 3-year vs. Entire Period Correlation for CRSP Financials and Real Estate Indexes



Note: Computed using monthly total return series

Given the observed differences between EICB-based CRSP Financials and Real Estate indexes in risk-return profile, factor exposures shown in Section III, and the additional data for shorter periods presented in this section, we can say

that there is a strong rationale for the creation of a new Real Estate Industry, separate from Financials. With roughly 200 securities in EICB-based CRSP Real Estate Index, the new sector index would provide investors with the different investment option from the CRSP Financials Index based on the historical data.

2. Telecommunications Index

The changes to EICB methodology have impacted CRSP Telecommunications Index in multiple ways:

1. The weight of Telecommunications sector has increased in Total Market by more than 100% (see Table 3)
2. The annualized return of EICB-based CRSP Telecommunications index relative to its ICB-based predecessor increased by ~4% while maintaining the same annual standard deviation of returns (see Figures 2 and 3)
3. CRSP Telecommunications Index MKT-factor exposure had a statistically significant increase relative to ICB-based CRSP Telecom index (see Figure 4)

However, there is another important adjustment that occurred in Telecommunications Index that is also useful to investors and was not captured directly by the above listed changes. The change has to do with the impact on CRSP Sector Indexes due to constraining of securities' weights to comply with IRS Code 25/50.

A. Understanding Sector Indexes – Constrained vs. Unconstrained Indexes

IRS has established rules for a fund to qualify as a Regulated Investment Company (RIC).[16] These rules state that at the end of each quarter of a RIC's tax year:

1. No more than 25 percent of the value of the RIC's assets may be invested in a single issuer
2. The sum of the weights of all issuers representing more than 5 percent of the fund's total assets should not exceed 50 percent

These rules generally would not impact securities' weight in a well-diversified float-adjusted market capitalization weighted index. However, if an index contains very few securities, and/or some securities are significantly larger than others, the rules 1 and/or 2 could be violated. If IRS RIC rules are violated, the weights of the securities of an index need to be changed from the float-adjusted market capitalization (or unconstrained) weight to a constrained weight that complies with IRS rules.

Table 8 – CRSP US Telecom Index using ICB methodology

			Security's Weight in			
Rank	Ticker	Company Name	CRSP US Total Market	Unconstrained Telecom	Constrained Telecom	Delta Constrained - Unconstrained
1	T	AT&T	0.9%	47.0%	22.6%	-24.4%
2	VZ	Verizon	0.8%	41.8%	22.2%	-19.7%
3	TMUS	T-Mobile	0.1%	3.9%	4.8%	1.0%
4	CTL	Centurylink	0.0%	2.4%	4.5%	2.1%
5	ZAYO	Zayo Group	0.0%	1.4%	4.9%	3.5%
		Remaining Index Members	0.1%	3.6%	41.1%	37.5%
		Total Weight	**1.9%**	**100.0%**	**100.0%**	

Note: Data is as of 12/31/2019; Constrained Telecom index uses CRSP Methodology to constrain float-adjusted market capitalization weights within Unconstrained Telecom index to comply with IRS RIC rules (for more details see CRSP US Equity Indexes Methodology)

[16] Detailed information on IRS Registered Investment Company rules can be found at https://www.law.cornell.edu/uscode/text/26/851

Under ICB methodology, unconstrained CRSP Telecom Index violates IRS 25/50 rules. As can be seen from Table 8, the weights for AT&T and Verizon in unconstrained Telecom index are over 25%, as such they violate the IRS RIC's first rule. Furthermore, the unconstrained Telecom index also violates IRS RIC's second rule since the two securities are over 5% and the sum of the two is over 50%. To make the CRSP Telecom Index comply with IRS requirements for RIC, the weights of AT&T and Verizon need to be reduced below 25% and the weights of other securities increased, while enforcing rule 2 (for more details on constrained index methodology see **CRSP US Equity Indexes Methodology Guide**). As a result of these changes constrained Telecom index, which would be used by funds available to investors, has securities' weights that are not proportional to the securities weights in the CRSP US Total Market Index. Note, AT&T contributes ~10x more than T-Mobile in CRSP US Total Market and unconstrained Telecom indexes. However AT&T contributes only ~5x more than T-Mobile in constrained Telecom index. Therefore constrained CRSP Telecom Index returns do not exactly represent the contribution of Telecom sector within CRSP US Total Market Index. The greater delta between constrained and unconstrained indexes, the greater deviation between the sector contribution within Total Market Index and the returns of IRS RIC's compliant sector index.

