DEVIATIONS BETWEEN ETF PRICES & THEIR NET ASSET VALUE

by

Claude Lamothe
BBA, Acadia University

and

Yudish Seetohul
MSc., University of Manchester

PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN FINANCE

In the Master of Science in Finance Program
of the
Beedie School of Business

SIMON FRASER UNIVERSITY

Fall 2019

Approval

Name: **Yudish Seetohul and Claude Lamothe**

Degree: **Master of Science in Finance**

Title of Project: **Deviations between ETF Prices & their Net asset value**

Supervisory Committee:

_____

Dr. Peter Klein
Senior Supervisor
Profesor

_____

Dr. Victor Song
Second Reader
Lecturer

Date Approved: _____

Abstract

This paper studies the deviations between the price of Exchanged-Traded-Funds (ETFs) and their net asset values (NAVs) of their respective securities by calculating the premium/discounts of approximately 2,300 industry ETFs from the period of January 1st, 2019 and October 1st, 2019.

Results show that prices of the ETFS included in this research can deviate significantly from their net asset values (NAVs), and seems to be more widespread for those that are international and contain illiquid securities. These findings are in line with the results of those found in the "Inefficiencies in the Pricing of Exchange-Traded Funds" CFA Research report done authored by Antti Petajisto (2017).

Keywords: Exchanged-Traded-Funds; net asset value; premium/discount; deviation, international; illiquid

Acknowledgements

We would like to take a moment to express our gratitude to Professor Peter Klein for his willingness to supervise our topic of interest and his guidance. We also appreciate Dr. Victor Song's participation in the process.

Table of Contents

List of Figures

List of Tables

1: Introduction

Literature published in 2017 regarding the topic of price deviation between ETFs and the NAV found that they can deviate substantially over time. Petajisto (2017), concluded that these deviations are larger in funds that hold international or illiquid securities. In theory, looking at how the ETF creation/redemption process functions, the transactions cost the Authorized Participants absorbs, the premium/discounts resulting from deviations between the price of an ETF and its NAV, and the incorporation of the bid-ask spread as an indication of liquidity, these results make sense.

The arbitrage process is what keeps the ETF prices deviating around its NAV. In theory, the deviation should be higher for ETFs that contain international stocks since while the market in which the creation basket securities trade is closed, the shares of the ETFs that contain those securities continue to trade in the domestic exchange. Also in theory, deviation should be higher for ETFs containing illiquid securities since the higher the transaction cost associated with trading a security, the higher the deviation required for the arbitrage process to be profitable. The lower the big-ask spread of an ETF, the lower the transaction cost associate with the securities within it. If the creation basket of an ETF is comprised of securities deemed difficult to purchase or sell, the AP will most likely allow the deviation to drift before acting on the arbitrage opportunity, which results in wider bid-ask spreads. These are the points explored during this research.

However, his studies were done with data from 2007 to 2014. The ETF industry has grown since then. Pagano, Serrano, and Zechner found that ETFs have grown substantially in size, diversity, scope, complexity and market significance in recent years (2019). We will be testing the theory of price deviations for approximately double the number of ETFs included in Petajisto's research, representing more than double his market cap.

This paper will focus on extending Petajisto (2017) regarding the price deviations between ETF prices and their net asset value. Different from Petajisto will be the time period of the data. We were able to gather the list and data of ETFs from the same source, making the sorting of ETF in their respective categories easy to compare.

2: Literature Review or Background on ETFs

2.1 The raise of Systematic Risk through ETFs

While most ETFs track liquid equity indices, one of their key features relates to their capacity to also replicate baskets of less liquid assets in the form of more liquid tradable securities, but this liquidity transformation could be subject to frictions (Deutsche Bundesbank, 2018; Turner and Sushko, 2018). There is evidence that the higher liquidity of ETFs shares vis-à-vis the underlying assets can attract investors who would not otherwise be willing to be exposed to the more illiquid underlying assets (Hamm, 2014; Broman, 2016). This is self-explanatory, the growth of the ETF industry can be partially attributed to the representing access to a side of capital market that the average investor would otherwise not have access to. This would apply to ETF categories such as Emerging Market Bonds, Commodities, and other types of alternative investments. Each will be analysed throughout the 2019 time period analysis included in this research paper.

An interesting study by Glosten et al. (2016) found that stocks tend to co-move more with their respective indices once they are included in ETF portfolios. It is no secret that investing in an index is said to elimination idiosyncratic risk through diversification, which often is associated with heavily investing in specific companies are a result of positive fundamental analysis results. However, once stocks are included in ETF portfolios, Glosten et al. concludes that they tend to respond more to systematic news rather than idiosyncratic, making non-systematic news of lower importance than if the specific stock would otherwise not be included in an ETF portfolio. This leads to a channel through which ETFs may raise systematic risk. Through higher volatility and co-

movement of security prices, especially at times of market stress and if the constituent securities are illiquid (Pagano, Serrano, Zechner, 2019). As ETFs contribute to increase importance of systematic risk as opposed to idiosyncratic, research suggest that they're very nature or existence is said to increase overall systematic risk in capital markets.

2.2 ETF Creation/redemption process

The only party authorized to participate in the creation or redemption of an Exchange-Trade-Fund is the Authorized Participant (AP). In the case of the biggest ETF players in the industry, the APs are also the ETF sponsors and are responsible to come up with the fund's investment strategy. In order to create new ETF shares, the AP purchases all the necessary stocks at the appropriate percentage weights to form what the industry calls a "creation basket". Afterwards, the process is simple. The basket of securities, or creation basket, is then exchange for shares of the ETF. This creating/redemption process is crucial in keeping the price of the ETF at its Net Asset Value (NAV). The deviation between the two is what we will be experimenting with during the empirical finding section.

Since the process of exchanging the creation basket of securities for actual ETF shares occurs at the end of the trading day, and the purchase of the securities within the creation basket can occur throughout it, the process creates a form of arbitrage that APs can take advantage of. This arbitrage process is what keeps the ETF prices deviating around its NAV. It is therefore obvious why the deviation is higher for ETF that contain international stocks since while the market in which the creation basket securities trade is closed, the shares of the ETFs that contain those securities continue to trade in the domestic exchange. Other contributions to the International nature of these ETFs are the

difference in regulation, currency exchange risk, and market segmentation. We will test if the International nature of ETFs actually does contribute to volatility of the premiums.

This arbitrage mechanism also explains why the deviation between prices and NAV is higher for ETFs containing illiquid securities. One of several advantages that ETFs have over mutual funds is the AP's responsibility of the transaction cost associated with the creation/redemption process. The higher the transaction cost associated with trading a security, the higher the deviation required for the arbitrage process to be profitable. This notion is why the bid-ask spread was included in Petajisto's original research, as well as ours. The lower the big-ask spread of an ETF, the lower the transaction cost associate with the securities within it. If the creation basket of an ETF is comprised of securities deemed difficult to purchase or sell, the AP will most likely allow the deviation to drift before acting on the arbitrage opportunity, which results in wider bid-ask spreads. However, since the bid-ask spread is sometimes obtained from different sources for each asset classes, the premiums/discounts of the allocation category (containing both Equity and Fixed Income) of ETFs will most likely not be mean reverting or normally distributed, which we will also be testing.

2.3 Passive or Active?

Smart beta or factor ETFs do not replicate value-weighted indices, but focus on the replication of alternative indices which are tilted towards one or several characteristics or factors (such as size, value, growth, volatility, dividends or momentum) to achieve particular risk profiles. (Pagano, Serrrano, Zechner 2019) Some market participants have argued that smart beta ETFs are not passive investment vehicles, like other types of ETF, but active ones, as they try to differentiate themselves from the usual physical ETFs which replicate an index based on market capitalization of the underlying securities (Vanguard, 2018).

An appropriate example can be comparing the iShares Emerging Market Dividend ETF (DVYE) to the MSCI Emerging Market Index from January 1st, 2018 to January 1st, 2019. During 2018, the MSCI Emerging Market Index saw an annual return of approximately -16%. Let's assume that a portfolio manager somewhat predicted that the MSCI Emerging Market Index (which represents 100% of his indexed emerging market exposure) was to perform poorly during the upcoming year, and that his IPS kept him from eliminating his Emerging Market Exposure. A possible option would to select a factor beta that, historically, tends to outperform during times of market stress. A decision is then made to transfer his emerging market index exposure to a dividend factor beta by investing what used to be fully indexed to the MSCI Emerging Market Index, to the iShares Emerging Market Dividend ETF.

This decision would have generated an annual active return of approximately 11.52%, tracking error of 7.82%, and an information ratio of 1.69. From a regional perspective and looking at Figure 2, the dividend yield factor beta selection resulted in

overweighing Europe, and underweighting Asia/Pacific and Central Asia. From a sector perspective, this factor-beta selection would have resulted in overweighing Real Estate, Materials, and Utilities, while underweighting Health Care, Consumer Staples, Consumer Discretionary, and Financials.

This experiment goes to have how factor-beta selection through ETFs should perhaps be considered active management. Throughout this analysis, smart-beta ETFs are sorted through their region or style, for example the Emerging Market Dividend ETF will be included in the International category under the Emerging Market ETF sub category.

Table 1: *Portfolio Characteristics: DVYE vs MSCI EM*

This table indicates the portfolio characteristics of the iShares Emerging Market Dividend ETF (DVYE) and its benchmark MSCI Emerging Market Index.

Portfolio Statistics	**iShares Emerging Market Dividend**	**MSCI Emerging Market Index**
Total Return	-4.94	-16.46
Active Return	**11.52**	
Standard Deviation	11.66	15.41
Skewness	-0.45	-0.15
VaR 95% (ex-post)	-1.21	-1.74
Tracking Error	**7.82**	
Sharpe Ratio	-0.54	-1.13
Jensen Alpha	**5.21**	
Information Ratio	**1.69**	
Treynor Measure	**-0.10**	

Figure 1: *Annual Return: DVYE vs MSCI EM*

This figure graphs the January 1st, 2018 – January 1st, 2019 daily compounded annual return for the iShares Emerging Market Dividend ETF (DVYE) and the MSCI Emerging Market Index (MSCI EM) .

