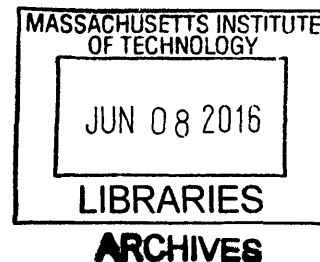


Creating custom ETFs and exploring performance versus peers and the iBoxx index

By

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Post Graduate Program in Management
Indian School of Business, 2013



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By

Vineet Khattar

Submitted to the MIT Sloan School of Management on May 06, 2016 in partial fulfillment of the requirements for the degree of Master of Science in Management Studies

ABSTRACT

The global financial crisis and following bond buyback actions and quantitative easing announcements by the ECB have led to strong demand for fixed income investments, particularly in Europe. This has increased demand for both active and passive fixed income funds. In this thesis, I review the Markit EUR Corporate Index, iShares (a passive index tracker fund) and several actively managed European investment grade-focused commercial bond funds. I propose new custom bond funds based on quantitative strategies using the bond constituents of Markit iBoxx index. I then compare the performance of these custom bond funds with the benchmark Markit EUR Corporate index, the passive tracker fund and the active bond funds. I highlight the strength of simple strategies which often perform at least as well as the index and the active bond funds.

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CHAPTER 1

OVERVIEW

I. Introduction

Over the past few years, there has been significant growth in demand for fixed income and fixed income related investment products in Europe. Many factors have fueled this growth, including and not limited to the financial crisis, the Greek debt crisis, and the consequent recession which have forced investors into a capital preservation mode. These factors, coupled with the European Central Bank's actions on reducing interest rates and consecutive bond buying announcements for both sovereign and corporate bonds, have pushed sovereign yields into negative territory and have brought corporate yields to all-time lows across the credit and the duration curves. These actions have further pushed up both the demand for and issuance of fixed income products in Europe, but overall have resulted in significantly lower liquidity.

Against this backdrop of increased demand and reduced liquidity, a number of fixed income ETFs and active bond funds have been created which aim to provide investors with exposure to European credit with increased liquidity. We examine some of these commercial products which are geared towards the European investment grade sector, and propose quantitative investment strategies that may have the potential to produce superior investment results.

II. Thesis Significance

In this thesis, I have studied various approaches for constructing fixed income indices from publicly available information. I have done this with the aim of comparing their returns and risk with those of benchmark index and actively managed funds, and evaluating whether there is value added by actively managed funds. Hence this thesis provides information on the performance of quantitative strategies relative to commercially available options.

III. Organization of Thesis

The thesis is divided into a number of chapters. Chapter 2 describes the benchmark index, the index tracker and the active bond funds which are used for comparison with our proposed investment strategies. Chapter 3 discusses the data sourcing, cleaning and methodology of index construction and returns calculations. Chapter 4 proposes a custom bond index based on random selection. Chapter 5 analyzes the performance of a bond index based on selection of underperforming bonds on a monthly basis. Chapter 6 analyzes the performance of a bond index based on selecting cheapest bonds relative to their duration. Chapter 7 analyzes the performance of a fixed income index based on selection of the most liquid bonds. Chapter 8 analyzes the performance of an index based on selection of cheapest bonds relative to their probability of default. Chapter 9 summarizes the results across all of the proposed indices. Chapter 10 discusses the limitations and future direction of this project, while the last Chapter 11 includes appendices and a list of tables and figures.

CHAPTER 2

INTRODUCTION TO THE BENCHMARK INDEX, TRACKER FUND AND ACTIVE BOND FUNDS

My custom indices will be compared with the Markit EUR benchmark index, benchmark tracker iShares EUR index and several active bond funds, all of which are briefly described in this Chapter:

I. Benchmark Index

I take the Markit EUR Corporate iBoxx (ISIN: DE0006301161) as the benchmark index. I also use the index constituents as the source of the bonds selected for all tested strategies. The index consists of European investment grade bonds chosen using index selection rules prescribed by Markit and rebalanced on a monthly basis. The typical number of bonds in the index ranges from 1250 to more than 1700 every month.

A variety of fixed rate bonds with cash flow denominated in Euros are eligible for selection for the benchmark index. However sinking funds, amortizing bonds, FRNs and fixed-to-floater bonds, convertibles, CDOs, retail bonds, private placements, subordinated bank or insurance debt with mandatory contingent conversion features or with any conversion options before the first call date are excluded from selection.

Eligible bonds are then further shortlisted for the index construction based on set of pre-determined rules including consideration for bond type, credit rating, time to maturity, amount outstanding and industry and country concentration levels among other factors. For example, all bonds selected for the iBoxx EUR index have an internal investment grade rating which is linked to the rating of the Standard & Poor rating, Fitch rating and Moody's rating. All of these bonds also have at least a year to maturity at the rebalancing date and amount outstanding of at least EUR500m.

The selected bonds are weighted on a market capitalization basis to construct the index and the index is rebalanced at the beginning of every month. Cash from coupon payments and from liquidated bonds that could not be used to buy other bonds is invested in money market instruments at the end of each month until the following month at which point it is reinvested back into the index.

II. Benchmark Tracker

Corporate iShares Euro Corporate Bond Large Cap UCITS ETF is an open-end, UCITS compliant exchange traded fund incorporated in Ireland. The Fund aims to track the performance of the Markit iBoxx EUR Liquid Corporates Large Cap Index. The index offers exposure to the most liquid, Euro denominated, investment grade corporate bonds. The fund has the following objectives:

- Diversified exposure to corporate bonds issued in Euros
- Direct investment in corporate bonds across sectors (industrials, utilities and financial companies)
- Euro denominated investment grade bond exposure

Fund performance data is taken from Bloomberg (IBCS GY Equity) and is gross of dividends. Fund performance is observed from January 2011 to December 2015.

**Source: Bloomberg*

III. Active Bond Funds

I compare the following three funds with the Tracker and the indices that I construct below:

- **L&G Euro Corporate Bond Fund**
The L&G Euro Corporate Bond Fund (BBG symbol: LGECBDA LN Equity) targets investors who are seeking a broad European investment grade credit strategy along with the flexibility to invest in global markets to improve diversification and enhance returns. The fund invests in

variety of Euro denominated fixed-interest instruments such as bonds, other fixed or floating-rate debt securities and short-term debt securities. The fund is managed by Legal & General Investment Management (LGIM) and is an open-end fund incorporated in the UK. It aims to produce a return from capital and income. The fund is benchmarked to Markit iBoxx Euro Corporate Index.

* Source: LGIM fund fact sheet/ Bloomberg

- **T-Rowe Euro Corporate Bond Fund**

T Rowe Price Funds SICAV - Euro Corporate Bond Fund is a SICAV incorporated in Luxembourg. The fund's objective is a maximum total return and it invests primarily in a diversified portfolio of Euro-denominated corporate bonds. The fund is allowed to invest in securities denominated in other European currencies. Included below is a snapshot of fund's characteristics versus the benchmark (Barclays Euro-Aggregate: Corporates Bond Index), which is similar to the Markit Euro IG benchmark.

Table 1: T.Rowe Euro Corporate Bond Fund

	Fund	Benchmark
Weighted Average Coupon	2.64%	2.95%
Weighted Average Maturity	5.49 years	5.51 years
Weighted Average Effective Duration	4.75 years	4.94 years
Current Yield	2.38%	2.76%
YTM	1.74%	1.06%
Average Credit Quality	BBB+	A-
Number of Holdings	173	1,706

Source: T.Rowe Price/ Data as of 31 March 2016; Benchmark: Barclays Euro-Aggregate: Corporates Bond Index

- **Standard Life Euro Corporate Bond Fund**

"This fund's stated aim is to provide long term growth from capital gains and the reinvestment of income generated by investing predominantly in European investment grade bonds. The fund is actively managed and permitted to invest in a wide range of bonds (e.g. corporate bonds including high yield bonds, government backed securities, overseas bonds, index-linked bonds, floating rate notes (FRNs) and asset backed securities (ABSs)

and/or money market instruments). Non-euro denominated assets held in the fund are generally hedged back to euros". The fund is benchmarked to iBoxx Euro Corporate All Stocks Index. I have also included below a snapshot of the fund characteristics as of 31 March 2016.

* Source: Standard Life Fund Fact Sheet; iBoxx EUR Corp All Stocks index is the iBoxx EUR Corp index (benchmark index)

Table 2: Standard Life Euro Corporate Bond Fund

Composition by Credit Rating		Composition by Maturity		Composition by Sector	
Rating	Fund %		Fund %		Fund %
AAA	2.4%	0-5yrs	51.0%	Corporates	48.9%
AA	6.1%	5-10yrs	40.2%	Financials	47.2%
A	34.4%	10-15yrs	6.6%	Sovereigns	2.2%
BBB	48.3%	15-20yrs	1.7%	Collateralized	0.8%
BB	7.6%	20-25yrs	0.2%	Not Classified	0.7%
B	0.5%	25+yrs	0.3%	Sub-Sovereigns	0.2%
N/R	0.7%				
Yield to Maturity	1.6			Modified Duration	5.2

Source: Standard Life Investments/ Data as of 31 March 2016

IV. Returns calculation

- **Custom indices**

Returns for the custom indices that I construct are calculated using the Bloomberg total return calculator available on the Bloomberg terminal. The calculator essentially allows for the investor to include the bond security with the trade dates and any financing and reinvestment rates so as to calculate the holding period return for the duration of the investment. The calculated returns include any currency impact, and incorporate the chosen bid-ask spread. The calculator also accounts for cash flows during the period of the investment.

To calculate monthly returns I take the trade prices, i.e., the mid-spread price for each bond, and take the beginning and ending working day of each month as the trading days, with

settlement occurring typically 3 days afterwards. Since all bonds are Euro currency denominated there is no impact from currency translation.

- **Rival indices**

For returns calculation of the benchmark, benchmark tracker index and the active bond funds, I rely on the reported total return index information available from Bloomberg. This data is collected gross of interest distribution. Monthly returns for all the indices including the benchmark are calculated as below:

$$\text{Return}_{\text{Month } i} = (\text{Total Return Level}_{\text{Month } i}) / (\text{Total Return Level}_{\text{Month } i-1}) - 1$$

For the Markit benchmark, all returns data is based on a bid-to-bid price comparison. Hence, Markit index return performance does not account for trading costs.