Table 9, shows the impact of constraining EICB-based CRSP Telecommunications Index. It is evident from Table 9 that despite an expansion of Telecommunications industry under EICB's methodology, the IRS RIC's rules are still violated. It is important to note that EICB-based unconstrained CRSP Telecommunications Index does not violate IRS RIC's rule 1, as all securities' weights are below the 25% threshold. However, securities with over 5% weight add up to more than 50% of the index, and, as a result, the index violates the second IRS RIC rule.

Table 9 – CRSP US Telecommunications Index using EICB methodology

			Security's Weight in			
Rank	Ticker	Company Name	CRSP US Total Market	Unconstrained Telecommunications	Constrained Telecommunications	Delta Constrained - Unconstrained
1	T	AT&T	0.9%	22.1%	17.7%	-4.3%
2	VZ	Verizon	0.8%	19.6%	15.4%	-4.3%
3	CMCSA	Comcast	0.6%	15.8%	11.4%	-4.3%
4	CSCO	Cisco	0.6%	15.7%	5.2%	-10.5%
5	CHTR	Charter Communications	0.2%	5.6%	5.0%	-0.7%
		Remaining Index Members	0.9%	21.2%	45.3%	24.1%
		Total Weight	**4.1%**	**100.0%**	**100.0%**	

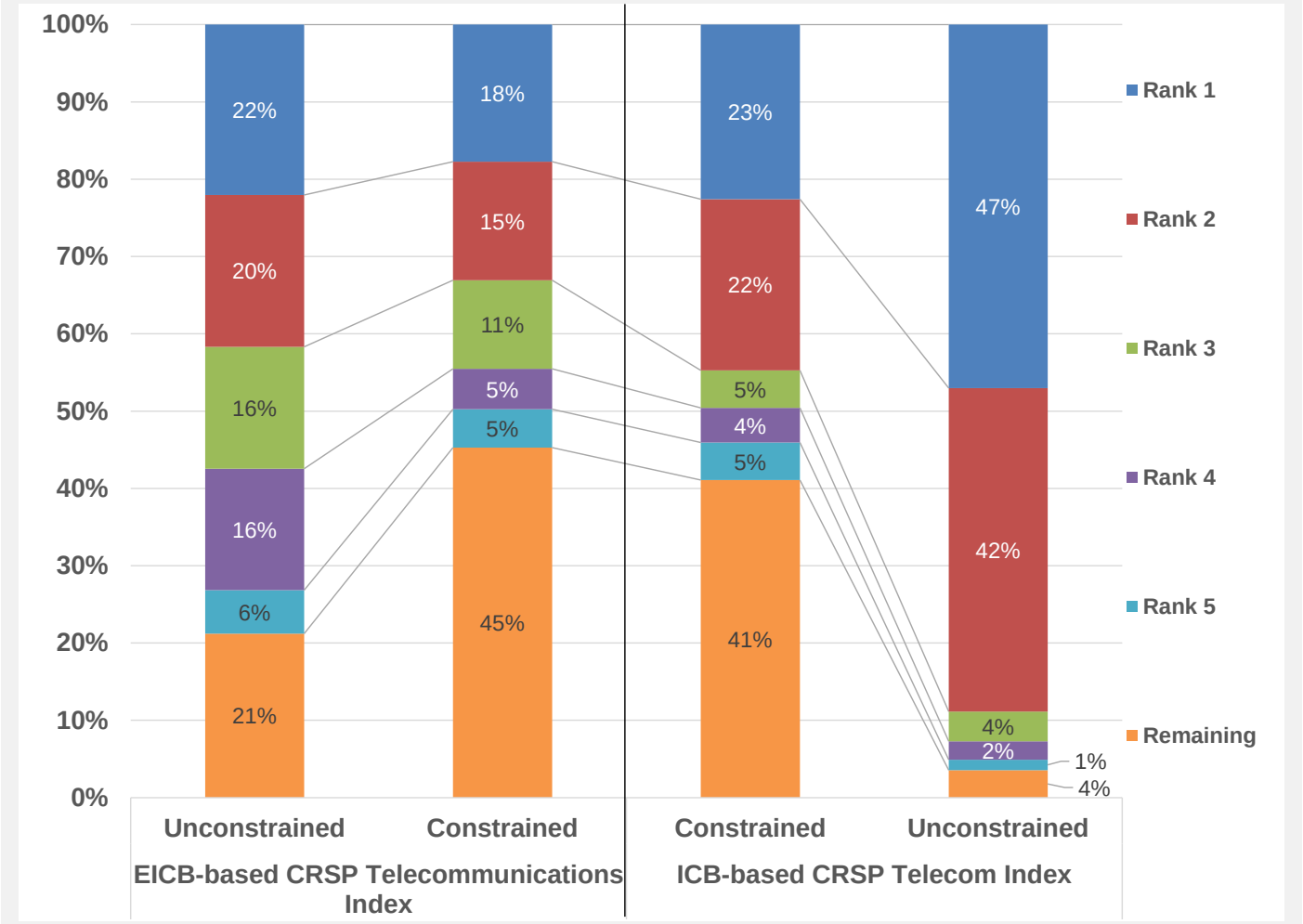
Note: Data is as of 12/31/2019; Constrained Telecommunications index uses CRSP Methodology to constrain float-adjusted market capitalization weights within Unconstrained Telecommunications index to comply to IRS RIC rules (for more details see CRSP US Equity Indexes Methodology)