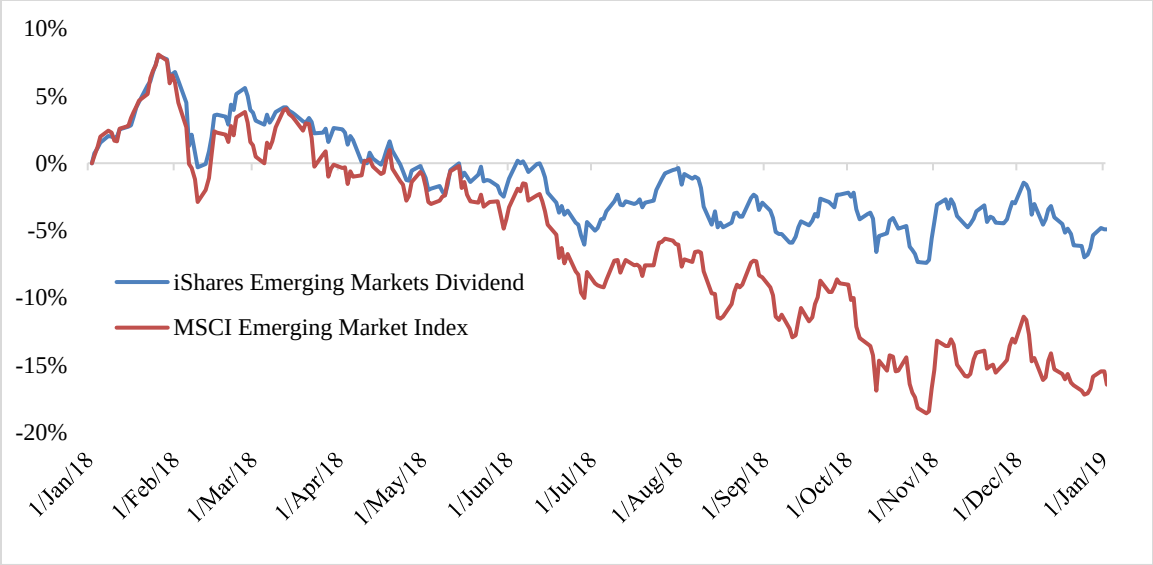


Figure 2: *All Per Region Active Weights DVYE vs. MSCI EM*

This figure indicates the average annual regional active weights of the iShares Emerging Market Dividend ETF (DVYE) and its hypothetical benchmark MSCI Emerging Market Index (MSCI EM) for the period of January 1st, 2018 to January 1st, 2019.

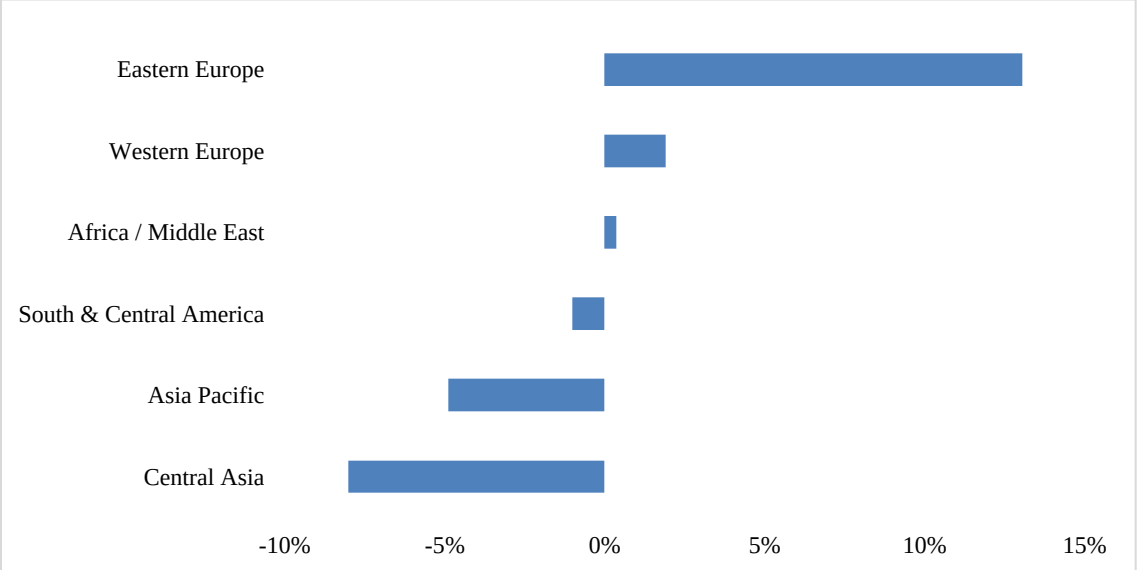
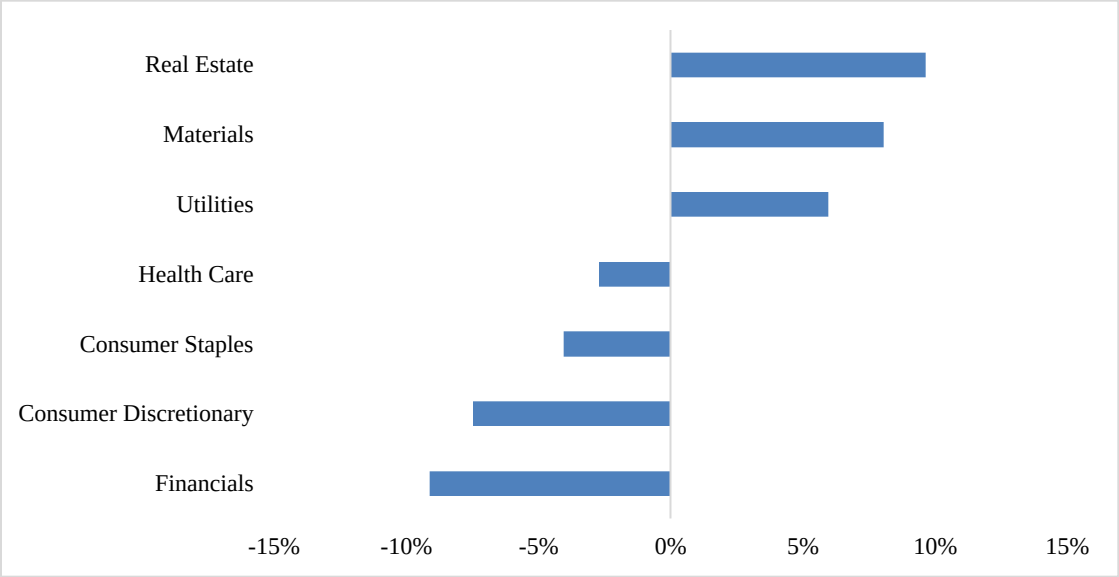


Figure 3: *Top 7 Active Weights Per Sector: DVYE vs MSCI EM*

This figure indicates the average annual sector active weights of the iShares Emerging Market Dividend ETF (DVYE) and its hypothetical benchmark MSCI Emerging Market Index (MSCI EM) for the period of January 1st, 2018 to January 1st, 2019.



3: Data

The entire list of ETFs included in the research was gathered from Morningstar, through which the names and categories of approximately 1,900 included in our table were gathered.

The source for our numbers was Bloomberg, through which we were able to gather the NAV, Closing Price, and bid-ask spread for each the ETFs included in the list generated from Morningstar. We gathered this data for every trading day between January 1st, 2019 to October 1st, 2019. This involved gathering, organizing, and analysing more than 1.4 million data points.

While Petajisto needed extra sources to complete his data set, we were able to have a good image set of data from these two sources to complete our research. We corrected stale pricing by simply excluding them from our analysis.

4: Methodology

After gathering the data discussed in the previous section. We calculated the daily premium/discount for each ETF included in our analysis. This measure is calculated by dividing the difference between an ETF's price Net Asset Value, by its Net Asset Value. The ETF is assumed to be trading a discount if it trades below its NAV, and at a premium if opposite is true.

The volatility of the premium for both the equal weighted and value weighted of the ETFs was also calculated. Equal weighted was calculated as the simple average, while the value weighted was adjusted per market cap of each ETF in our analysis. The 'min VW' is the value weighted volatility of the premium and minimizes its absolute value thereby assuming the most efficient market price within the bid-ask spread. (Petasjisto.A,2017). We therefore had to replace the last closing price with the midpoint between the bid and the asking price. The volatility metrics were the results carrying the most weight in the determination and comparison of our results.

The cross – sectional average of the time-series median bid-ask spread was also obtained as a measure of liquidity. As previously discussed, the wider the bid-ask spread, the higher the transaction cost associated with purchasing/selling the securities included in the ETF's creation basket.

The focus was on the 2019 with daily data spanning from January 2019 to October 2019 with the objective being a cross sectional analysis of the ETF landscape as a snapshot of the whole ETF timeline.

The Augmented Dicker Fuller test was performed on each premium category to ascertain trend stationarity based on the conditional presence of a unit root in the time series model. The results are summarized in a table at the end of each category with the test statistics, p – value and critical value given. This was a way to verify if the AP's jumping to act on arbitrage mechanism caused by price deviations is effective, as well as to verify if ETF containing both equities and bonds violate the mean reverting nature of this process.

5: Empirical Findings

5.1 Overall

Looking at Table 2, compared to Petajisto's analysis of the 2007-2014 time period, the total market cap of the ETFs included in the 2019 time period analysis increased from USD905 billion to USD1.8 trillion. In addition, the number of funds included in the analysis has increase from 301 for Petajisto's analysis to 402. Petajisto (2017) concluded in 2015 that the average premium for the ETFs included in his 2007-2014 analysis of 6 bps, indicates that the typical ETF is neither under-priced nor overpriced. The 2019 analysis saw similar results, with an average premium of -3 bps, also indicating that the typical ETF is fairly valued. Different then Petajisto's analysis, the high deviations from NAV resulted from the International Bond and Allocation categories, as opposed to General Bonds and International Equity categories.