For the tracker and the active bond funds, the total return levels are net of transactions costs and management expenses. Hence the returns are net of transaction and management costs.

CHAPTER 3

DATA AND METHODOLOGY

I. Data Source

I use the Markit iBoxx EUR index (ISIN: DE0006301161) as the benchmark index. The index is published by Markit and rebalanced every month. I select all bonds for every month from January 2011 to December 2015. I then select a subset of these bonds for every month according to specific set of rules (strategies) to form my investable index. The rules are described in the following chapters. I collect data for all the bonds in each month using Bloomberg as a source. The data is further described in the individual chapters along with the strategy considered.

II. Data Cleaning

The available data is incomplete for multiple fields. This is especially true for data fields such as OAS spreads, effective duration and 1 year probability of default measures. The problem applies to multiple bonds each month. I also observed implausibly wide spreads for some bonds. This may be because of lack of trading at end-of-the-month dates. To address these problems, I did not consider the bonds for which I did not have the required data or where I had incorrect/stale spread information.

III. Index Construction Methodologies

I select 200 bonds to construct my indices. 200 bonds are enough to minimize the effect of idiosyncratic risk while allowing for tangible impact of an investment strategy. I construct the index using three methodologies:

- **Notional weighted**

To create a notional weighted index, I select bonds for every month that are consistent with the strategy under consideration. I also obtain the notional amount issued for these bonds. I then weight each bond selected in the custom index using the notional amount issued. For example to obtain the index weight of a particular bond in a given month, notional value of the shortlisted bond is divided by sum of the notional amounts of all of the 200 shortlisted bonds in the index. Because we are weighting the bonds by their notional issued, large issues will get over-weighted relative to smaller sized issues. Generally, mature companies tend to do relatively big issues and also repeatedly tap into capital markets. Hence their bonds are more liquid and incur lower trading costs, and also exhibit lower price volatility. This implies similar characteristics for the notional constructed index. However it also means potentially higher concentration of mature, stable companies in the index. Please refer to the working example below.

Table 3: Notional weighted index weighting

	Notional	Index weight
XS0188853526	750,000,000	0.41%
XS0260057285	1000,000,000	0.55%
XS0614919701	200,000,000	0.11%
...
Total Notional	181,883,597,740	100.00%

- **Price weighted**

To create a price weighted index, I weight each bond in the index relative to its market price per dollar of face value. Given the method of index creation, higher priced bonds are over-weighted in the index. Please refer to a working example in Table 4:

Table 4: Price weighted index weighting

	Market Price per dollar of Face Value	Index weight
XS0188853526	99.286 (A)	0.46% (A/D)
XS0260057285	98.233 (B)	0.45% (B/D)
BE0931376793	97.392 (C)	0.45% (C/D)
...

Total	21618.55 (D)	100.00%
--------------	--------------	---------

- **Duration-Price weighted**

For constructing an index using this methodology, I collect duration and price for every bond for every month at the beginning of the month. I then weight each bond by the product of the duration and price. Please refer to the example below. Typically in this method longer duration and higher priced bonds will be over-weighted. This means potentially the index will be relatively more volatile and earn a higher term premium.

Table 5: Duration-Price weighted index weighting

	Duration (A)	Market Price (B)	Product (A*B)	Index weight
XS0188853526	2.8	99.3	279.0	0.0015%
XS0260057285	3.0	98.2	294.7	0.0016%
BE0931376793	2.8	97.4	276.6	0.0015%
...
Total			18,600,326.7	100.0000%

CHAPTER 4

CUSTOM INDEX FROM RANDOM SELECTION OF TWO HUNDRED BONDS

I. Introduction

The iBoxx EUR Corporate index rebalances every month with a new selection of bonds. I select two hundred bonds every month from this new selection of bonds and then use it to form custom indices. I form the indices in the three different ways described in the previous chapter. I then track the total return performance of these indices against the performance of commercially available indices over a five year period.

II. Rationale

The intent behind selecting random bonds for index construction is to examine whether a randomly constructed index with no regard for constituent bond selection can match or outperform active index construction i.e. whether there is value added from actively selecting bonds. This helps us understand the value added by active managers and to assess whether the bond market is informationally efficient.

III. Methodology for data selection and index construction

- **Data selection**

The number of constituent bonds in the IBoxx EUR Corporate index each month ranges from 1253 to 1734. From this set of bonds, I randomly select 200 bonds for index construction.

To ensure bonds are indeed randomly selected, I number each bond starting from 1 for every month. I then use a uniform random generator series in Excel to pick a serial number between 1 and the maximum of bonds for the month. I repeat this process if the generated output number is 0 or if a duplicate serial number within the same month is generated.

After selecting the serial numbers of all two hundred bonds, I then match these to the

corresponding ISIN (International Securities Identification Number) details of the bond. The ISIN details are then used to identify price and spread data for each bond. I discard any bonds for which I am unable to obtain spread, pricing or returns data. An example of selecting a bond using random number is included below:

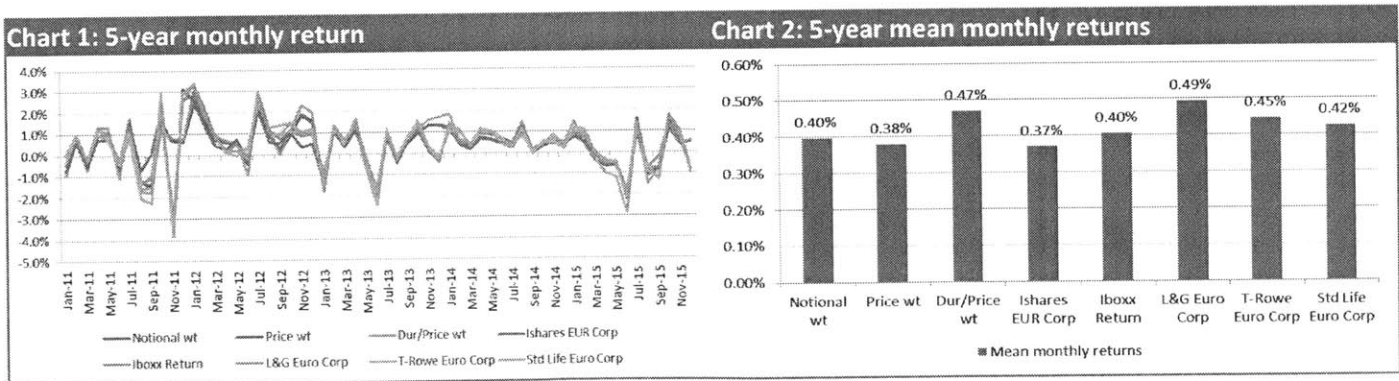
Table 6: Selecting random bond

Step No	Step	Example
Step 1	Random number generated	102
Step 2	ISIN of bond number 102:	B1224283739525
Step 3	If ISIN is repeated then discard and redo process	

Source: Markit

IV. Comparison of the monthly return performance of custom indices vs the monthly return performance of all indices

I calculate the monthly returns of the custom bond indices, the iBoxx index, benchmark tracker fund and commercial actively managed bond funds over a five year period. The mean monthly return of the Duration-Price weighted index exceeds the mean monthly return of the benchmark which is weighted by market capitalization. It also exceeds the mean monthly return of the benchmark tracker, and is comparable to the mean monthly returns of the active bond funds. The historical mean monthly returns for Notional and the Price weighted indices are comparable with the mean monthly returns of the benchmark and the benchmark tracker but below those of the active bond funds.



Source: Bloomberg, Markit iBoxx EUR index

*All custom indices are penalized by 0.2% in portfolio value every month to account for trading costs.

Despite differing means of the monthly returns of the custom indices, the commercial funds and the benchmark, I note that the means are statistically comparable. I confirm this result using paired t-tests to prove the null hypothesis of no difference in the mean of monthly returns between custom indices and the commercial indices. Please refer to the paired t-test results in Appendix F. Prior to running this analysis; I also confirmed that the returns for all indices are normal or nearly normal. Please refer to Appendix E for confirmation on the normality of the returns for all indices including the custom indices.

This is a very important result because despite penalizing the monthly returns of the custom indices by 0.2% of portfolio value per month i.e. cumulative 2.4% of portfolio value per annum, the monthly returns of the custom indices are statistically comparable to the returns of the active bond funds and the benchmark. There is no statistical outperformance in the returns of an active bond funds relative to the returns of a randomly constructed index.

Table 7: Paired t-test for comparing difference of mean returns of custom indices vs commercial funds

<i>Null =</i>	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Notional wt	TRUE	TRUE	TRUE	TRUE	TRUE
Price wt	TRUE	TRUE	TRUE	TRUE	TRUE
Dur/Price wt	TRUE	TRUE	TRUE	TRUE	TRUE

Null hypothesis: Difference in means is '0'; 95% confidence interval

Please refer to Appendix F for detailed charts on t-test comparisons

I also observe the active bond funds and the iShares index to have outliers. My custom indices do not contain outliers. Additionally the Notional and Price weighted indices are narrower in range implying lower volatility (I subsequently discuss this in detail).

Although the means of the monthly returns for the custom indices are lower than means of the monthly returns of the commercial indices, I note that these are statistically comparable. I again confirm this result using paired t-tests to prove the null hypothesis of zero difference between the mean of monthly returns between custom indices and the commercial indices. Please refer to the paired t-test results in Appendix G which includes verification of the paired t-tests for all combinations of the custom indices with the commercial bond funds including the benchmark index.

Prior to running this analysis, I also confirmed that the returns for all indices are normal. Please refer to Appendix E for confirmation on the normality of the returns for all indices including the custom indices.