While EICB-based CRSP Telecommunications index must be constrained to comply with IRS RIC's rules, the difference between Constrained and Unconstrained indexes is smaller for the EICB-based CRSP Telecommunications index than for its ICB-based predecessor, as seen from column Delta in Tables 8 and 9.

Figure 7 illustrates the adjustments that the weights of the top 5 holdings undergo when an index is constrained. EICB-based Constrained CRSP Telecommunication Index is clearly more similar to its unconstrained version than ICB-based constrained counterparty. In fact, the weight for the remaining holdings in EICB-based constrained CRSP Telecommunication Index is 45%, just double the 21% weight in its unconstrained version. At the same time, the weight of remaining holdings in constrained ICB-based CRSP Telecom Index is 41%, which is ~10 times larger than the 4% weight of remaining holdings in unconstrained ICB-based CRSP Telecom Index.

The minimized difference between constrained and unconstrained weights under EICB methodology should result in the improved tracking between constrained and unconstrained Telecommunications indexes. Therefore, Telecommunications index compliant with IRS RIC rule would have exposure that is more similar to the Telecommunications sector exposure within CRSP Total Market Index.

Figure 7 –EICB and ICB-based Unconstrained and Constrained Telecom Indexes



Note: Data is as of 12/31/2019; Constrained indexes use CRSP Methodology to constrain float-adjusted market capitalization weights within Unconstrained indexes to comply to IRS RIC rules (for more details see CRSP US Equity Indexes Methodology)

B. Impact of EICB methodology on CRSP Telecommunications Constrained Index

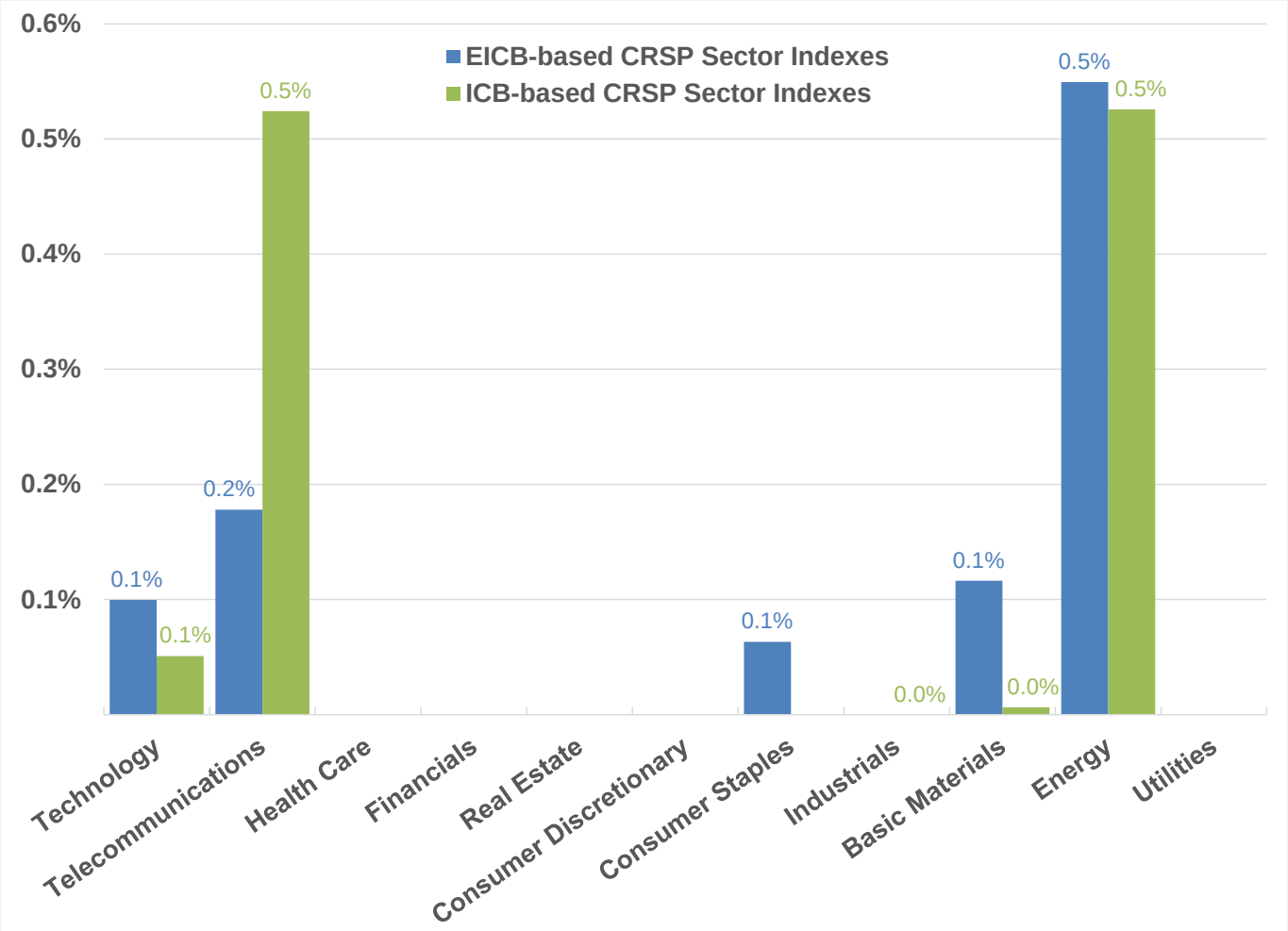
Reducing the difference between the securities' weights in constrained and unconstrained sector indexes is important for an investor who wants to get exposure to the sector returns that are similar to the sector exposure in CRSP Total Market Index.