Looking at Table 3, the value-weighted volatility of premiums of 17 as opposed to 49 for Petajisto's analysis indicated that the 2019 data shows that Prices of ETFs fluctuate less around the fund's NAV. However, this is misleading since the time period applied in the 2019 analysis is much shorter than Petajisto's. Another important consideration is Petajisto's inclusion of the 2008 financial crisis data in his time period analysis. A more focus should therefore be the ranking of the volatility results. In theory and as previously discussed in the creation/redemption section, premium/discount volatility should be highest for ETFs containing illiquid (commodities) and international securities, which is the case for both the 2019 and Petajisto's analysis. The bid-ask spread tells a similar story. As previously discuss, the higher the big-ask spread of an ETF, the higher the transaction cost associate with the securities within it. Since high transaction

cost are often associated with illiquid securities, the fact that Commodities and Miscellaneous have the highest bid-ask spread and high volatility metrics among the category is expected. This result is qualitatively consistent with the limits-to-arbitrage hypothesis because the securities with the highest transaction costs and the least transparent NAVs have the most volatility premiums (Petajisto, 2017)

Table 2: *Overall - Average Premium*

	Market Cap ($ mil)		**All**		**NAV**		**Avg. Premium**	
Category	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**
US Equity: Diversified	**1,850,646**	**904,995**	**402**	**301**	**402**	**296**	**-1**	**0**
All equity: Sectors	**371,358**	**273,067**	**292**	**343**	**292**	**328**	0	**2**
US Bonds: Government	**185,236**	**52,556**	**41**	**42**	**41**	**42**	**5**	**4**
US bonds: General	**502,305**	**219,342**	**172**	**120**	**172**	**120**	**-9**	**20**
US bonds: Munis	**40,669**	**14,184**	**32**	**33**	**32**	**33**	**-4**	**5**
International equity	**720,026**	**379,613**	**386**	**351**	**386**	**345**	**-6**	**20**
International bonds	**51,698**	**18,293**	**40**	**44**	**26**	**41**	**-14**	**4**
Allocation	**19,520**	**3,852**	**59**	**43**	**59**	**43**	**-16**	**–11**
Commodities	**82,914**	**51,159**	**66**	**45**	**66**	**45**	**-3**	**1**
Miscellaneous	**61,709**	**46,769**	**269**	**266**	**269**	**263**	**-2**	**1**
Total	**3,886,082**	**1,963,830**	**1745**	**1588**	**1745**	**1556**	**-3**	**6**

Figure 4: *Overall Premium Distribution*

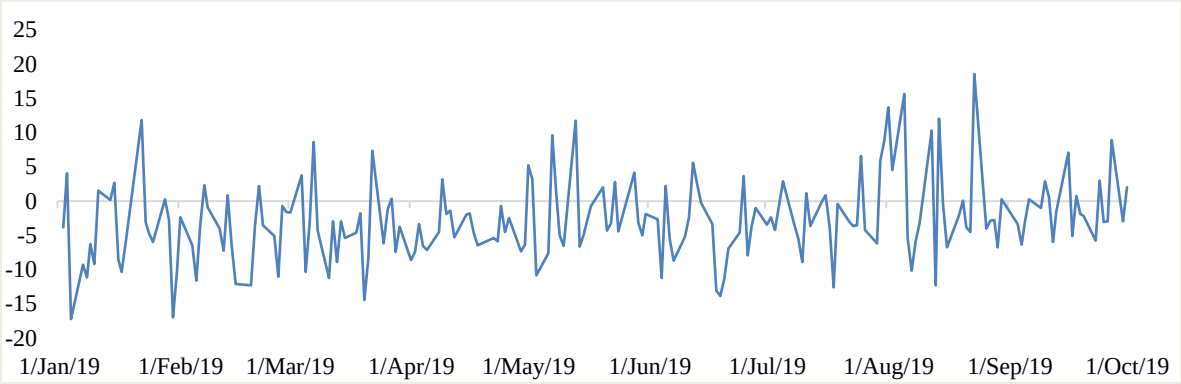


Table 3: *Overall Volatility of Premiums and Bid-Ask Spread*

	Volatility of Premiums						Bid-Ask Spread			
	EW		VW		Min VW		EW		VW	
Category	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**
US Equity: Diversified	**10**	**18**	**4**	**9**	**3**	**7**	**19**	**18**	**5**	**3**
All equity: Sectors	**15**	**42**	**11**	**19**	**9**	**15**	**16**	**32**	**5**	**7**
US Bonds: Government	**7**	**17**	**6**	**16**	**5**	**14**	**28**	**12**	**3**	**3**
US bonds: General	**15**	**41**	**13**	**55**	**10**	**50**	**61**	**24**	**8**	**5**
US bonds: Munis	**12**	**64**	**11**	**60**	**10**	**51**	**30**	**23**	**5**	**11**
International equity	**43**	**87**	**41**	**84**	**35**	**78**	**47**	**57**	**7**	**6**
International bonds	**19**	**75**	**22**	**75**	**19**	**64**	**20**	**47**	**9**	**13**
Allocation	**14**	**67**	**10**	**42**	**5**	**22**	**11**	**51**	**23**	**26**
Commodities	**34**	**98**	**33**	**98**	**28**	**94**	**89**	**43**	**13**	**4**
Miscellaneous	**31**	**39**	**23**	**35**	**18**	**21**	**93**	**50**	**17**	**8**
Total	**20**	**55**	**17**	**49**	**14**	**42**	**41**	**36**	**9**	**9**

5.2 US Equity: Diversified

The first ETF category is the Diversified US Equity. Since Petajisto's analysis of the 2007-2014 time period, the market cap for this category has approximately doubled. Compared to Petajisto's analysis, the 2019 analysis contained 402 ETFs as opposed to 301. With regards to the Small value ETFs, it is the only sub-category where the market

cap has decreased since Petajisto's analysis. This is due to inconsistent data Bloomberg had on the ETFs of this category. The NAV and last closing price were not available on a daily basis for approximately 8 small value ETFs on our list. They were therefore excluded from the analysis. Nevertheless, similar to the other sub-categories, the inclusion of the small value ETFs with inconsistent data most likely wouldn't have changed our average premium result. As expected and similar to Petajisto's results, the average premium for the Diversified US Equity category is insignificant, meaning the ETFs, on average, tend to be fairly valued.

Looking at Figure 5, the distribution of the premiums/discounts of the Diversified US Equity ETF category from January 1st, 2019 to October 1st, 2019 appears to be normally distributed. To verify this, we performed the Dickey-Fuller test in table 5 to verify if the distribution is stationary and mean reverting. It successfully rejects the null hypothesis that the data is not mean reverting.

As indicated in Table 6, volatility and bid-ask spread confirm that the ETFs are mostly fairly valued and the securities within the ETFs are liquid. These results were expected.

Table 4: *US Equity: Diversified – Average Premium*

This table shows the total market cap of the US Equity: Diversified ETFs included in the January 1st – October 1st time period analysis, as well as the ones included in Petajisto's (2007-14). It also includes the number of ETFs included in each category. Lastly, the average premium/discount per category for both times periods is also included.

	Market Cap ($ mil)		All		NAV		Avg. Premium	
Category	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**
US Equity: Diversified	**1,850,646**	**904,995**	**402**	**301**	**402**	**296**	**-1**	**0**
Large blend	972,322	454,381	151	71	151	68	-1	1
Large growth	240,551	110,506	46	39	46	38	-1	–1
Large value	279,502	123,356	81	56	81	56	-1	2
Mid-cap blend	138,156	70,995	36	29	36	29	1	–1
Mid-cap growth	31,055	16,693	29	19	29	18	0	2
Mid-cap value	39,602	35,209	23	23	23	23	1	1
Small blend	108,609	62,292	35	28	35	28	-1	0
Small growth	25,965	14,622	15	17	15	17	1	–1
Small value	14,885	16,941	20	19	20	19	-1	0

Figure 5: *Premium Distribution for US Equity: Diversified*

This figure indicates the distribution of all the premiums/discounts for the US Diversified Equity ETFs included in the January 1st to October 1st , 2019 time period analysis.

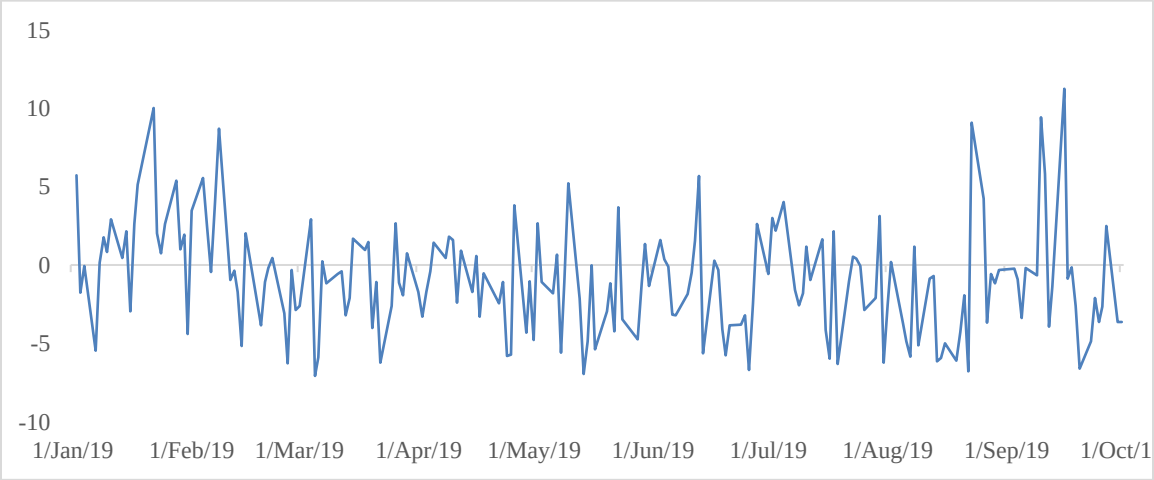


Table 5: *US Equity: Diversified – Stationarity test*

This table is the stationary test of the premium/discount distribution indicated figure above. As per the Dickey Fuller test result, it successfully rejects the null hypothesis that the data is not mean reverting and variance stationary.

	Unit-Root Null Hypothesis				Conclusion	
Category	**h-value ***	**p-value**	**T-Stat**	**Critical Value**	**(Reject or Do not reject Null)**	**Dickey Fuller Test**
US Equity: Diversified	1	0.001	-10.82	-1.942	Reject	Stationary (Mean-reverting)

Table 6: *US Equity Diversified – Volatility of Premiums and Bid-Ask Spread*

This tables includes the equal weighted (EW), value weighted (VM), and minimum value weighted volatility (Min VM) of premiums/discounts for the US Equity Diversified ETFs included in this paper. It also includes their equal weighted (EW) and value weighted (VW) bid-ask spread.

	Volatility of Premiums						**Bid-Ask Spread**			
	EW		**VW**		**Min VW**		**EW**		**VW**	
Category	**2019**	**07-14**	**2019**	**07-14**	**2019**	**2007-14**	**2019**	**07-14**	**2019**	**07-14**
US Equity: Diversified	**10**	**18**	**4**	**9**	**3**	**7**	**19**	**18**	**5**	**3**
Large blend	10	20	3	9	2	7	29	17	1	2
Large growth	11	20	5	8	4	6	11	19	3	3
Large value	7	15	3	11	2	7	12	18	2	4
Mid-cap blend	7	23	4	9	3	7	13	15	3	3
Mid-cap growth	11	26	4	10	2	6	19	16	7	6
Mid-cap value	8	14	4	10	3	7	11	15	5	5
Small blend	9	15	5	11	4	9	17	19	3	3
Small growth	9	21	6	11	4	7	33	20	8	5
Small value	12	12	6	12	4	8	25	19	9	6

5.3 All Equity: Sectors

Second on the list is the All Equity Sector ETFs category. Looking at table 7, The total market cap for this category has grown from 273 to approximately 371 billons since Petajisto's 2007-2014 analysis. The market cap for each sub-category with the exception of Energy. However similar to the Small Value ETF category in the previous section, it is unlikely that the inclusion of more Energy ETFs would have changed to the total average premium/discount for the Sector category. Surprisingly, the overall number of ETFs including in the 2019 analysis decreased from 343 to 292. Our original list generated from Morningstar contained 356, however where Petajisto adjusted for stale pricing, the ETFs that required this adjustment were excluded from the 2019 analysis. A second anomaly is the difference in average premium/discount in the previous metals sub-

category. However, this is somewhat misleading, since indicated in Table 7 the volatility measures were similar.