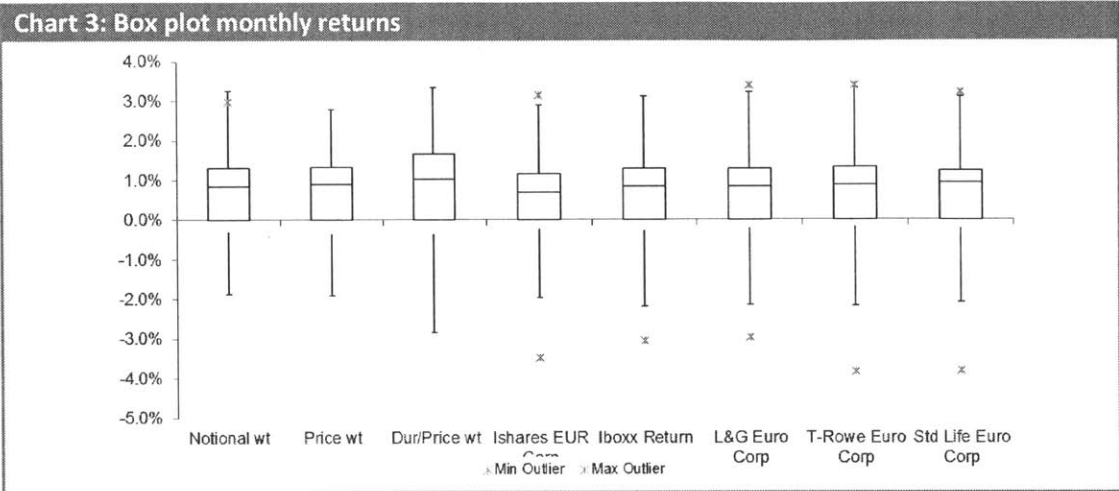
Table 10: Paired t-test for comparing difference of mean returns of custom indices vs commercial funds

<i>Null =</i>	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Notional wt	TRUE	TRUE	TRUE	TRUE	TRUE
Price wt	TRUE	TRUE	TRUE	TRUE	TRUE
Dur/Price wt	TRUE	TRUE	TRUE	TRUE	TRUE

Null hypothesis: Difference in means is '0'

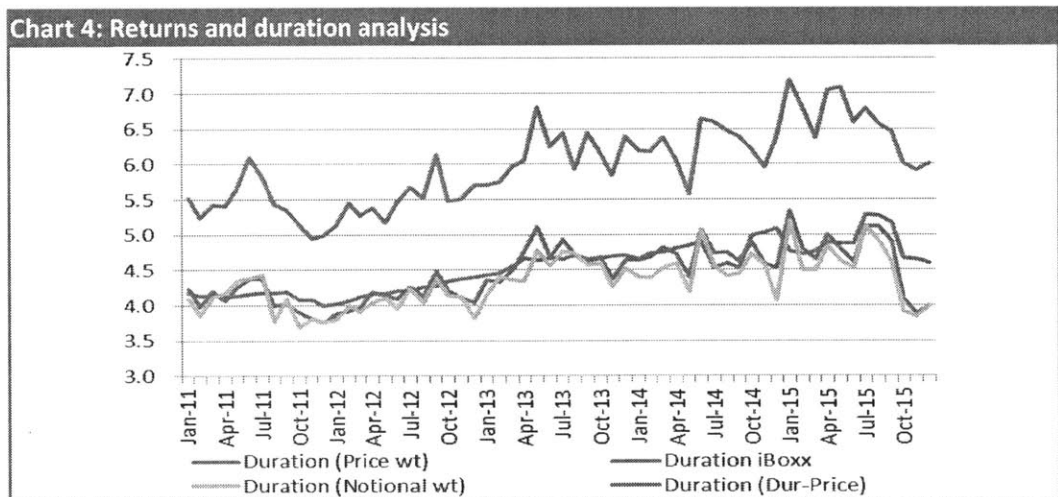
Please refer to Appendix G for detailed charts on t-test comparisons

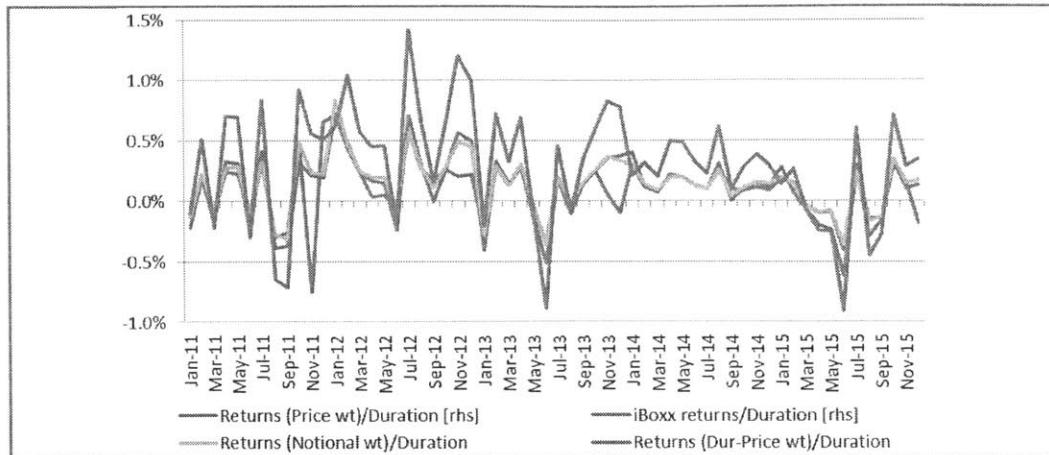
Additionally, on observing the box plots for this index, I see a wider dispersion of monthly returns with outliers for all three custom indices. It implies higher historical volatilities of the custom indices (I discuss this later in detail).



V. Additional observations

- Exploring portfolio duration and returns**
 The duration-price weighted index reflects higher and more volatile duration relative to the iBoxx and other custom indices. The Notional and Price weighted indices maintain lower duration than the iBoxx index. The custom indices also show more volatile returns per unit duration relative to the iBoxx.



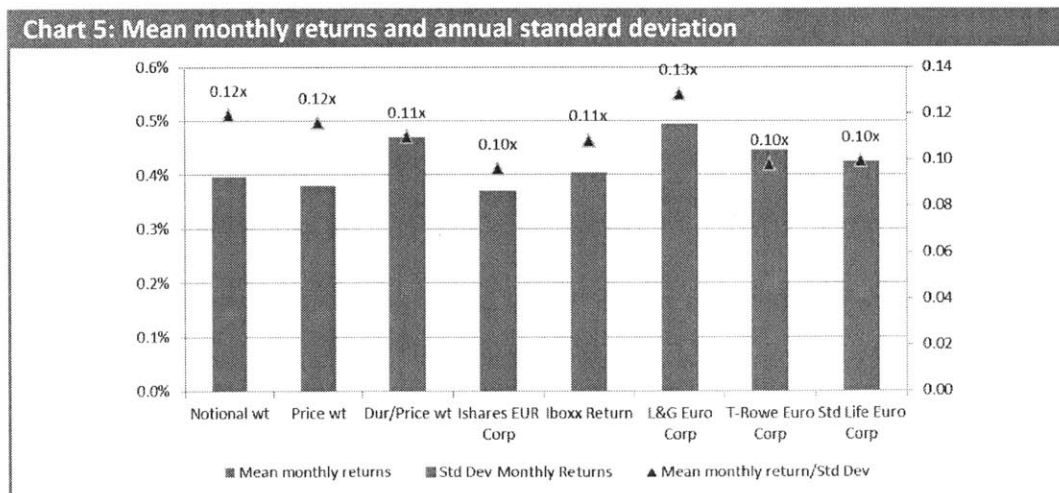


Source: Markit/Bloomberg

* I did not have access to time series of duration values for commercially available indices

- **Volatility of historical returns**

I observe lower volatility in annual returns for the Price weighted and Notional weighted indices relative to volatility of all other indices and active funds. The Duration-Price weighted index exhibits comparable volatility versus the volatility of the active funds, and higher volatility relative to volatility of the benchmark index and index tracker. Additionally, I also observe mean of the monthly returns to volatility of the three custom indices to be comparable to the mean of the monthly returns per unit of volatility of the active bond funds and exceeding similar measures of the benchmark and benchmark index.



Source: Bloomberg, Markit iBoxx EUR index; *All custom indices except for active bond funds are penalized by 0.2% in portfolio value every month to account for trading costs.

Table 8: 5-year mean monthly returns and standard deviation

	Notional wt	Price wt	Dur/Price wt	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Mean Monthly Return	0.40%	0.38%	0.47%	0.37%	0.40%	0.49%	0.45%	0.42%
Std Dev	0.033	0.033	0.043	0.039	0.037	0.039	0.046	0.043
Mean Monthly Return/Std Dev	0.12x	0.12x	0.11x	0.10x	0.11x	0.13x	0.10x	0.10x

**All custom indices are penalized by 0.2% in portfolio value every month to account for trading costs.*

- Correlation among returns**

I also calculate the correlations between the monthly returns for all the indices. Since the custom indices are formed using same set of bonds hence there is a strong correlation between them. Correlation of the returns of custom indices with the returns of the remaining commercial indices including the benchmark stays around 0.7. This high correlation is because the constituent bonds for the custom indices are a subset of the iBoxx constituent list. The surprising observation is that despite the mandate for active management, there is high correlation of monthly returns of the active bonds funds with the monthly returns of the iBoxx index and the index tracker.

Table 9: 5-year returns correlation table for custom index constructed from randomly selected bonds

	Notional wt	Price wt	Dur/Price wt	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Notional wt	1.000	0.996	0.980	0.701	0.778	0.777	0.762	0.760
Price wt		1.000	0.991	0.698	0.772	0.764	0.749	0.749
Dur/Price wt			1.000	0.700	0.767	0.756	0.727	0.734
iShares EUR Corp				1.000	0.967	0.953	0.924	0.947
iBoxx Return					1.000	0.988	0.973	0.986
L&G Euro Corp						1.000	0.969	0.978
T-Rowe Euro Corp							1.000	0.987
Std Life Euro Corp								1.000

Source: Markit/Bloomberg

CHAPTER 5

SELECTING UNDERPERFORMING BONDS FOR INDEX CONSTRUCTION

I. Introduction:

The iBoxx EUR Corporate index rebalances every month with a new selection of bonds. I select two hundred bonds every month from the selection of bonds in the previous month, which have underperformed the most on a Z-spread basis during the month, i.e., bonds which have widened the most on a Z-spread basis. I use these bonds to form custom indices using my three different weightings. I then track the performance of these indices against the performance of commercial indices over a five year period.

II. Rationale:

The intent behind this approach is to test whether an index constructed of previously underperforming bonds can match or outperform active bond funds. The hypothesis behind this approach is that bonds which have underperformed in a given month will outperform in the next month as they are cheap relative to the universe of comparable bonds. Further as fund managers chase yield when deploying cash, it is reasonable to expect underperforming bonds to outperform in the following period.