The smaller the difference in securities' weights between constrained and unconstrained indexes, the closer the performance of the two indexes should be. Figure 8 compares the difference in annualized returns between constrained and unconstrained sector indexes. As can be seen from Figure 8, Telecommunications is not the only CRSP Sector

Index that has return differences between constrained and unconstrained versions. The difference in returns implies that at some point over the 11-year backtest history, a sector index was not in compliance with IRS RIC rules, and, therefore, the weights of securities had to be adjusted.

While other CRSP Sector Indexes, both under ICB and EICB methodologies, had to be constrained to comply with IRS RIC rules, Telecom and Telecommunications indexes have one of the largest impacts on their performance due to constraining. Figure 8 shows a difference of 0.5% in annualized returns for ICB-based Telecom index between constrained and unconstrained versions. The performance discrepancy between constrained and unconstrained Telecommunications indexes is reduced to 0.2% under EICB methodology.

Figure 8 – Absolute Difference in Annualized Returns between Constrained and Unconstrained Indexes



Note: Annualized return computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; the values represent absolute value of Constrained less Unconstrained Index annualized returns; EICB-based CRSP Sector Indexes names are used for the labels; pairings between EICB and ICB-based CRSP Sector indexes are the same as in Table 2; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

To see if EICB methodology reduced the difference between constrained and unconstrained EICB-based CRSP Telecommunications indexes we can compare correlations.

As shown within Table 10, the correlation between constrained and unconstrained CRSP Telecommunications Indexes improves to 0.99 under EICB-based methodology. The increase from 0.88 under ICB-based methodology is statistically significant at alpha 10% based on Fisher's z-test.