The total average/discount for the 2019 All Equity Sector ETF category, similar to Petajisto's analysis, indicated that in general these types of ETFs are fairly valued.

Looking at Figure 6, the distribution of the premiums/discounts in the All Equity Sector ETF category from January 1st, 2019 to October 1st, 2019 appears to be normally distributed. To verify this, we performed the Dickey-Fuller test in table 8 to verify if the distribution is stationary and mean reverting. It successfully rejects the null hypothesis that the data is not mean reverting.

As per Table 9, the most volatile within the Sector Equity category are the Miscellaneous, Previous Metals, and Natural Resources sub-categories.

Table 7: *All Equity: Sectors – Average Premium*

This table shows the total market cap of the All Equity Sectors ETFs included in the January 1st – October 1st time period analysis, as well as the ones included in Petajisto's (2007-14). It also includes the number of ETFs included in each category. Lastly, the average premium/discount per category for both times periods is also included.

	Market Cap ($ mil)		**All**		**NAV**		**Avg. Premium**	
Category	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**
All equity: Sectors	**371,358**	**273,067**	**292**	**343**	**292**	**328**	0	**2**
Communications	9,348	2,153	8	14	8	12	-1	2
Consumer cyclical	21,834	19,222	19	23	19	22	2	–3
Consumer defensive	22,775	16,651	13	17	13	17	1	3
Energy	7,889	22,549	25	33	25	32	2	1
Financials	36,037	36,706	26	42	26	41	2	3
Health care	35,836	40,180	28	32	28	30	3	3
Industrials	22,159	17,210	20	29	20	29	-1	–2
MSc. Sector	9,562	4,770	23	24	23	24	2	1
Natural resources	15,754	14,146	25	42	25	42	5	4
Precious metals	17,603	7,378	11	10	11	10	-3	18
Real estate	65,662	43,117	26	18	26	18	-4	2
Technology	86,828	36,051	55	43	55	36	-1	1
Utilities	20,071	12,935	13	16	13	15	-3	–1

Figure 6: *Distribution of All Equity Sector ETF Premiums*

This figure indicates the distribution of all the premiums/discounts for the All Equity Sector ETFs included in the January 1st to October 1st, 2019 time period analysis.

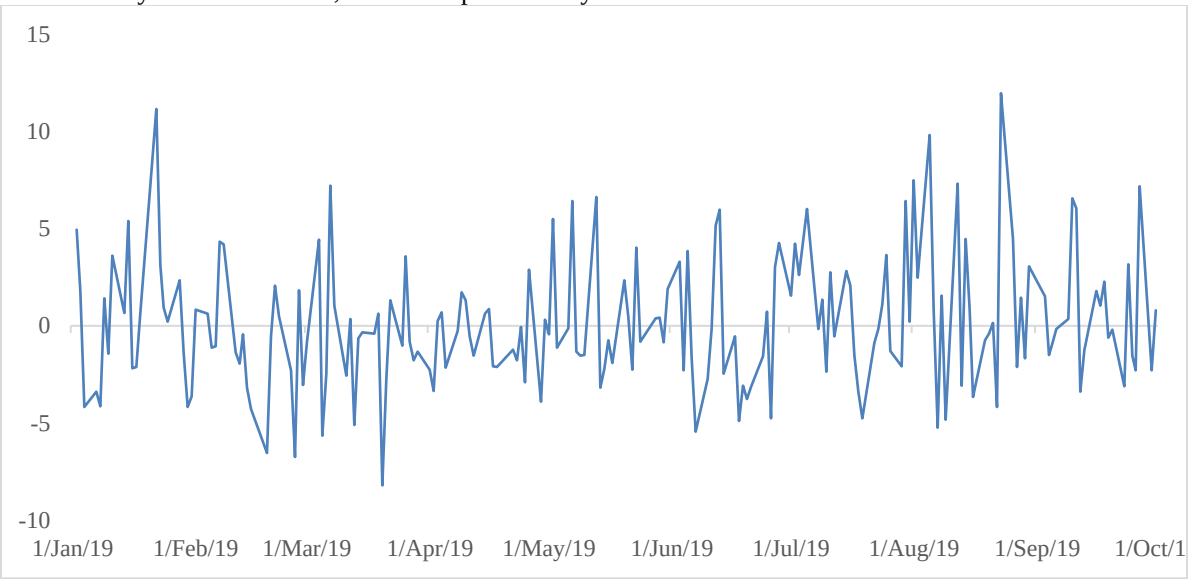


Table 8: *All Equity: Sector – Stationarity test*

This table is the stationary test of the premium/discount distribution indicated figure above. As per the Dickey Fuller test result, we successfully reject the null hypothesis that the data is not mean reverting and variance stationary.

	Unit-Root Null Hypothesis				Conclusion	
Category	**h-value ***	**p-value**	**T-Stat**	**Critical Value**	**(Reject or Do not reject Null)**	**Dickey Fuller Test**
All equity: Sectors	1	0.001	-13.12	-1.942	Reject	Stationary (Mean-reverting)

Table 9: *All Equity Sector – Volatility of Premiums and Bid-Ask Spread*

This tables includes the equal weighted (EW), value weighted (VM), and minimum value weighted volatility (Min VM) of premiums/discounts for the All Equity Sector ETFs included in both time periods. It also includes their equal weighted (EW) and value weighted (VW) bid-ask spread.

	Volatility of Premiums						**Bid-Ask Spread**			
	EW		**VW**		**Min VW**		**EW**		**VW**	
Category	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**
All equity: Sectors	**15**	**42**	**11**	**19**	**9**	**15**	**16**	**32**	**5**	**7**
Communications	8	47	4	25	3	18	9	40	4	12
Consumer cyclical	8	39	4	14	2	8	11	25	3	6
Consumer defensive	12	40	5	13	3	8	17	38	4	6
Energy	12	36	8	13	6	10	16	32	7	5
Financials	10	41	6	25	5	21	49	31	4	7
Health care	8	30	5	11	3	7	8	27	6	7
Industrials	13	43	4	13	2	8	19	33	4	7
MSc. Sector	22	51	22	44	15	31	30	28	14	18
Natural resources	18	53	15	28	12	22	14	37	8	10
Precious metals	51	62	60	39	57	37	14	51	7	6
Real estate	10	34	5	21	4	17	7	19	3	4
Technology	14	38	5	11	3	7	10	35	5	7
Utilities	12	36	4	10	3	6	18	36	4	5

5.4 US Bonds: Government

Moving on to domestic Fixed Income ETFs, the first on the list is the Government US Bond ETF category, where the market cap included in the analysis has more than tripled since Petajisto's 2007-2014 analysis. Surprisingly, however, the number of ETFs has remained the same, most likely representing the growth in popularity in fixed income ETFs but the limited amount of possible strategies that would differentiate one government bond ETF from another other than duration and certain convexity measures. Aside from this, the results from the 2019 analysis are similar to Petajisto's, indicating an average premium of 5 instead of 4.

Looking at Figure 7 the distribution of the premiums/discounts in the Government US Bonds ETF category from January 1st, 2019 to October 1st, 2019 appears to be normally distributed. To verify this, we performed the Dickey-Fuller test in table 11 to verify if the distribution is stationary and mean reverting. It successfully rejects the null hypothesis that the data is not mean reverting.

The volatility of the premiums and Bid-Ask Spread tell a similar story for both time periods, with both Long Government and Inflation-protected bonds topping the list. The abnormal equal weighted bid-ask spread for the long government sub-category is due to an outlier representing a small portion of the total market cap. This explains the adjustment in the value-weighted result.

Table 10: *US Bonds ETFs – Average Premiums*

This table shows the total market cap of the US Bonds ETFs included in the January 1st – October 1st time period analysis, as well as the ones included in Petajisto's (2007-14). It also includes the number of ETFs included in each category. Lastly, the average premium/discount per category for both times periods is also included.

	Market Cap ($ mil)		**All**		**NAV**		**Avg. Premium**	
Category	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**
US Bonds: Government	**185,236**	**52,556**	**41**	**42**	**41**	**42**	**5**	**4**
Short government	33,184	12,650	9	12	9	12	3	0
Intermediate government	64,821	5,319	10	8	10	8	4	6
Long government	44,058	15,116	8	10	8	10	12	7
Inflation-protected bond	43,173	19,471	14	12	14	12	2	6

Figure 7: *Distribution of Government US Bond ETF Premiums*

This figure indicates the distribution of all the premiums/discounts for the Government US Bonds ETFs included in the January 1st to October 1st, 2019 time period analysis.

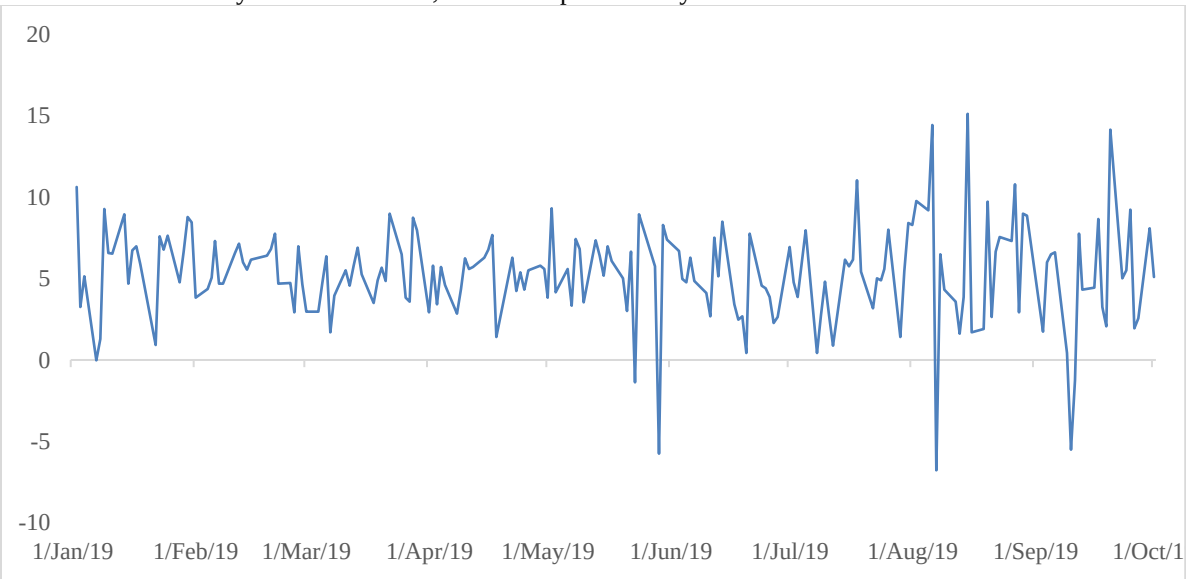


Table 11: *US Bonds: Government – Stationarity test*

This table is the stationary test of the premium/discount distribution indicated figure above. As per the Dickey Fuller test result, we successfully reject the null hypothesis that the data is not mean reverting and variance stationary.