III. Methodology for bond selection

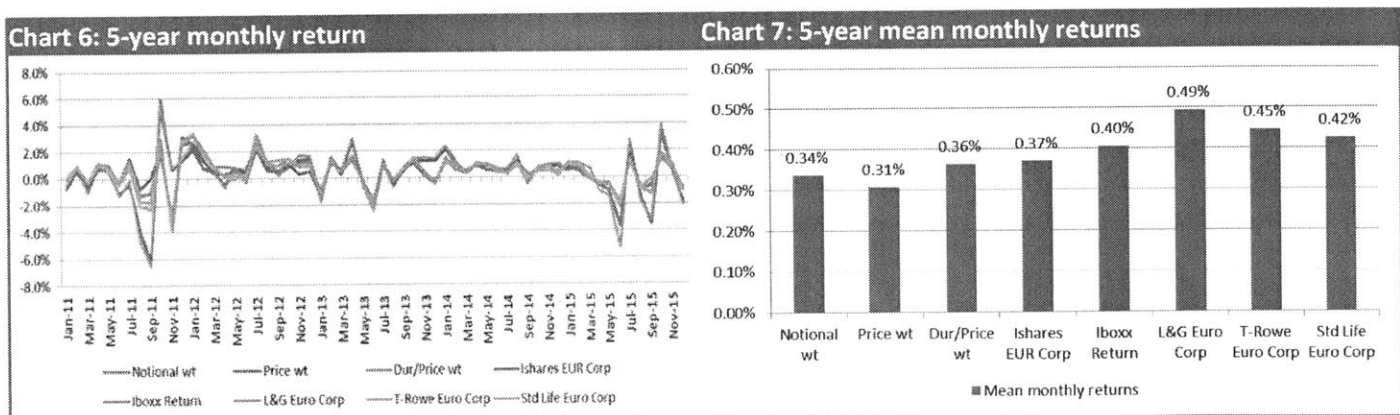
The number of constituent bonds in the IBoxx EUR Corporate index each month ranges from 1253 to 1734. Each month, I select the top 200 most underperforming bonds from this set of bonds to form my custom indices.

To obtain the top underperforming bonds every month, I obtain the Z spread (bid) for each bond at the beginning of the current month and 30 days prior. I ensure that prior 30 days date is a workday which helps in obtaining the Z spreads. I do not consider bonds for which I am unable

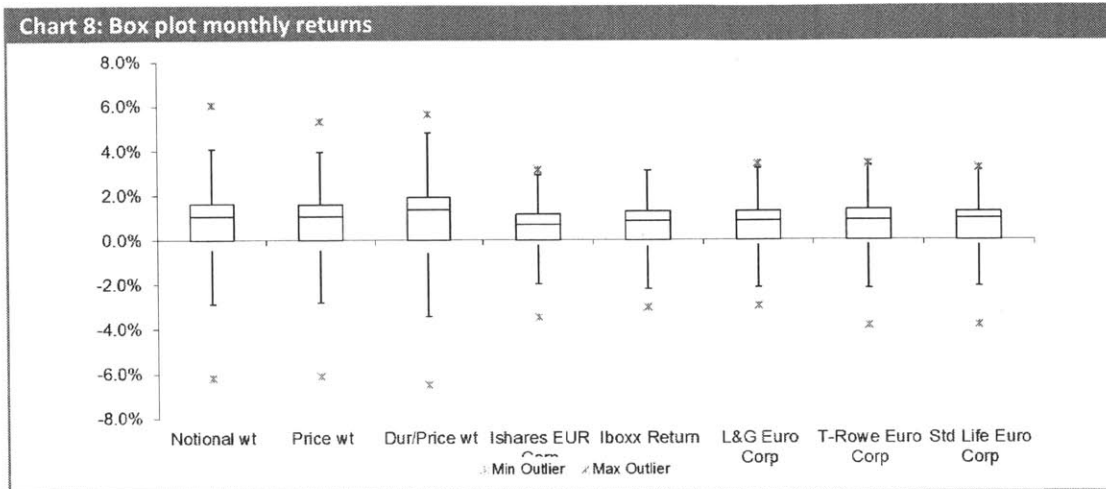
to obtain Z-spreads. I then calculate the change in the Z-spreads for each bond. The bonds are then ranked according to their performance i.e. bonds which reflect the most widened spreads have underperformed and are ranked near the top. This process is done for each month.

IV. Comparison of the monthly return performance of custom indices vs the monthly return performance of all indices

I observe the monthly returns of the custom bond indices, the iBoxx index, benchmark tracker fund and commercial actively managed bond funds over a five year period. After accounting for an assumed penalty of 0.2% of portfolio value per month representing trading costs on the custom indices, I observe the 5 year mean monthly return of all the custom indices to be lower than the mean monthly returns of the active bond funds and the iBoxx benchmark index. This suggests that bonds that have declined in value tend to continue to perform relatively poorly. I repeat this process by selecting bonds which have shown both lower month-on-month pricing and also by selecting bonds which have shown higher month-on-month OAS spreads. These two methods are analogous to selecting underperforming bonds. I again observe similar historical performance relative to the mean monthly returns of the iBoxx EUR index, index tracker and the active bond funds. Essentially a contrarian view on the market would not have resulted in outperformance over the past five years.



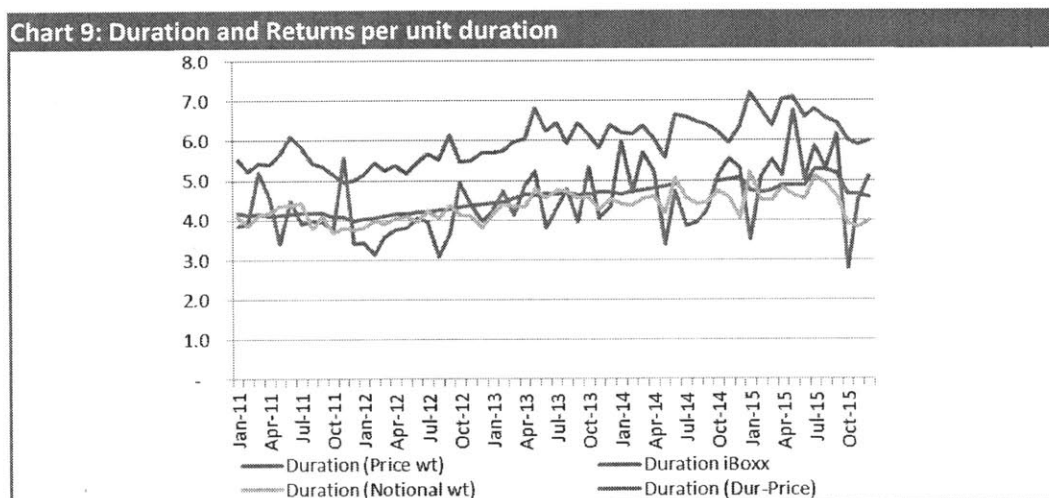
Source: Bloomberg, Markit iBoxx EUR index
 *All custom indices are penalized by 0.2% in portfolio value every month to account for trading costs.

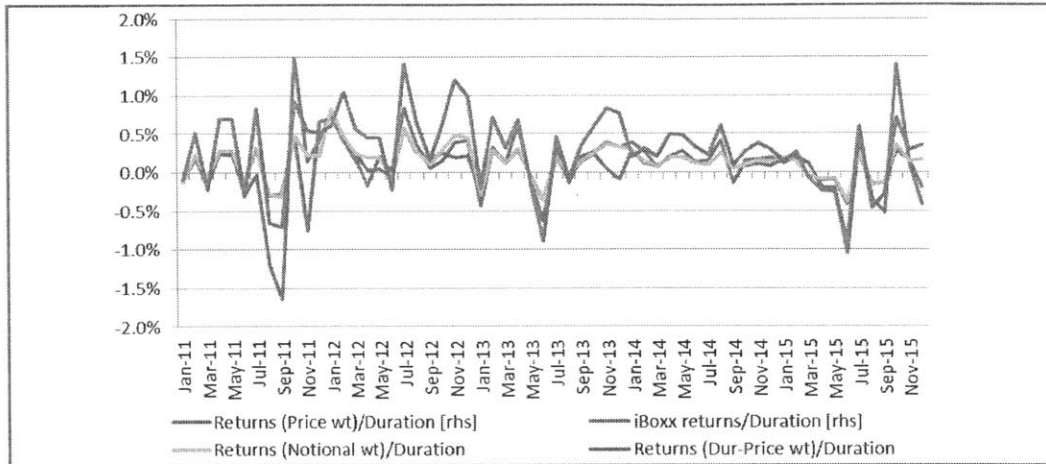


V. Additional observations

- Exploring portfolio duration and returns

I observe the portfolio duration and other portfolio characteristics for both the custom indices and the iBoxx index to determine if any source of diverging performance was due to higher duration risk or concentration risk. I see Dur-Price weighted index consistently reflecting higher duration while the duration for the Price weighted index remains volatile.





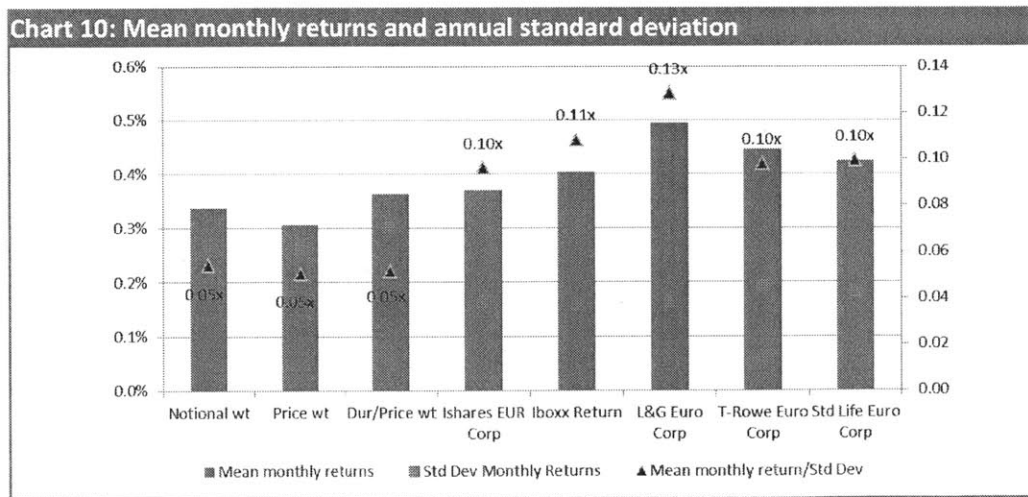
Source: Markit/Bloomberg

* I did not have access to time series of duration values for commercially available indices

The return per unit duration for the Price weighted index is also consistently more volatile than the returns per unit duration for the iBoxx, and the custom indices.