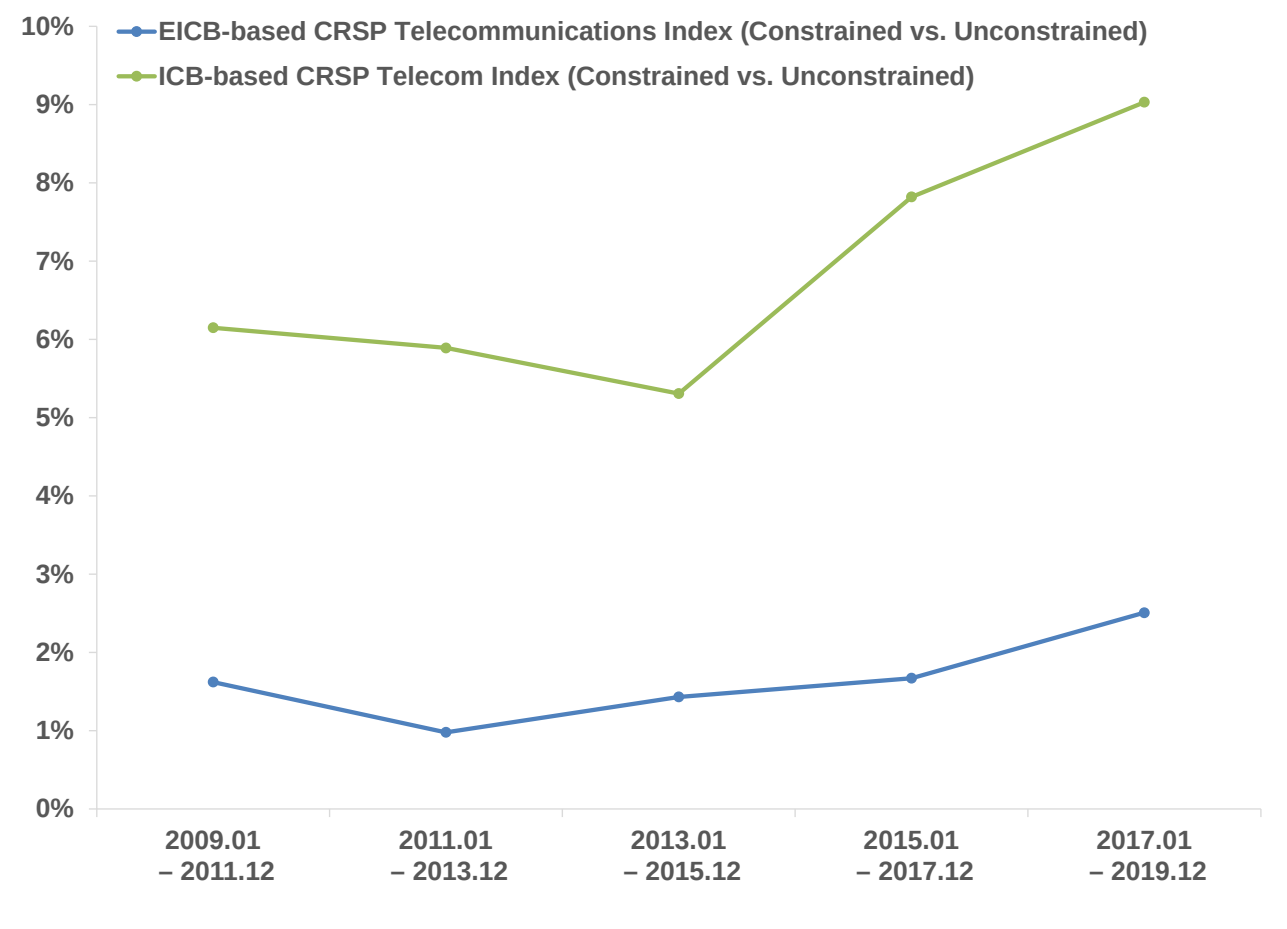
Table 10 – Correlation Coefficient Between Constrained and Unconstrained Telecom Indexes

Correlation between Constrained and Unconstrained Telecom Indexes		Fisher's z-test for Correlation Difference
EICB-based	ICB-based	
0.99	0.88	11

Note: Computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

Next we analyze tracking error between constrained and unconstrained indexes. The analysis should help us to further confirm whether EICB methodology minimizes the difference between constrained and unconstrained versions of Telecommunications indexes.

Figure 9 – Tracking Error between Constrained and Unconstrained Telecommunications Indexes



Note: Computed for the 3-year periods from January to December, using monthly total return series; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

Figure 9 shows the 3-year rolling tracking error between EICB-based constrained and unconstrained CRSP Telecommunications indexes vs. tracking error between ICB-based constrained and unconstrained CRSP Telecom indexes. We can observe that the tracking error for EICB-based indexes is consistently lower than the tracking error for ICB-based indexes. As such, we can conclude that under EICB-based methodology, CRSP Telecommunications Index has a lower standard deviation of the difference in monthly returns between constrained and unconstrained versions than under ICB-based methodology.

Lower tracking error taken together with improved correlation implies that under EICB methodology the CRSP Telecommunications Index that complies with IRS RIC rules better reflects the contribution of Telecommunications sector within CRSP Total Market Index than under the previous ICB methodology.

3. Consumer Discretionary/Staples Indexes

As we discussed previously, under EICB methodology "Consumer Staples companies provide essential everyday products and services, whose sales are typically not impacted by the economic environment. Their stocks offer defensive qualities and tend to be less volatile, even when markets are risk averse… By contrast, sales and profits of Consumer Discretionary companies tend to ebb and flow with the economic cycle, and the stocks typically perform more in line with market growth expectations and risk appetites."[17]

We have observed that the EICB-based CRSP Consumer Staples Index reduced MKT-factor exposure accompanied by the increase in "large-cap" exposure relative to its ICB-based predecessor. At the same time, EICB-based CRSP Consumer Discretionary Index increased its "small cap" exposure relative to its ICB-based predecessor. As a result of these changes we have noticed that EICB-based CRSP Consumer Discretionary Index has increased its risk profile relative to ICB-based CRSP Consumer Services as measured by standard deviation of returns, while EICB-based CRSP Consumer Staples Index, on the other hand, reduced its risk relative to ICB-based CRSP Consumer Goods Index. Taken together these changes would not be inconsistent with the above stated goals to reflect cyclical and counter-cyclical companies.