	Unit-Root Null Hypothesis				Conclusion	
Category	**h-value ***	**p-value**	**T-Stat**	**Critical Value**	**(Reject or Do not reject Null)**	**Dickey Fuller Test**
US Bonds: Government	1	0.001	-5.35	-1.942	Reject	Stationary (Mean-reverting)

Table 12: *US Bonds: Government – Volatility of Premiums and Bid-Ask Spread*

This tables includes the equal weighted (EW), value weighted (VM), and minimum value weighted volatility (Min VM) of premiums/discounts for the US Government Bonds ETFs included in both time periods. It also includes their equal weighted (EW) and value weighted (VW) bid-ask spread.

	Volatility of Premiums						Bid-Ask Spread			
	EW		VW		Min VW		EW		VW	
Category	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**
US Bonds: Government	**7**	**17**	**6**	**16**	**5**	**14**	**8**	**12**	**3**	**3**
Short government	3	20	2	4	2	3	2	13	2	1
Intermediate government	6	13	5	9	3	6	11	10	4	5
Long government	11	21	11	17	10	15	85	14	2	3
Inflation-protected bond	8	13	6	24	5	22	13	9	2	4

5.5 US Bonds: General

The General US Bond ETF category is the category with the biggest difference in terms of results. First, as indicated in Table 13, the market cap for this category has more than double in market cap. The number of funds has also increase. However, the premium/discounts, led by the Long-term, Corporate, High Yield, and Preferred stock categories, are 29bps apart on average.

Looking at Figure 8, the distribution of the premiums/discounts in the General US Bond ETF category from January 1st, 2019 to October 1st, 2019 appears to be normally distributed. To verify this, we performed the Dickey-Fuller test in table 14 to verify if the distribution is stationary and mean reverting. It successfully rejects the null hypothesis that the data is not mean reverting.

As per Table 15, the sub-category rankings for both time period analysis are similar, with Long-Term, Convertible, and Non-Traditional bonds at the top of the list. Meanwhile, the value-weighted bid-ask spread results are in line with Petajisto's findings.

Table 13: *US Bonds ETFs – Average Premiums*

This table shows the total market cap of the US Bonds: General ETFs included in the January 1st – October 1st time period analysis, as well as the ones included in Petajisto's (2007-14). It also includes the number of ETFs included in each category. Lastly, the average premium/discount per category for both times periods is also included.

	Market Cap ($ mil)		All		NAV		Avg. Premium	
Category	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**
US bonds: General	**502,305**	**219,342**	**172**	**120**	**172**	**120**	**-9**	**20**
Ultrashort bond	89,261	9,655	22	8	22	8	-1	1
Short-term bond	79,596	40,639	25	15	25	15	-9	29
Intermediate-term bond	142,315	68,087	18	16	18	16	-7	8
Long-term bond	12,162	2,084	6	5	6	5	-24	–5
Corporate bond	81,348	37,710	26	33	26	33	-16	31
High-yield bond	50,432	34,494	41	19	41	19	-13	31
Convertibles	4,667	2,860	3	2	3	2	-4	6
Preferred stock	32,414	16,461	15	10	15	10	-11	16
Bank loan	8,964	6,792	6	4	6	4	2	13
Non-traditional bond	1,146	560	10	8	10	8	1	–2

Figure 8: *Distribution of General US Bond ETF Premiums*

This figure indicates the distribution of all the premiums/discounts for the General US Bonds ETFs included in the January 1st to October 1st, 2019 time period analysis.

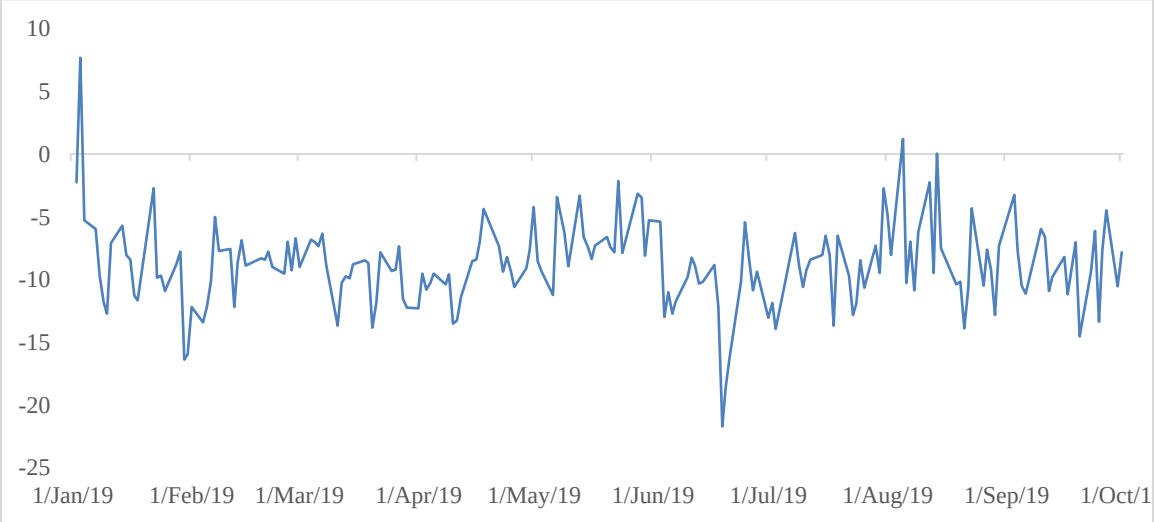


Table 14: *US Bonds: General – Stationarity test*

This table is the stationary test of the premium/discount distribution indicated figure above. As per the Dickey Fuller test result, we successfully reject the null hypothesis that the data is not mean reverting and variance stationary.

	Unit-Root Null Hypothesis				Conclusion	
Category	**h-value ***	**p-value**	**T-Stat**	**Critical Value**	**(Reject or Do not reject Null)**	**Dickey Fuller Test**
US bonds: General	1	0.0076	-2.69	-1.942	Reject	Stationary (Mean-reverting)

Table 15: *US Bonds: General – Volatility of Premiums and Bid-Ask Spread*

This tables includes the equal weighted (EW), value weighted (VM), and minimum value weighted volatility (Min VM) of premiums/discounts for the General US Bonds ETFs included in both time periods. It also includes their equal weighted (EW) and value weighted (VW) bid-ask spread.

	Volatility of Premiums						Bid-Ask Spread			
	EW		**VW**		**Min VW**		**EW**		**VW**	
Category	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**
US bonds: General	**15**	**41**	**13**	**55**	**10**	**50**	**61**	**24**	**8**	**5**
Ultrashort bond	3	24	2	13	1	8	138	6	3	2
Short-term bond	6	28	5	45	5	42	37	15	2	3
Intermediate-term bond	8	45	6	32	5	28	39	23	2	3
Long-term bond	21	55	21	48	18	42	6	22	6	13
Corporate bond	14	42	13	70	12	66	35	29	2	6
High-yield bond	17	43	16	98	15	92	18	14	9	4
Convertibles	18	61	11	70	6	36	12	101	4	13
Preferred stock	18	47	14	63	11	51	28	27	6	8
Bank loan	18	24	19	30	17	27	185	8	5	5
Non-traditional bond	22	57	20	38	12	23	114	56	43	38

5.6 US Bonds: Munis

As per Table 16, the market cap of the ETFs included in the analysis of the Munis category more than doubled, led by the increase in the Muni-Intermediate category. While the average premium for all four sub-categories are different for both time periods, the overall result indicated that on average, this type of ETF is fairly priced.

Looking at Figure 9, the distribution of the premiums/discounts in the Municipal US Bonds ETF category from January 1st, 2019 to October 1st, 2019 appears to be normally distributed. To verify this, we performed the Dickey-Fuller test in table 17 to verify if the distribution is stationary and mean reverting. It successfully rejects the null hypothesis that the data is not mean reverting.

As per Table 18, while the volatility ranking of the sub-category remain relatively consistent with Petajisto's analysis, the Munis US Bond category is where there is the largest overall discrepancy between both time periods. With regards to the Bid-Ask Spread, the high equal-weighted results are due to outliers of ETF that represent low market cap. This is proven by examining the value-weighted results.

Table 16: *US Bonds Munis ETFs – Average Premium*

This table shows the total market cap of the Municipal US Bonds (Munis) ETFs included in the January 1st – October 1st (2019) time period analysis, as well as the ones included in Petajisto's (2007-14). It also includes the number of ETFs included in each sub-category. Lastly, the average premium/discount per category for both times periods is also included.

	Market Cap ($ mil)		**All**		**NAV**		**Avg. Premium**	
Category	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**
US bonds: Munis	**40,669**	**14,184**	**32**	**33**	**32**	**33**	**-4**	**5**
Muni short	6,872	4,110	9	13	9	13	3	14
Muni Intermediate	22,102	5,828	13	8	13	8	-8	19
Muni Long	7,345	2,359	7	9	7	9	1	–14
High-yield muni	4,350	1,886	3	3	3	3	0	–17

Figure 9: *Distribution of Municipal US Bonds ETF Premiums*

This figure indicates the distribution of all the premiums/discounts for the Municipal Bond ETFs included in the January 1st to October 1st, 2019 time period analysis.

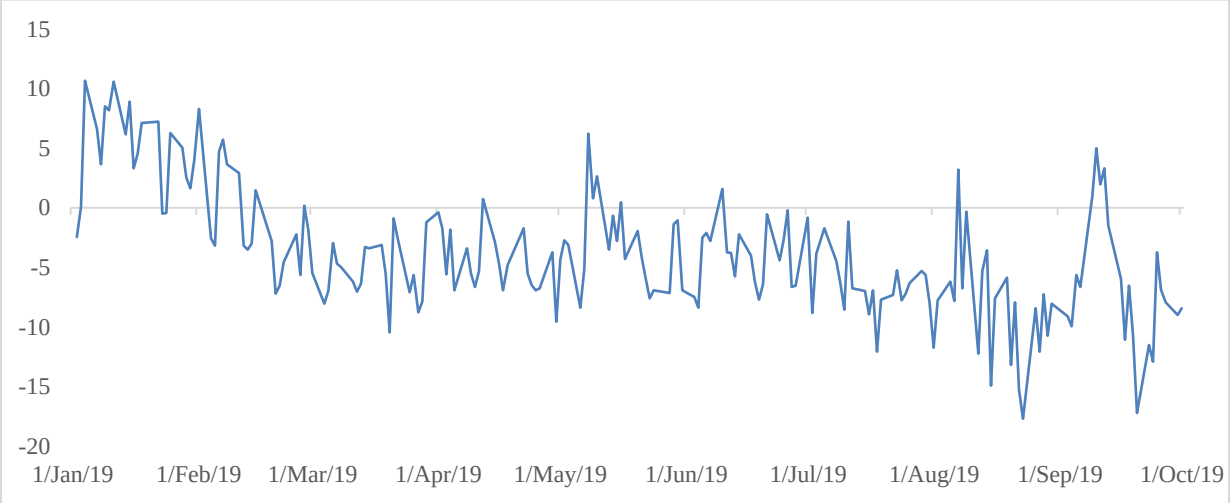


Table 17: *US Bonds: Munis – Stationarity test*

This table is the stationary test of the premium/discount distribution indicated figure above. As per the Dickey Fuller test result, we successfully reject the null hypothesis that the data is not mean reverting and variance stationary.