- **Volatility of historical returns**

I observe higher return volatility of the monthly returns for all of the custom indices relative to the volatilities of the monthly returns of all the remaining indices. This is also expected as a momentum driven strategy i.e. of buying underperforming bonds will likely have higher volatility. Consequentially, the custom indices reflect poor return to risk ratios relative to the active bond funds and the benchmark indices.



Source: Bloomberg, Markit iBoxx EUR index; *All custom indices except for active bond funds are penalized by 0.2% in portfolio value every month to account for trading costs.

Table 11: 5-year mean monthly returns and standard deviation

	Notional wt	Price wt	Dur/Price wt	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Mean Monthly Return	0.34%	0.31%	0.36%	0.37%	0.40%	0.49%	0.45%	0.42%
Std Dev	0.063	0.061	0.071	0.039	0.037	0.039	0.046	0.043
Mean Monthly Return/Std Dev	0.05x	0.05x	0.05x	0.10x	0.11x	0.13x	0.10x	0.10x

*All custom indices are penalized by 0.2% in portfolio value every month to account for trading costs.

- **Correlation among returns**

I observe lower correlations of the historical returns for the custom indices with the returns of the benchmark and benchmark tracker. The correlation is relatively higher with the returns of the active bond funds.

Table 12: 5-year returns correlation table for custom index constructed from randomly selected bonds

	Notional wt	Price wt	Dur/Price wt	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Notional wt	1.000	0.998	0.986	0.626	0.709	0.697	0.773	0.742
Price wt		1.000	0.990	0.626	0.710	0.695	0.770	0.742
Dur/Price wt			1.000	0.662	0.742	0.730	0.786	0.764
iShares EUR Corp				1.000	0.967	0.953	0.924	0.947
iBoxx Return					1.000	0.988	0.973	0.986
L&G Euro Corp						1.000	0.969	0.978
T-Rowe Euro Corp							1.000	0.987
Std Life Euro Corp								1.000

Source: Markit/Bloomberg

- **Industry/Geography concentration**

Macro news can differentially impact returns for particular sectors. This can lead to higher concentration levels for particular sectors in the proposed custom indices. I examine whether the source of returns for the proposed custom indices are due to potential concentration in particular industries, issuer names or countries or other similar factors.

Chart 11: Index weights by sector

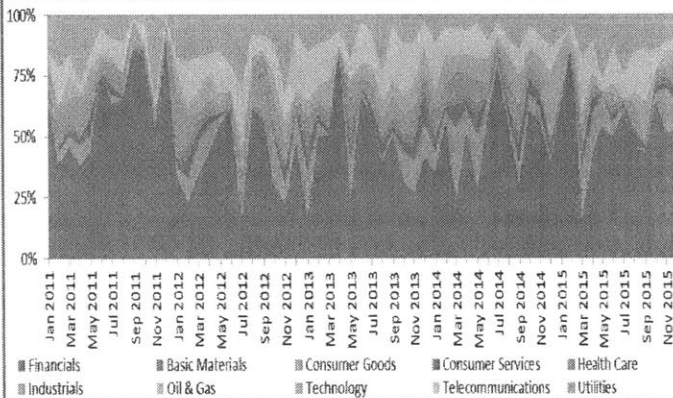
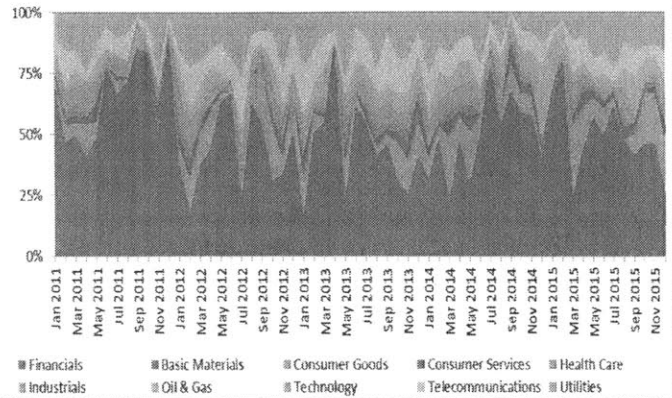


Chart 12: Count of index constituents by sector



Source: Markit/Bloomberg

Chart 13: Index weights by country

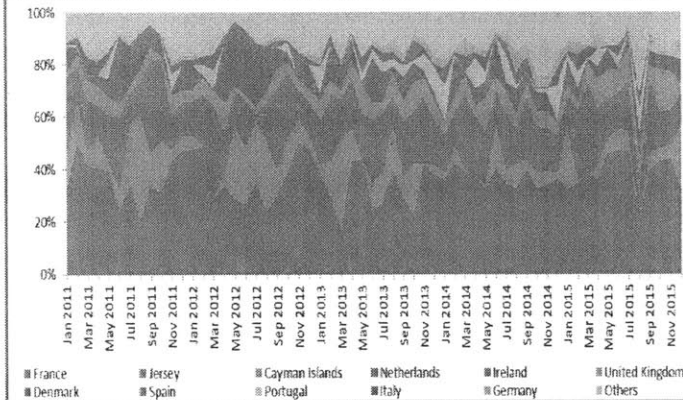
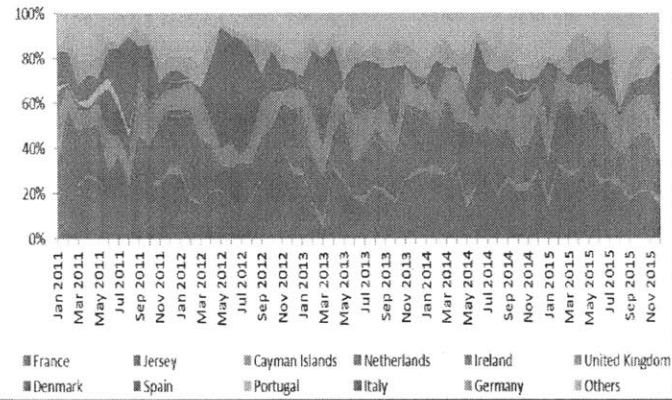


Chart 14: Count of index constituents by country



Source: Markit/Bloomberg

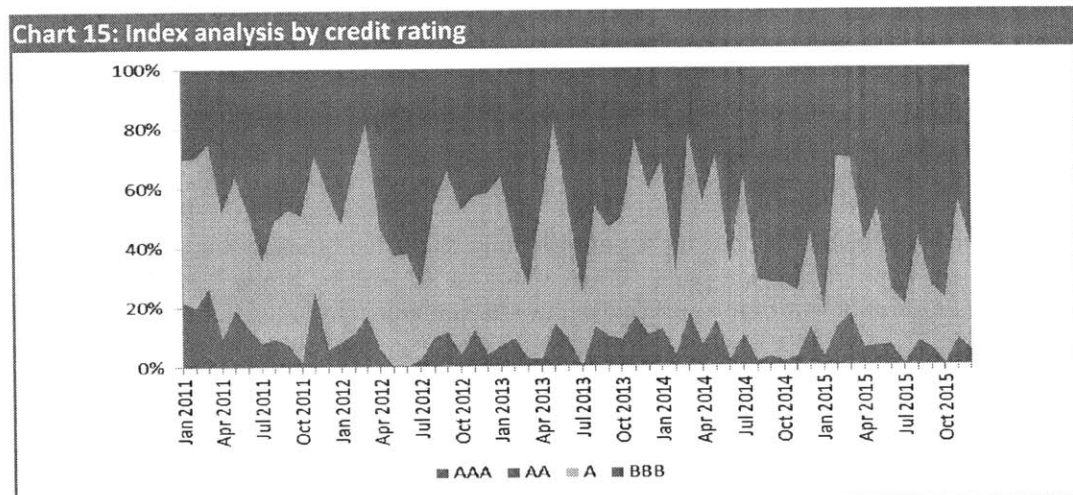
In the above graphs, I observe high and fluctuating concentration levels of the sector 'Financials' in the custom index. During the period of 2011-2015, European Financials remained under significant pressure for a host of reasons including ECB and ratings actions, weak results and a continuing poor economic environment. Consequently, a disproportionate number of those issues experienced widening spreads and therefore higher representation in this custom index. Because financials have continuously underperformed on a total return basis, and this can potentially explain the mediocre historical performance for the proposed custom indices over this period (Please refer to

Appendix C for benchmark and returns performance of iBoxx Financials index versus iBoxx EUR Corp).

This is in contrast to the iBoxx index, which has upper concentration ceiling levels for individual issuer names, countries, industry segments and other similar factors. Additionally, index trackers tend to diversify, as do active bond fund managers to limit risk taking.

- **Credit Ratings breakdown**

I check the credit ratings breakdown for the custom indices. I observe that credit ratings swing between A and BBB credit rating segments while the proportion of AAA and AA single credits remain relatively small.



Source: Markit/Bloomberg

CHAPTER 6

SELECTING THE CHEAPEST BONDS RELATIVE TO DURATION FOR INDEX CONSTRUCTION

I. Introduction:

The iBoxx EUR Corporate index rebalances every month with a new selection of bonds. I select two hundred bonds every month from this new selection of bonds, which have the widest OAS spreads relative to their duration and then use it to form custom indices. I form the indices in three different ways. I then track the total return performance of these indices against the performance of commercially available indices over a five year period.