To see if those changes resulted in other differences, we compare the intra-sector correlations.

In Table 11, the yellow cells indicate where the correlation between EICB-based sector indexes has significantly increased relative to the correlation between corresponding ICB-based sector indexes. At the same time entries marked in red font, indicate cases where correlation between EICB-based sector indexes has significantly decreased relative to corresponding ICB-based sector indexes.

As seen, most of the correlations between EICB-based Consumer Staples index and other EICB-based sector indexes are lower than between ICB-based Consumer Goods index and other corresponding indexes. Notably, correlation between EICB-based CRSP Consumer Staples Index and CRSP US Total Market Index (0.75) is lower than between its ICB-based predecessor, Consumer Goods, and Total Market (0.89). The difference is statistically significant at alpha 10%.

[17] FTSE Russell Research, "Industry Classification Benchmark (ICB) reclassification, Expanded and improved," December 2019, https://www.ftserussell.com/research/industry-classification-benchmark-icb-reclassification

Given that the intent of Consumer Staples sector under EICB methodology is to represent companies "whose sales are typically not impacted by the economic environment", the decreased correlation of EICB-based CRSP Consumer Staples Index with CRSP Total Market Index is not inconsistent with the stated goals and, therefore, CRSP Consumer Staples Index appears to behave as intended based on the backtested data.

Table 11 – Comparison of Correlations between EICB and ICB sectors

		EICB-based CRSP Sector Indexes										
		Technology	Telecommunications	Health Care	Financials	Real Estate	Consumer Discretionar	Consumer Staples	Industrials	Basic Materials	Energy	Utilities
EICB-based CRSP Sector Indexes	Technology	1.00										
	Telecommunications	0.76	1.00									
	Health Care	0.63	0.65	1.00								
	Financials	0.71	0.73	0.65	1.00							
	Real Estate	0.57	0.70	0.53	0.64	1.00						
	Consumer Discretionary	0.84	0.83	0.71	0.81	0.70	1.00					
	Consumer Staples	0.56	0.75	0.66	0.59	0.63	0.68	1.00				
	Industrials	0.82	0.84	0.72	0.88	0.75	0.91	0.67	1.00			
	Basic Materials	0.77	0.79	0.65	0.79	0.64	0.83	0.58	0.89	1.00		
	Energy	0.61	0.67	0.53	0.66	0.50	0.65	0.51	0.75	0.80	1.00	
	Utilities	0.32	0.47	0.43	0.27	0.61	0.34	0.65	0.40	0.29	0.30	1.00
	Total Market	0.88	0.88	0.80	0.89	0.74	0.93	0.75	0.96	0.89	0.77	0.46

		ICB-based CRSP Sector Indexes										
		Technology	Telecom	Health Care	Financials	REIT	Consumer Services	Consumer Goods	Industrials	Materials	Oil & Gas	Utilities
ICB-based CRSP Sector Indexes	Technology	1.00										
	Telecom	0.58	1.00									
	Health Care	0.63	0.55	1.00								
	Financials	0.74	0.60	0.67	1.00							
	REIT	0.53	0.59	0.48	0.72	1.00						
	Consumer Services	0.83	0.69	0.74	0.84	0.66	1.00					
	Consumer Goods	0.73	0.71	0.70	0.78	0.68	0.84	1.00				
	Industrials	0.81	0.67	0.72	0.90	0.70	0.90	0.83	1.00			
	Materials	0.77	0.65	0.64	0.80	0.59	0.79	0.76	0.88	1.00		
	Oil & Gas	0.60	0.58	0.52	0.67	0.46	0.65	0.64	0.75	0.80	1.00	
	Utilities	0.28	0.49	0.40	0.33	0.59	0.34	0.55	0.37	0.25	0.28	1.00
	Total Market	0.88	0.71	0.79	0.92	0.69	0.94	0.89	0.96	0.89	0.78	0.42

Note: computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; to compute statistical significance at 10% alpha, we used Fisher's z-scores for correlation

V. CONCLUSION

Having examined the behavior of CRSP Sector Indexes based on ICB and EICB methodologies, we can conclude that despite some major changes introduced in EICB methodology, the EICB-based CRSP Sector Indexes are relatively similar to their ICB-based predecessors, as defined in Table 2, based on performance, risk, correlation, tracking and factor exposure metrics.