	Unit-Root Null Hypothesis				Conclusion	
Category	**h-value ***	**p-value**	**T-Stat**	**Critical Value**	**(Reject or Do not reject Null)**	**Dickey Fuller Test**
US bonds: Munis	1	0.001	-4.66	-1.942	Reject	Stationary (Mean-reverting)

Table 18: *US Bonds: Munis – Volatility of Premiums and Bid-Ask Spread*

This tables includes the equal weighted (EW), value weighted (VM), and minimum value weighted volatility (Min VM) of premiums/discounts for the Municipal US Bonds ETFs included in the analysis of both time periods. It also includes their equal weighted (EW) and value weighted (VW) bid-ask spread.

	Volatility of Premiums						Bid-Ask Spread			
	EW		VW		Min VW		EW		VW	
Category	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**
US bonds: Munis	**12**	**64**	**11**	**60**	**10**	**51**	**30**	**23**	**5**	**11**
Muni short	8	41	7	37	5	29	18	20	7	10
Muni Intermediate	11	84	9	71	8	62	50	26	3	10
Muni Long	14	68	12	50	10	42	42	29	5	12
High-yield muni	16	95	17	116	15	102	10	14	5	12

5.7 International Equity

Moving on to International ETFs, first on the list is the International Equity ETF category, where the market cap has approximately doubled from 379 to 720 billion. The number of ETFs included in the 2019 time period analysis have increased from 351 to 386. The premiums/discount results are different; however, this is to be expected considering the volatility measure indicated on table 19. Given the volatility measures, the chances of having similar premium/discounts results are low.

Looking at Figure 10, the distribution of the premiums/discounts in the International Equity ETF category from January 1st, 2019 to October 1st, 2019 appears to be normally distributed. To verify this, we performed the Dickey-Fuller test in table 20 to verify if the distribution is stationary and mean reverting. It successfully rejects the null hypothesis that the data is not mean reverting.

As per Table 21, China, India, and Japan ranked top 3 in terms of volatility of Premiums/Discounts. This is in line with Petajisto's findings. However, the bid-ask spread rankings for the 2019 analysis are different than Petajisto's. As previously discussed, the high volatility and bid-ask spread results is due to market segmentation, differences in regulation, a foreign exchange risk included in these ETFs.

Table 19: International Equity ETFs – Average Premiums

This table shows the total market cap of the International Equity ETFs included in the January 1st – October 1st (2019) time period analysis, as well as the ones included in Petajisto's (2007-14). It also includes the number of ETFs included in each sub-category. Lastly, the average premium/discount per category for both times periods is also included.

	Market Cap ($ mil)		All		NAV		Avg. Premium	
Category	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**
International equity	**720,026**	**379,613**	**386**	**351**	**386**	**345**	**-6**	**20**
World stock	36,397	17,574	32	22	32	22	-4	19
Foreign large blend	312,398	109,051	56	28	56	27	-10	27
Foreign large growth	6,582	1,991	14	6	14	5	-6	15
Foreign large value	23,794	11,295	35	24	35	22	-10	29
Foreign small/mid blend	19,499	6,820	8	8	8	8	-6	37
Foreign small/mid growth	2	1	1	1	1	1	15	–1
Foreign small/mid value	2,344	1,104	6	6	6	6	-3	22
Lating America Stock	10,164	4,976	8	17	8	16	0	18
Europe Stock	35,689	32,847	32	15	32	14	5	29
Diversified Pacific/Asia	4,736	2,646	3	4	3	4	-1	–4
Misc. region	29,253	29,061	82	77	82	77	-2	16
Japan stock	19,949	27,700	20	19	20	19	10	13
China region	18,865	16,683	42	34	42	34	0	22
India equity	7,311	3,804	7	7	7	7	-3	17
Pacific/Asia ex-japan stock	9,341	6,870	11	13	11	13	1	12
Diversified emerging markets	172,521	96,945	69	59	69	59	-7	22
Global real estate	11,182	10,245	9	11	9	11	8	25

Figure 10: *Distribution of International Equity ETF Premiums*

This figure indicates the distribution of all the premiums/discounts for the International Equity ETFs included in the January 1st to October 1st, 2019 time period analysis.

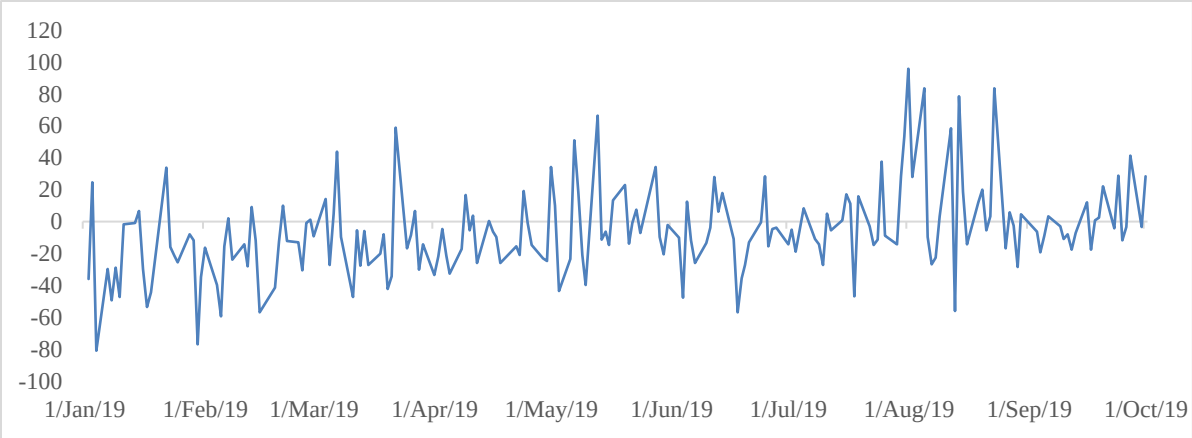


Table 20: *International Equity – Stationarity test*

This table is the stationary test of the premium/discount distribution indicated figure above. As per the Dickey Fuller test result, we successfully reject the null hypothesis that the data is not mean reverting and variance stationary.

	Unit-Root Null Hypothesis				Conclusion	
Category	**h-value ***	**p-value**	**T-Stat**	**Critical Value**	**(Reject or Do not reject Null)**	**Dickey Fuller Test**
International equity	1	0.001	-11.56	-1.942	Reject	Stationary (Mean-reverting)

Table 21: *International Equity – Volatility of Premiums and Bid-Ask Spread*

This tables includes the equal weighted (EW), value weighted (VM), and minimum value weighted volatility (Min VM) of premiums/discounts for the International Equity ETFs included in the analysis of both time periods. It also includes their equal weighted (EW) and value weighted (VW) bid-ask spread.

	Volatility of Premiums						Bid-Ask Spread			
	EW		VW		Min VW		EW		VW	
Category	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**
International equity	**43**	**87**	**41**	**84**	**35**	**78**	**47**	**57**	**7**	**6**
World stock	21	62	16	49	12	38	39	37	15	11
Foreign large blend	30	59	26	71	24	67	34	35	3	4
Foreign large growth	31	59	30	87	26	76	29	39	13	11
Foreign large value	35	80	32	89	27	75	57	38	11	15
Foreign small/mid blend	31	78	35	89	28	70	86	24	6	13
Foreign small/mid growth	55	24	55	24	28	12	149	30	4	30
Foreign small/mid value	41	80	39	94	34	81	88	37	16	20

Lating America Stock	40	78	45	75	42	71	9	49	4	4
Europe Stock	31	87	22	62	20	55	22	31	4	9
Diversified Pacific/Asia	42	89	27	30	21	23	21	404	5	15
Misc. region	45	91	44	105	41	98	33	88	7	9
Japan stock	63	122	62	129	59	122	35	31	4	12
China region	76	115	72	144	66	133	89	28	6	6
India equity	58	107	59	119	55	112	26	38	7	10
Pacific/Asia ex-japan stock	56	92	56	116	52	106	21	42	9	8
Diversified emerging markets	51	81	48	75	46	72	36	70	4	4
Global real estate	26	85	23	82	20	71	16	26	8	13

5.8 International Bonds

Moving on to the International Bond ETF category, similar to earlier cases of data inconsistencies, the number of ETFs in this category has remained almost identical. The decrease by four is due to the exclusion of the ETFs requiring stale pricing adjustments. Since Petajisto's analysis, the market cap of the International Bond category has more than doubled.

Looking at Figure 11, the distribution of the premiums/discounts in the International Bonds category from January 1st, 2019 to October 1st, 2019 appears to be normally distributed and mean reverting. To verify this, we performed the Dickey-Fuller test in table 23 to verify if the distribution is stationary and mean reverting. It successfully rejects the null hypothesis that the data is not mean reverting.

As per the volatility results in Table 24, both subcategories had similar results, and produce overall results that are high in terms of rankings of the main categories. This is expected, considering the illiquidity and international nature of the securities included in the ETFs. The bid-ask spread, however, indicates that the volatility of the premiums is

mostly due to the international nature of the ETFs as opposed to the illiquidity of the Bonds included in them.

Table 22: *International Bonds ETFs – Average Premiums*

This table shows the total market cap of the International Bonds ETFs included in the January 1st – October 1st (2019) time period analysis, as well as the ones included in Petajisto's (2007-14). It also includes the number of ETFs included in each category. Lastly, the average premium/discount per category for both times periods is also included.

	Market Cap ($ mil)		**All**		**NAV**		**Avg. Premium**	
Category	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**
International bonds	**51,698**	**18,293**	**40**	**44**	**26**	**41**	**-14**	**4**
World bond	31,477	7,986	22	25	22	25	-10	–13
Emerging market bond	20,221	10,307	18	19	18	16	-18	31

Figure 11: *Distribution of International Bond ETF Premiums*

This figure indicates the distribution of all the premiums/discounts for the International Bond ETFs included in the January 1st to October 1st, 2019 time period analysis.