II. Rationale

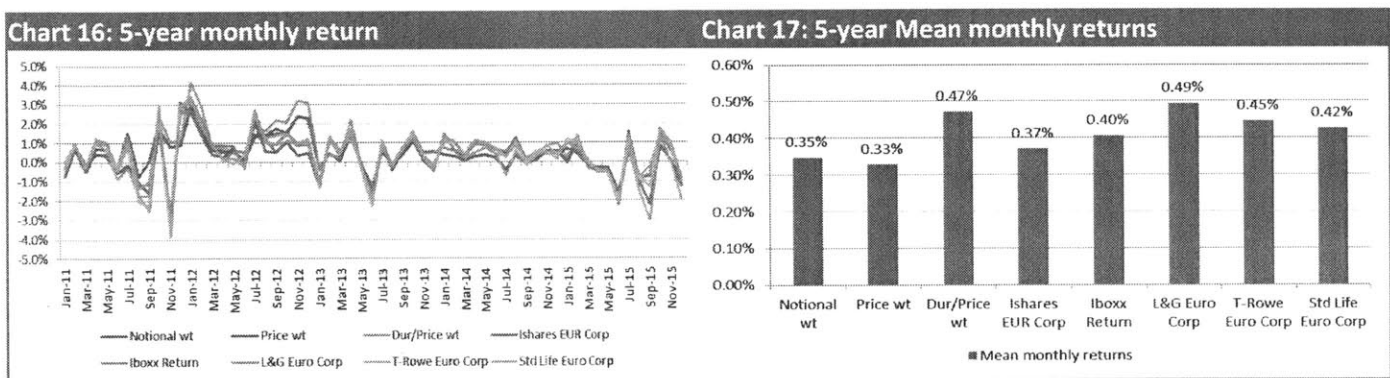
Many fund managers use duration as one of the key factors in managing the risk of their portfolio. Hence when I select the bonds with the widest OAS spreads relative to their duration for index construction, I am essentially imitating a fund manager who is trying to add to the least duration risk of the portfolio per unit of spread.

III. Methodology for data selection and index construction

The number of constituent bonds in the iBoxx EUR Corporate index each month ranges from 1253 to 1734. From this set of bonds, I select the top 200 bonds with the cheapest OAS spread to duration for constructing my custom indices. To select these bonds, I first obtain the OAS spread (bid) and the effective duration for each bond at the beginning of the month from Bloomberg. I do not consider the bonds for which there is no spread or duration data. For the remaining bonds, I divide the OAS spread by the duration values and then rank them the bonds based on the output. I then select the top two hundred bonds for each month which have the highest spread to duration values to form my custom indices.

IV. Comparison of the monthly return performance of custom indices vs the monthly return performance of all indices

I observe the historical monthly returns of the custom bond indices, the iBoxx index, benchmark tracker fund and commercial actively managed bond funds over a five year period. After accounting for an assumed penalty of 0.2% of portfolio value per month representing trading costs on the returns of the custom indices, I observe the 5 year mean monthly returns of the Notional and Price weighted indices to be comparable with the mean monthly returns of the benchmark and benchmark tracker indices. The mean monthly return of the Duration-Price weighted index is comparable with the active bond funds and exceeds the mean monthly returns of the iBoxx benchmark index.



Source: Bloomberg, Markit iBoxx EUR index

*All custom indices except for active bond funds are penalized by 0.2% in portfolio value every month to account for trading costs.

Although the mean of the monthly returns of the custom indices and the commercial funds including the benchmark index are different, I again note that they are statistically comparable. I confirm this result using paired t-tests to prove the null hypothesis of no difference in the mean of monthly returns between custom indices and the commercial indices. Please refer to the paired t-test results in Appendix H.

Prior to running this analysis, I confirmed that the returns for all indices are normal or nearly normal. Please refer to Appendix E for confirmation on the normality of the returns for all indices including the custom indices formed using the spread-duration strategy.

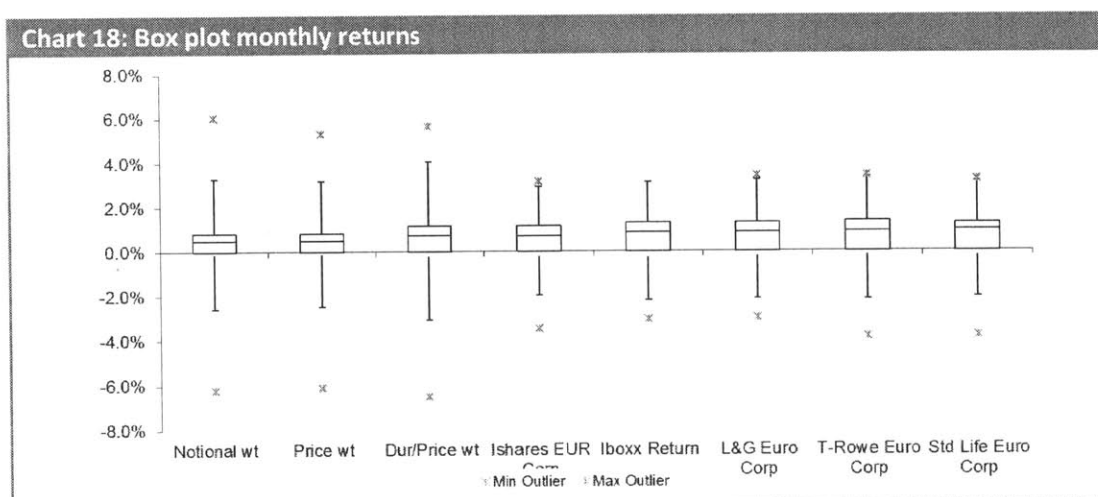
Table 13: Paired t-test for comparing difference of mean returns of custom indices vs commercial funds

Null =	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Notional wt	TRUE	TRUE	TRUE	TRUE	TRUE
Price wt	TRUE	TRUE	TRUE	TRUE	TRUE
Dur/Price wt	TRUE	TRUE	TRUE	TRUE	TRUE

Null hypothesis: Difference in means is '0'

Please refer to Appendix H for detailed charts on t-test comparisons

I also observe that the custom indices have significantly wide outliers which is in contrast with the active bond funds and benchmark indices which reflect narrower outliers.



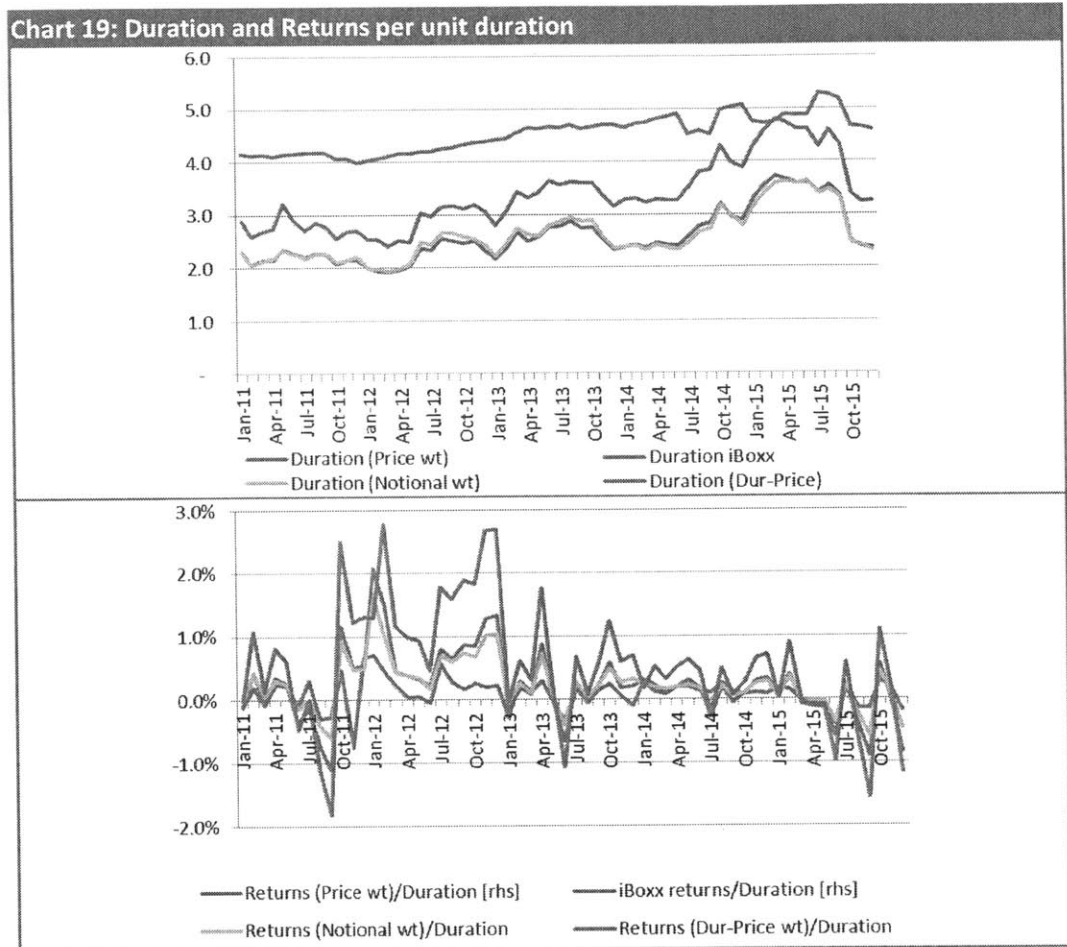
Source: Bloomberg, Markit iBoxx EUR index

*All custom indices except for active bond funds are penalized by 0.2% in portfolio value every month to account for trading costs.

V. Additional observations

- Exploring portfolio duration and returns

I also check for whether the historical performance of the custom indices is due to adding duration risk or concentration risk to the portfolio. To do this, I observe the portfolio duration and other portfolio characteristics for the custom indices and the iBoxx index.



Source: Markit/Bloomberg

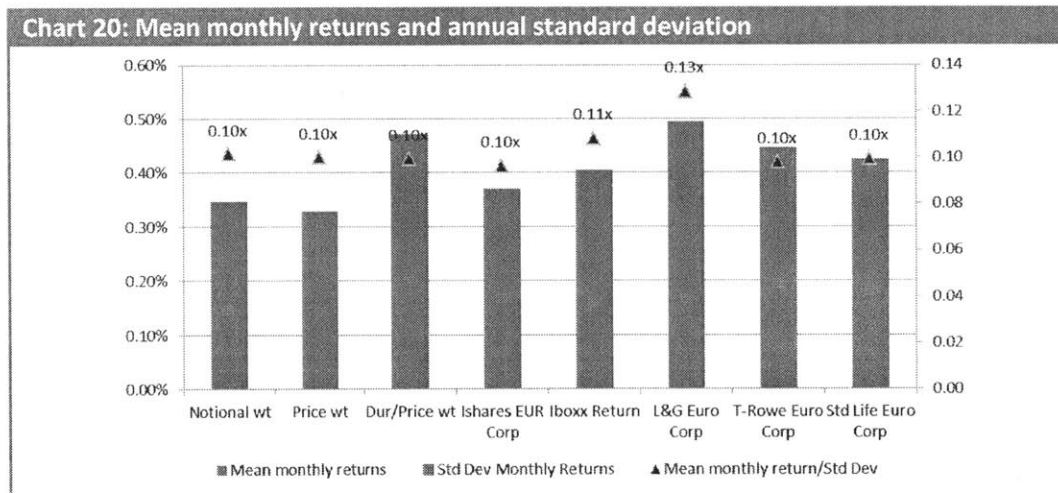
* I did not have access to time series of duration values for commercially available indices

From the above chart, I observe the duration of the custom indices to be lower than the duration of the iBoxx index. This is probably because shorter duration bonds are more likely to have a high spread-duration ratio, leading to overall lower duration of the portfolio. Despite lower duration, I find the returns per unit of duration to be significantly ahead of the returns per duration of iBoxx index especially during the time period of Oct 2011 to Oct 2012. This time period of higher returns significantly pushes up performance over the five year period. Returns per unit of duration for the proposed custom index continued to stay ahead of returns per unit duration for the iBoxx index for most of the remaining years.