At the same time, the changes introduced by EICB methodology improve the CRSP Sector Indexes in the following ways:

1. A new Real Estate Index enables investors to get exposure to companies that are different from the companies included in Financials Index, as illustrated by the differences in risk-return profiles, correlation and factor exposures

2. EICB-based CRSP Telecommunications has higher correlation and lower tracking error between constrained and unconstrained version than ICB-based predecessor; the implication of this improvement is that the EICB-based Constrained CRSP Telecommunications index, which is the version available to investors, would more accurately reflect the Telecommunications sector contribution within CRSP US Total Market Index than its ICB-based predecessor

3. The reorganization of EICB-based CRSP Consumer Staples Index resulted in changes in risk-return profile and factor exposures compared to ICB-based predecessor. As a result EICB-based CRSP Consumer Staples Index decreased correlation with other EICB-based CRSP Sector Indexes and CRSP Total Market vs. its ICB-based predecessor. This change is not inconsistent with the stated goal for Consumer Staples sector to reflect companies “whose sales are typically not impacted by the economic environment.”

APPENDIX A – DATA METHODOLOGY

CRSP US Sector Indexes based on ICB methodology have a live history starting from 2/1/2012. The earliest EICB historical data starts in December 2008. Given that our quarterly rankings occur in December, and the transitional reconstitution usually finishes by late December (see our **index calendar** on line), we chose to start the comparison post-reconstitution on January 2009. We chose to use backtest simulated data for both CRSP Sector Indexes based on ICB and EICB methodologies to enable us to compare the two classification methodologies with the most available data. The backtest simulation uses the latest methodology as of January 2020. However, due to increased concentration of ICB-based Telecom sector we increased maximum weight ratio from 10 to 15 starting December 2018 ranking to enable optimization. Other differences due to data availability could occur.

APPENDIX B – SECTOR WEIGHTS WITHIN CRSP US TOTAL MARKET INDEX

Below is an illustrative example of computing sector weight within CRSP US Total Market Index using security membership in CRSP Sector Indexes. Please note that this is different than computing sector weights based on security EICB and ICB codes due to potential timing differences between rankings and ICB updates. We chose to compute sector weights based on membership in CRSP Sector Indexes because the goal of the analysis is to compare how CRSP Sector Indexes behavior differ under the two methodologies.

Securities	Security Weight in CRSP US Total Market Index	Security Membership in ICB-based CRSP Sector Indexes	Security Membership in EICB-based CRSP Sector Indexes
Security 1	50%	CRSP US Sector A	CRSP US Sector A’
Security 2	25%	CRSP US Sector A	CRSP US Sector A’
Security 3	15%	CRSP US Sector A	CRSP US Sector B’
Security 4	10%	CRSP US Sector B	CRSP US Sector B’

ICB-based Sector	ICB-based Sector Weight in CRSP Total Market	Delta (EICB-ICB)	EICB-based Sector Weight in CRSP Total Market	EICB-based Sector
Sector A	90%	-15%	75%	Sector A’
Sector B	10%	+15%	25%	Sector B’

APPENDIX C – COMPARING REGRESSION SLOPES

Analysis of standard error for regression slope coefficients reveals that the slope coefficients between EICB and ICB-based CRSP Sector Indexes counterparties have the smallest standard errors.

Standard Error for Regression Slope Coefficients (β)

EICB-based CRSP Sector Indexes	ICB-based CRSP Sector Indexes: Technology	Telecom	Health Care	Financials	REIT	Consumer Services	Consumer Goods	Industrials	Materials	Oil & Gas	Utilities
Technology	0.01	0.08	0.08	0.05	0.06	0.06	0.08	0.05	0.04	0.06	0.12
Telecommunications	0.05	0.04	0.07	0.04	0.05	0.04	0.06	0.04	0.04	0.04	0.09
Health Care	0.06	0.07	0.00	0.05	0.05	0.06	0.07	0.05	0.04	0.05	0.09
Financials	0.07	0.10	0.10	0.02	0.07	0.07	0.10	0.05	0.05	0.06	0.14
Real Estate	0.08	0.09	0.11	0.06	0.01	0.08	0.10	0.06	0.06	0.07	0.11
Consumer Discretionary	0.04	0.07	0.07	0.04	0.05	0.02	0.06	0.03	0.04	0.05	0.11
Consumer Staples	0.05	0.05	0.05	0.04	0.04	0.05	0.03	0.04	0.04	0.04	0.06
Industrials	0.05	0.08	0.08	0.04	0.05	0.05	0.07	0.01	0.03	0.05	0.12
Basic Materials	0.07	0.10	0.10	0.06	0.07	0.08	0.10	0.05	0.01	0.05	0.15
Energy	0.09	0.11	0.12	0.08	0.08	0.10	0.12	0.07	0.05	0.00	0.15
Utilities	0.06	0.06	0.07	0.05	0.04	0.07	0.07	0.05	0.05	0.05	0.01

Note: Computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; the return series for constrained sector indexes is used; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

We further examine the intercept for the counterparty indexes to confirm that it is not statistically significant, that is, the regression line passes through the origin.