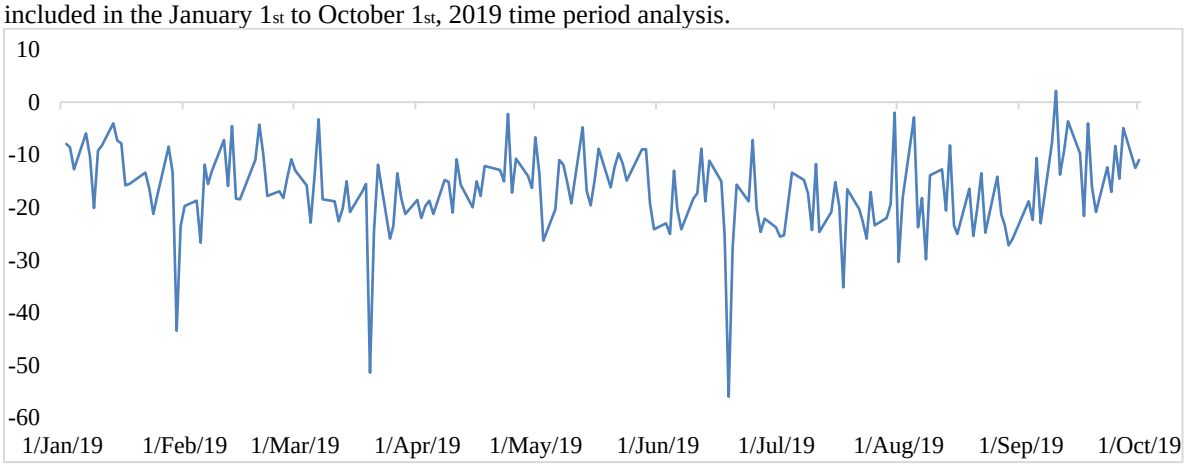


Table 23: *International Bonds – Stationarity test*

This table is the stationary test of the premium/discount distribution indicated figure above. As per the Dickey Fuller test result, we successfully reject the null hypothesis that the data is not mean reverting and variance stationary.

	Unit-Root Null Hypothesis				**Conclusion**	
Category	**h-value ***	**p-value**	**T-Stat**	**Critical Value**	**(Reject or do not reject null)**	**Dickey Fuller Test**
International bonds	1	0.001	3.66	-1.942	Reject	Stationary (Mean-reverting)

Table 24: *International Bonds – Volatility of Premiums and Bid-Ask Spread*

This tables includes the equal weighted (EW), value weighted (VM), and minimum value weighted volatility (Min VM) of premiums/discounts for the International Bonds ETFs included in the analysis of both time periods. It also includes their equal weighted (EW) and value weighted (VW) bid-ask spread.

	Volatility of Premiums						**Bid-Ask Spread**			
	EW		**VW**		**Min VW**		**EW**		**VW**	
Category	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**
International bonds	**19**	**75**	**22**	**75**	**19**	**64**	**20**	**47**	**9**	**13**
World bond	19	70	22	48	18	40	26	52	15	16
Emerging market bond	19	83	23	94	20	81	13	40	3	10

5.9 Allocation

The total market cap of the Allocation ETFs include in the 2019 analysis has changed from 3.8 billion to 19.5 billion compared to Petajisto's analysis, while the number of funds has increased by 16. The premium/discount result are similar, indicating.

Looking at Figure 12, the distribution of the premiums/discounts in the Allocation ETF category from January 1st, 2019 to October 1st, 2019 appears to be normally distributed and mean reverting. To verify this, we performed the Dickey-Fuller test in table 26 to verify if the distribution is stationary and mean reverting. In this case, it failed to reject the null hypothesis that the data is not mean reverting. From table # above, it can be seen that the T-stat does not exceed the left tail bounded by the critical value of -1.944. The null could not be rejected in this case. This tend to agree with the essence of the category in itself as it includes subjective elements in terms what defines conservative, moderate, aggressive and tactical. This is not surprising, since the allocation ETF contain both Equity and Fixed Income, resulting in different source for

the bid-ask spread for corporate bonds and Equity, which violates the arbitrage mechanism that usually is the cause of the distribution being mean reverting.

Looking at the volatility of premiums/discounts in Table 27, the top three most volatility categories match up to Petajisto's findings. They are Aggressive Allocation, World Allocation, and Target Date sub-categories. As expected, world allocation has the top bid-ask spread result. The equal weighted bid-ask spread results are misleading, since they are skewed towards ETFs with low market cap. This is also shown in the value-weighted bid-ask spread results, that bring the 2019 results in line with Petajisto's.

Table 25: *Allocation ETFs – Average Premiums*

This table shows the total market cap of the Allocation ETFs included in the January 1st – October 1st (2019) time period analysis, as well as the ones included in Petajisto's (2007-14). It also includes the number of ETFs included in each category. Lastly, the average premium/discount per category for both times periods is also included.

	Market Cap ($ mil)		**All**		**NAV**		**Avg. Premium**	
Category	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**
Allocation	**19,520**	**3,852**	**59**	**43**	**59**	**43**	**-16**	**–11**
Conservative allocation	3,543	1,204	12	4	12	4	-7	–40
Moderate allocation	2,600	1,404	8	4	8	4	-4	11
Aggressive allocation	1,251	430	6	4	6	4	-3	6
Target date	11,178	116	19	14	19	14	-25	–37
World allocation	493	642	11	11	11	11	3	18
Tactical allocation	455	56	3	6	3	6	1	–7

Figure 12: *Distribution of Allocation ETF Premiums*

This figure indicates the distribution of all the premiums/discounts for the Allocation ETFs included in the January 1st to October 1st, 2019 time period analysis.

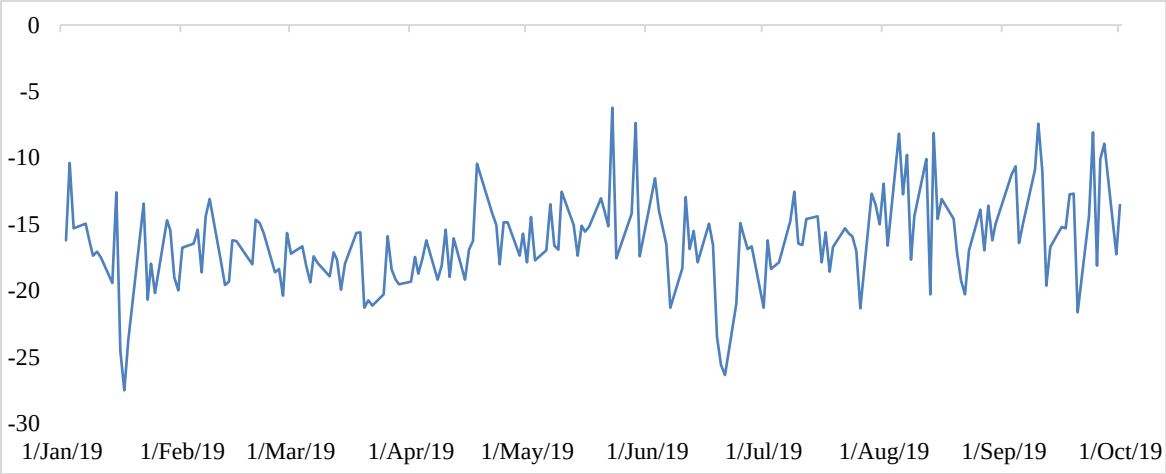


Table 26: *Allocations – Stationarity test*

This table is the stationary test of the premium/discount distribution indicated figure above. As per the Dickey Fuller test result, we fail to reject the null hypothesis that the data is not mean reverting and variance stationary.

	Unit-Root Null Hypothesis				Conclusion	
Category	**h-value ***	**p-value**	**T-Stat**	**Critical Value**	**(Reject or do not reject Null)**	**Dickey Fuller Test**
Allocations	0	0.226	-1.17	-1.944	Do not reject	Non-stationary

Table 27: Allocation – Volatility of Premiums and Bid-Ask Spread

This tables includes the equal weighted (EW), value weighted (VM), and minimum value weighted volatility (Min VM) of premiums/discounts for the Allocation ETFs included in the analysis of both time periods. It also includes their equal weighted (EW) and value weighted (VW) bid-ask spread.

	Volatility of Premiums						Bid-Ask Spread			
	EW		VW		Min VW		EW		VW	
Category	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**
Allocation	**14**	**67**	**10**	**42**	**5**	**22**	**11**	**51**	**23**	**26**
Conservative allocation	14	99	11	36	4	13	1	45	23	14
Moderate allocation	11	36	10	17	3	5	1	40	19	15
Aggressive allocation	16	70	9	66	2	18	0	40	17	22
Target date	17	92	8	141	6	104	0	59	12	82
World allocation	14	49	15	35	10	23	22	51	46	30
Tactical allocation	10	35	7	21	4	10	42	49	19	28

5.10 Commodities

As indicated on Table 28, the commodities ETFs included in the 2019 analysis changed from 51 to 83 billion compared to Petajisto's analysis, mostly due to the increase in the precious metals sub-category. The total number of funds have also increased, while the premium/discount total remains somewhat unchanged.

Looking at Figure 13, the distribution of the premiums/discounts in the Commodities ETF category from January 1st, 2019 to October 1st, 2019 appears to be normally distributed and mean reverting. To verify this, we performed the Dickey-Fuller test in table 29 to verify if the distribution is stationary and mean reverting. It successfully rejects the null hypothesis that the data is not mean reverting.

As expected, and Led by the Energy and by both the Precious and industry Metals subcategories, Table 30 shows an overall volatility and bid-ask spread results that top our list of all the main categories of our analysis. This is mainly due to the illiquidity nature of the commodities within the ETFs of this category.

Table 28: *Commodities ETFs - Average Premiums*

This table shows the total market cap of the Commodities ETFs included in the January 1st – October 1st (2019) time period analysis, as well as the ones included in Petajisto's (2007-14). It also includes the number of ETFs included in each category. Lastly, the average premium/discount per category for both times periods is also included.

	Market Cap ($ mil)		All		NAV		Avg. Premium	
Category	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**
Commodities	**82,914**	**51,159**	**66**	**45**	**66**	**45**	**-3**	**1**
Agriculture	779	1,197	12	7	12	7	5	–42
Broad basket	6,133	6,014	12	6	12	6	2	17
Energy	2,442	2,492	14	11	14	11	1	0
Industrial metals	183	224	7	3	7	3	2	–14
Previous metals	73,377	41,232	21	18	21	18	-4	9

Figure 13: *Distribution of Commodities ETF Premiums*

This figure indicates the distribution of all the premiums/discounts for the US Commodities ETFs included in the January 1st to October 1st, 2019 time period analysis.