- **Volatility of historical returns**

I observe lower returns volatility for the Price weighted and Notional weighted indices relative to volatility of all other indices and active funds. The Duration-Price weighted index exhibits modestly higher volatility relative to the volatility of the active funds, and higher volatility relative to volatility of the benchmark index and index tracker.

Additionally, I also observe mean monthly returns to volatility of the three custom indices to be comparable to the mean monthly returns per unit of volatility of the active bond funds and exceeding similar measures of the benchmark and benchmark index. Only L&G Euro Corp fund outperforms on this measure.



Source: Bloomberg, Markit iBoxx EUR index; *All custom indices except for active bond funds are penalized by 0.2% in portfolio value every month to account for trading costs.

Table 14: 5-year mean monthly returns and standard deviation

	Notional wt	Price wt	Dur/Price wt	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Mean Monthly Return	0.35%	0.33%	0.47%	0.37%	0.40%	0.49%	0.45%	0.42%
Std Dev	0.034	0.033	0.047	0.039	0.037	0.039	0.046	0.043
Mean Monthly Return/Std Dev	0.10x	0.10x	0.10x	0.10x	0.11x	0.13x	0.10x	0.10x

*All custom indices are penalized by 0.2% in portfolio value every month to account for trading costs.

- **Correlation among returns**

I observe lower correlations of the historical monthly returns of the custom indices with the monthly returns of the benchmark and benchmark tracker. The correlation is relatively higher with the returns of the active bond funds.

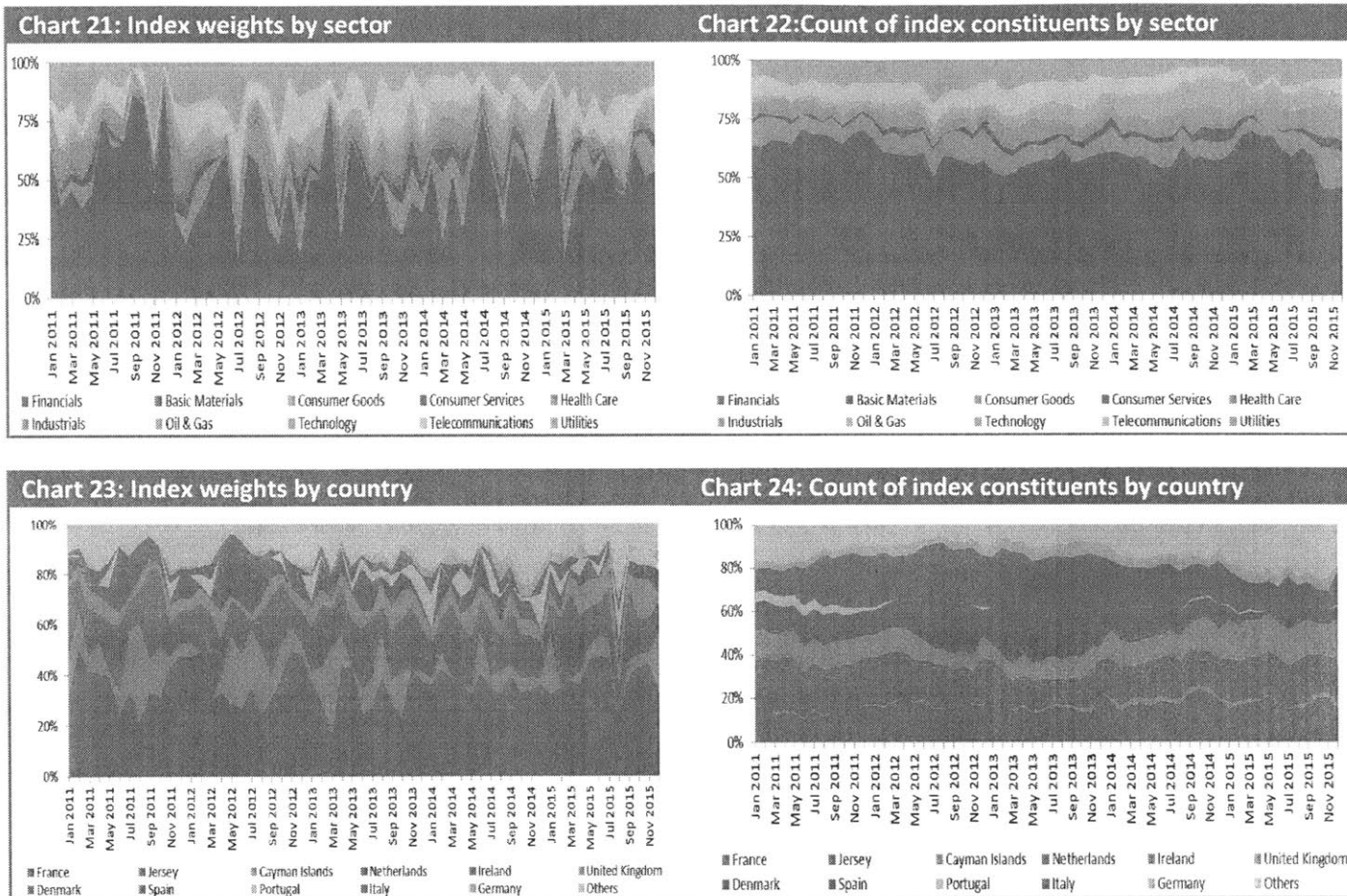
Table 15: 5-year returns correlation table for custom index constructed from randomly selected bonds

	Notional wt	Price wt	Dur/Price wt	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Notional wt	1.000	0.998	0.994	0.588	0.692	0.700	0.731	0.708
Price wt		1.000	0.994	0.588	0.693	0.698	0.729	0.708
Dur/Price wt			1.000	0.595	0.703	0.713	0.744	0.721
iShares EUR Corp				1.000	0.967	0.953	0.924	0.947
iBoxx Return					1.000	0.988	0.973	0.986
L&G Euro Corp						1.000	0.969	0.978
T-Rowe Euro Corp							1.000	0.987
Std Life Euro Corp								1.000

Source: Markit/Bloomberg

- **Industry/Geography analysis:**

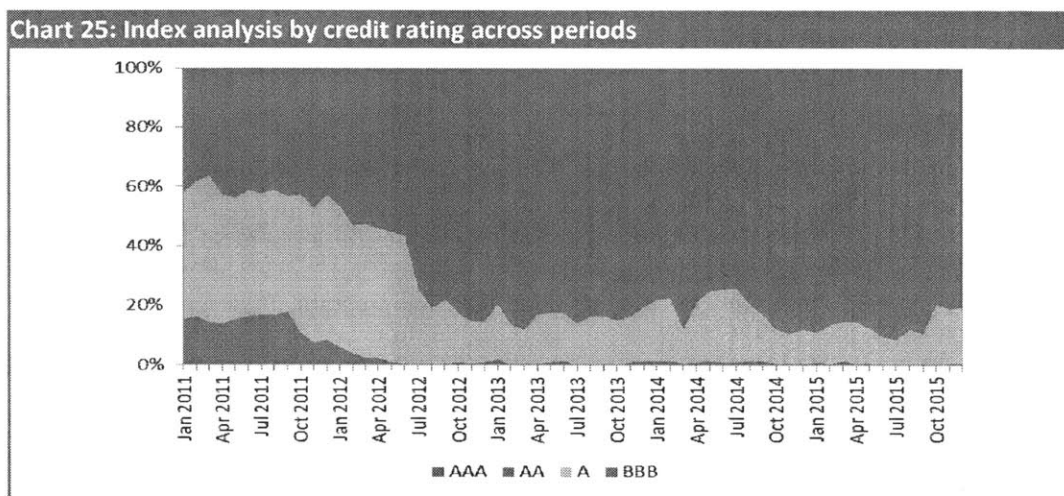
The downside of buying cheap bonds relative to their duration is that this strategy can lead to excess concentration in particular industry segments. Macro news periodically can lead to wider spreads for issuers from particular industry sector relative to their duration. Consequentially this will lead to a build of concentration levels for the particular industry sector in our custom index. I explore if the source of returns for the proposed custom indices is due to any build-up of concentration in particular industries, issuer names or countries or other similar factors.



In the above graphs, I observe high concentration levels of the sector 'Financials' in our index and a high concentration for Spanish and Italian issuers. This is also expected as 'Financial' issuers from these countries have constantly faced poor economic news and their credit spreads have remained under stress. Hence they are over represented in our custom index and this can be a potential explanation for higher returns. This is in contrast to the iBoxx index, which has upper concentration ceiling levels for individual issuer names, countries, industry segments and other similar factors. Additionally, index trackers also tend to diversify so as to track the index and active bond fund managers also tend to diversify to ensure pragmatic risk taking.

- **Credit Rating breakdown**

I further observe the evolution of the credit rating breakdown for the custom index portfolio over time. I observe significant buildup of BBB credits at the expense of A and AA credits which leads to lower portfolio diversification. This is also expected as the yields collapsed across all the credit grades over the past five years and hence the lower rated BBBs with relatively higher spreads dominate the index at the expense of the AA and A credits. Note that the method nearly filters out the AAA credits which have extremely tight and historically low spreads near to zero yields.



Source: Markit/Bloomberg

CHAPTER 7

SELECTING MOST LIQUID BONDS FOR INDEX CONSTRUCTION

I. Introduction:

The iBoxx EUR Corporate index rebalances every month with a new selection of bonds. I select two hundred bonds every month based on the bond liquidity from this new selection of bonds and then use it to form custom indices. I form the indices in three different ways. I then track the total return performance of these indices against the performance of commercially available indices over a five year period.