As evident from the table below, most of the intercepts are not statistically different from 0 at alpha 10%. The exceptions are Telecommunications, Industrials, Basic Materials and Utilities Sector Indexes. In case of Basic Materials, Industrials and Utilities, alpha is barely different than zero, even if it is statistically significant.

Intercept (Alpha)

CRSP Sector Index: EICB-based	vs. ICB-based	Alpha	p-value
Technology	Technology	0.0%	
Telecommunications	Telecom	0.4%	2.6%
Health Care	Health Care	0.0%	
Financials	Financials	-0.1%	
Real Estate	REIT	0.0%	
Consumer Discretionary	Consumer Services	-0.1%	
Consumer Staples	Consumer Goods	0.1%	
Industrials	Industrials	0.1%	8.4%
Basic Materials	Materials	0.1%	3.7%
Energy	Oil & Gas	0.0%	
Utilities	Utilities	0.0%	6.5%

Note: Computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; the return series for constrained sector indexes is used; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

APPENDIX D – ANALYSIS OF STATISTICAL SIGNIFICANCE OF FACTOR EXPOSURE FOR CRSP SECTOR INDEXES

The table below presents the factor exposure for CRSP Sector Indexes. We indicate the coefficients that are statistically significant at alpha 10% with the red font.

Statistical Significance of Constrained CRSP Sector Indexes Factor Exposure

	Index Name	Factors MKT	SMB	HML	Mom
EICB-based CRSP Sector Indexes	Technology	1.11	-0.05	-0.39	-0.06
	Telecommunications	0.89	-0.06	0.01	-0.04
	Health Care	0.88	0.01	-0.34	0.07
	Financials	1.11	-0.01	0.70	-0.03
	Real Estate	0.87	0.13	0.18	-0.12
	Consumer Discretionary	1.03	0.15	-0.09	0.02
	Consumer Staples	0.71	-0.43	-0.03	0.03
	Industrials	1.13	0.18	0.08	-0.06
	Basic Materials	1.21	0.12	0.01	-0.24
	Energy	0.99	0.25	0.17	-0.19
	Utilities	0.47	-0.24	0.06	0.13
	Total Market	1.00	0.00	0.00	0.00

	Index Name	Factors MKT	SMB	HML	Mom
ICB-based CRSP Sector Indexes	Technology	1.12	-0.08	-0.38	-0.06
	Telecom	0.73	-0.05	0.06	0.03
	Health Care	0.88	0.01	-0.34	0.08
	Financials	1.07	-0.02	0.54	-0.05
	REIT	0.84	0.09	0.22	-0.12
	Consumer Services	1.00	0.06	-0.09	0.05
	Consumer Goods	0.81	-0.23	-0.04	-0.02
	Industrials	1.12	0.22	0.09	-0.04
	Materials	1.23	0.11	-0.01	-0.24
	Oil & Gas	0.99	0.25	0.17	-0.18
	Utilities	0.45	-0.25	0.06	0.14
	Total Market	1.00	0.00	0.00	0.00

Note: Computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; Factors series returns are taken from Kenneth French website; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

We used t-test to assess whether the exposure is different between EICB and ICB-based Sector Indexes. Below is the table displaying p-values for differences in factor exposure between corresponding Sector Indexes.

P-values for Factor Exposure Differences between EICB and ICB-based Constrained CRSP Sector Indexes

CRSP Sector Indexes			p-values for Factor Difference			
EICB-based	**less**	**ICB-based**	**MKT**	**SMB**	**HML**	**Mom**
Technology		Technology	-	-	-	-
Telecommunications		Telecom	9%	-	-	-
Health Care		Health Care	-	-	-	-
Financials		Financials	-	-	8%	-
Real Estate		REIT	-	-	-	-
Consumer Discretionary		Consumer Services	-	-	-	-
Consumer Staples		Consumer Goods	-	5%	-	-
Industrials		Industrials	-	-	-	-
Basic Materials		Materials	-	-	-	-
Energy		Oil & Gas	-	-	-	-
Utilities		Utilities	-	-	-	-

Note: Computed for the period from 1/1/2009 through 12/31/2019, using monthly total return series; Factors series returns are taken from Kenneth French website; the term "constrained" implies that securities' weights within sector indexes are adjusted to comply with IRS Regulated Investment Company rules

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