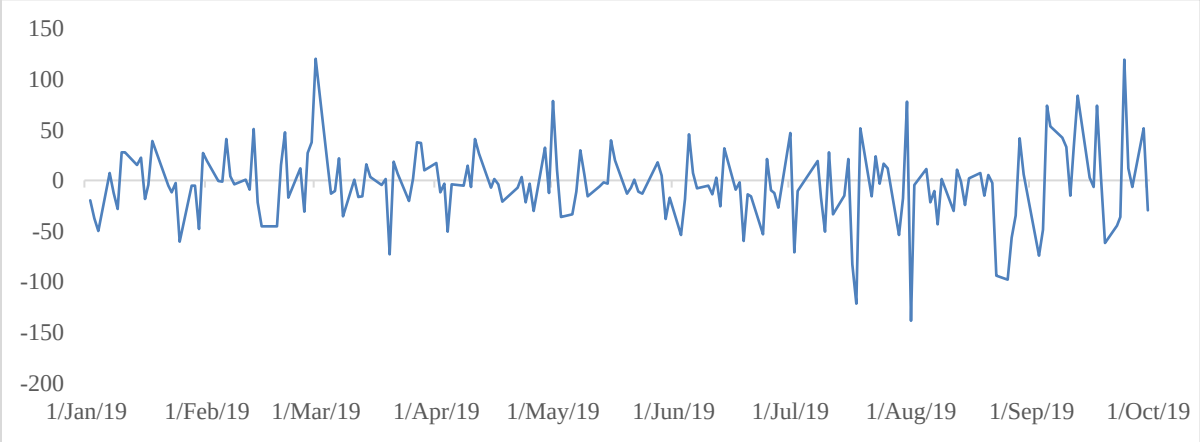


Table 29: *Commodities – Stationarity test*

This table is the stationary test of the premium/discount distribution indicated figure above. As per the Dickey Fuller test result, we successfully reject the null hypothesis that the data is not mean reverting and variance stationary.

	Unit-Root Null Hypothesis				Conclusion	
Category	**h-value ***	**p-value**	**T-Stat**	**Critical Value**	**(Reject or do not reject null)**	**Dickey Fuller Test**
Commodities	1	0.001	-4.45	-1.95	Reject	Stationary (Mean-reverting)

Table 30: *Commodities – Volatility of Premiums and Bid-Ask Spread*

This tables includes the equal weighted (EW), value weighted (VM), and minimum value weighted volatility (Min VM) of premiums/discounts for the Commodities ETFs included in the analysis of both time periods. It also includes their equal weighted (EW) and value weighted (VW) bid-ask spread.

	Volatility of Premiums						Bid-Ask Spread			
	EW		VW		Min VW		EW		VW	
Category	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**
Commodities	**34**	**98**	**33**	**98**	**28**	**94**	**89**	**43**	**13**	**4**
Agriculture	22	127	17	114	16	109	76	104	13	5
Broad basket	18	55	18	107	17	101	43	15	10	7
Energy	41	82	43	114	22	59	24	16	18	7
Industrial metals	30	158	27	229	26	220	254	41	21	16
Previous metals	61	102	60	94	60	94	46	45	4	3

5.11 Miscellaneous

As indicated on Table 31, the total market cap for miscellaneous ETF category changed from 46.7 to 61.7 compared to Petajisto's analysis. This is led by the increase in Energy Limited Partnership, Leveraged, market neutral, and Volatility subcategories, which more than offsets the decrease in trading (misc.) and multi-alternatives subcategories. Meanwhile, the number of funds and average premium/discount remains close to identical. However, the total premium/discount result is misleading since the sub-category results are quite different, this is most likely due to the volatility measures included in table 32, which decrease the chances of both time period analysis resulting in similar outcomes.

Looking at Figure 13, the distribution of the premiums/discounts of the Miscellaneous ETF category from January 1st, 2019 to October 1st, 2019 appears to be normally distributed. To verify this, we performed the Dickey-Fuller test in table 21 to verify if the distribution is stationary and mean reverting. It successfully rejects the null hypothesis that the data is not mean reverting.

Table 31: *Miscellaneous ETFs – Average Premiums*

This table shows the total market cap of the Miscellaneous ETFs included in the January 1st – October 1st (2019) time period analysis, as well as the ones included in Petajisto's (2007-14). It also includes the number of ETFs included in each category. Lastly, the average premium/discount per category for both times periods is also included.

	Market Cap ($ mil)		All		NAV		Avg. Premium	
Category	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**	**2019**	**2007-14**
Miscellaneous	**61,709**	**46,769**	**269**	**266**	**269**	**263**	**-2**	**1**
Currency	1,567	2,691	26	23	26	23	5	0
Long-short	708	620	16	11	16	10	3	4
Market neutral	1,044	172	10	11	10	11	11	–11
Multi-alternative	1,105	1,658	6	3	6	3	8	5
Trading (misc.)	537	1,093	7	11	7	11	5	–4
Volatility	3,377	992	10	4	10	4	-19	–1
Managed Futures	332	213	4	2	4	2	0	24
Energy limited partnership	17,882	9,897	9	8	9	8	-2	8
Leveraged	23,012	16,618	100	81	100	81	1	–2
Bear Market	12,145	12,815	81	112	81	110	-5	–2

Figure 14: *Distribution of Miscellaneous ETF Premiums*

This figure indicates the distribution of all the premiums/discounts for the Miscellaneous ETFs included in the January 1st to October 1st , 2019 time period analysis.

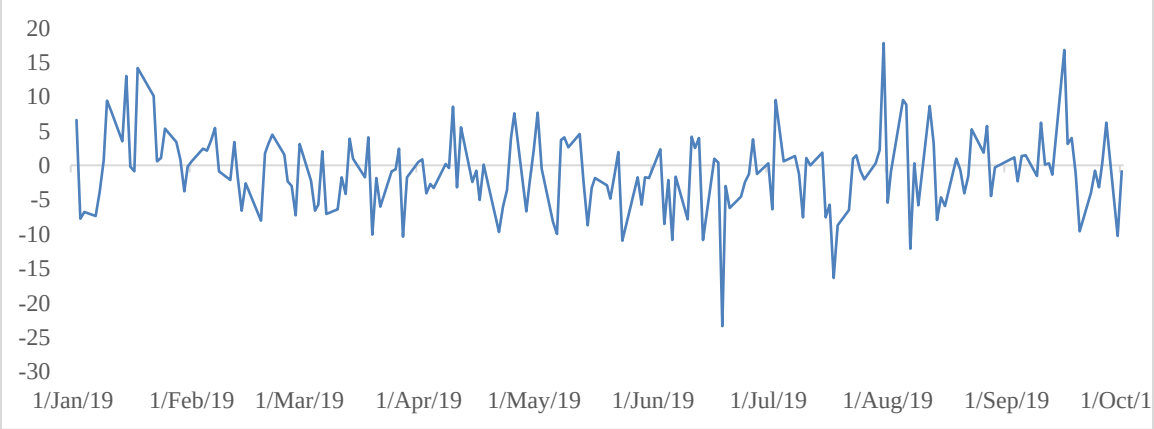


Table 32: *Miscellaneous – Stationarity test*

This table is the stationary test of the premium/discount distribution indicated figure above. As per the Dickey Fuller test result, we successfully reject the null hypothesis that the data is not mean reverting and variance stationary.

	Unit-Root Null Hypothesis				Conclusion	
Category	**h-value ***	**p-value**	**T-Stat**	**Critical Value**	**(Reject or do not reject null)**	**Dickey Fuller Test**
Miscellaneous	1	0.001	-11.58	-1.942	Reject	Stationary (Mean-reverting)

Table 33: *Miscellaneous - Volatility of Premiums and Bid-Ask Spread*

This tables includes the equal weighted (EW), value weighted (VM), and minimum value weighted volatility (Min VM) of premiums/discounts for the Miscellaneous ETFs included in the analysis of both time periods. It also includes their equal weighted (EW) and value weighted (VW) bid-ask spread.

	Volatility of Premiums						**Bid-Ask Spread**			
	EW		**VW**		**Min VW**		**EW**		**VW**	
Category	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**	**2019**	**07-14**
Miscellaneous	**31**	**39**	**23**	**35**	**18**	**21**	**93**	**50**	**17**	**8**
Currency	52	53	18	45	16	40	0	24	9	7
Long-short	18	102	15	34	10	23	1	40	46	24
Market neutral	25	51	13	34	7	17	100	56	17	33
Multi-alternative	26	15	12	18	5	7	64	15	30	14
Trading (misc.)	23	26	12	17	4	6	415	33	18	7
Volatility	88	112	102	132	105	135	14	11	6	11
Managed Futures	4	62	13	15	8	9	166	32	21	16
Energy limited partnership	21	18	18	8	11	5	91	23	11	8
Leveraged	29	38	12	47	6	26	62	24	7	9
Bear Market	25	33	15	33	8	17	20	27	7	6

6: Conclusion

As per Petajisto's (2017) 2007-2014 time period findings, we conclude that ETF containing liquid domestic assets are efficiently priced compared to those containing illiquid or international funds. Our paper confirms these findings as the volatility of premium for equally weighted was smallest for US Equity and US Bonds, 10 and 7 bps, compared to the International Equity and International Bond (43 and 21 bps).

The bid-ask spread for equal weighted is considerably higher than that of value-weighted, confirming Petajisto's findings that larger ETFs have generated considerably higher trading activity. The domestic liquid ETF funds, such the US government bonds, and US equity funds displayed the lowest bid-ask spread (5 and 3 bps) compared to the relatively higher International bond and International equity ETF bid-ask (9 and 7 bps).

To conclude, we found that the volatility of premiums/discounts were indeed higher for ETFs containing illiquid or international securities, which make sense in theory and were the expected results.

Bibliography

Works Cited

Broman, M. (2016), "Liquidity, style investing, and excess co-movement of Exchange-Traded Fund returns", *Journal of Financial Markets,* Vol. 30, pp. 27-53.

Deutsche Bundesbank (2018), "The growing importance of exchange traded funds in the financial markets", *Monthly Report,* October.

Glosten, L. R., Nallareddy, S. and Zou, Y. (2016), "ETF trading and informational efficiency of underlying securities", *Columbia Business School Research Paper,* No 16-71.

Hamm, S. (2014), "The effect of ETFs on stock liquidity"

Pagano, M., Serrano, A.S., Zechner, J. (2019), "Can ETFs contribute to systematic risk", *Report of the Advisory Scientific Committee,* 2-30.

Petajisto, A. (2017), "Inefficiencies in the pricing of Exchange-Traded Funds, *Financial Analysts Journal,* Vol. 73(1), 24-54.

Turner, G. and Sushko, V. (2018), "What risks do exchange-traded funds pose?", *Banque de France Financial Stability Review,* April.

Vanguard (2018), "The case for low-cost index-fund investing", April.