II. Rationale:

Secondary market liquidity in the fixed income markets has been on the decline due to a multitude of reasons including increased regulations on investment banks and broker dealers and the ECB's announcement of its bond buyback program. Tight liquidity implies that illiquid bonds have wider spreads and more volatile spreads. They can also reflect poor total monthly returns, since in a shallow market even a minor sell-off will lead to substantial widening which will impact the total return. Since I mark to market the bonds for calculating the monthly total returns, hence I expect liquid bonds to have higher returns than illiquid bonds especially in liquidity strained scenario. However, an offsetting effect is that more liquid bonds have lower expected returns all else equal.

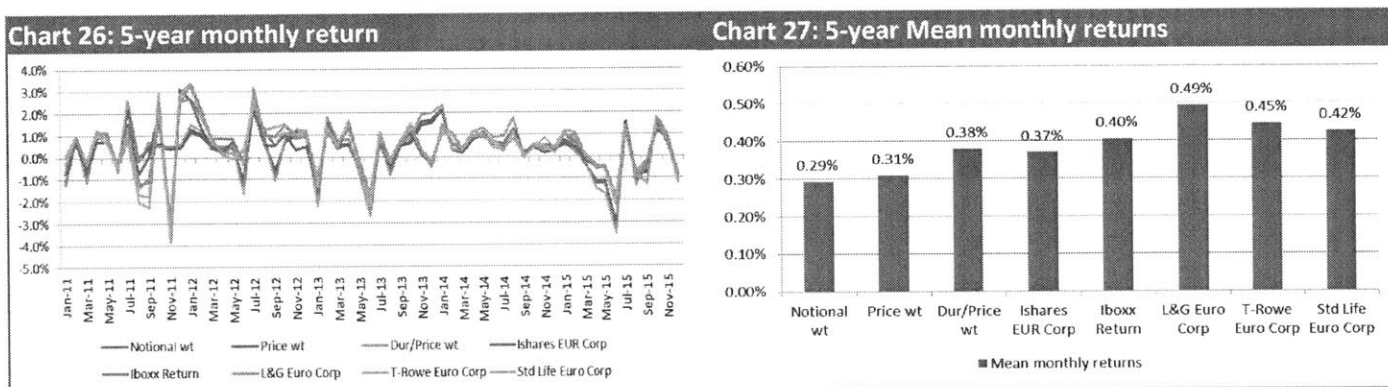
III. Methodology for bond selection

The number of constituent bonds in the iBoxx EUR Corporate index each month ranges from 1253 to 1734. From this set of bonds, I select the top 200 most liquid bonds for the construction of the custom indices. To obtain the top most liquid bonds, I use the spread between bid-ask quotes as a proxy for liquidity. I first obtain the Z spread (bid) and Z spread (ask) for each bond

at the beginning of each month. I do not consider bonds for which I am unable to obtain Z-spreads. I then calculate the bid-ask difference for the Z-spreads for all the bonds of each month. The bonds for each month are then ranked according to spread differential, with the bonds having lower differential ranked higher. I select the top 200 of these bonds. This process is repeated each month.

IV. Comparison of the monthly return performance of custom indices vs the monthly return performance of all indices

I calculate the monthly returns of the custom bond indices, the iBoxx index, benchmark tracker fund and commercial actively managed bond funds over a five year period. The mean of the 5 year monthly returns of the Notional and Price weighted indices are below the mean monthly returns for the benchmark and the commercial indices. The mean of the 5 year monthly returns for the Duration-Price weighted index is comparable with the returns of the benchmark and benchmark tracker but below the mean of the monthly returns of the active bond funds.

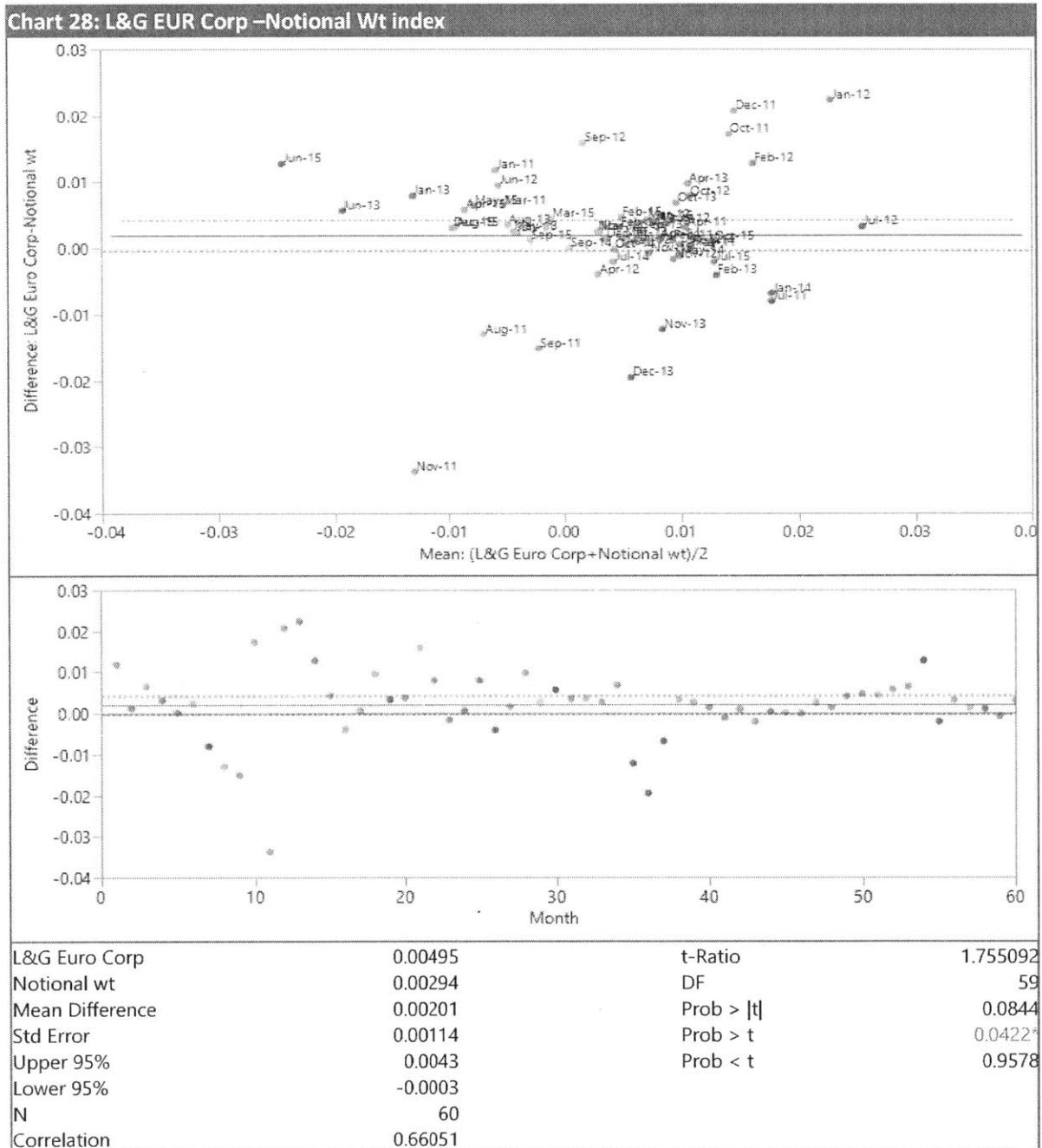


Source: Bloomberg, Markit iBoxx EUR index

*All custom indices are penalized by 0.2% in portfolio value every month to account for trading costs.

I also performed t-tests for comparing the mean of the monthly returns of the custom indices with the mean of the monthly returns for the benchmark and the commercial indices. I observe no statistical difference in the means for all the possible comparisons between the custom indices and commercial indices except when comparing the mean for the L&G EUR Corp with the

Notional weighted index. In this case, I observe statistical significance in the difference of the means at 95% confidence level. I observe L&G EUR Corp fund outperforming the Notional weighted index as evidenced below.



* Paired t-test done because of equal sample size implies that t-test will be robust even if sample variances differ

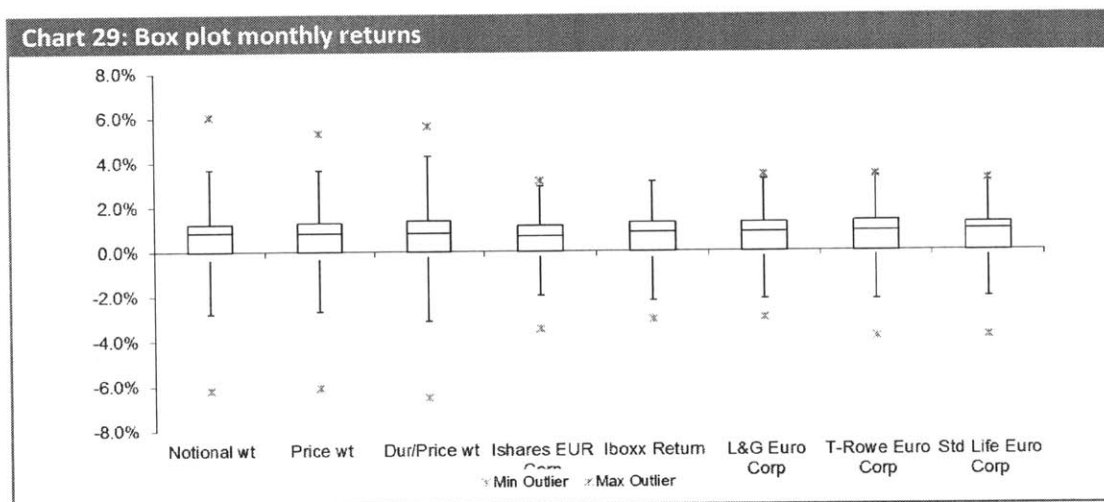
Table 16: Paired t-test for comparing difference of mean returns of custom indices vs commercial funds

Null =	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Notional wt	TRUE	TRUE	FALSE	TRUE	TRUE
Price wt	TRUE	TRUE	TRUE	TRUE	TRUE
Dur/Price wt	TRUE	TRUE	TRUE	TRUE	TRUE

Null hypothesis: Difference in means is '0'

Please refer to Appendix I for detailed charts on t-test comparisons

Additionally, on observing the box plots for this index, I see a wider dispersion of monthly returns with outliers for all three custom indices.



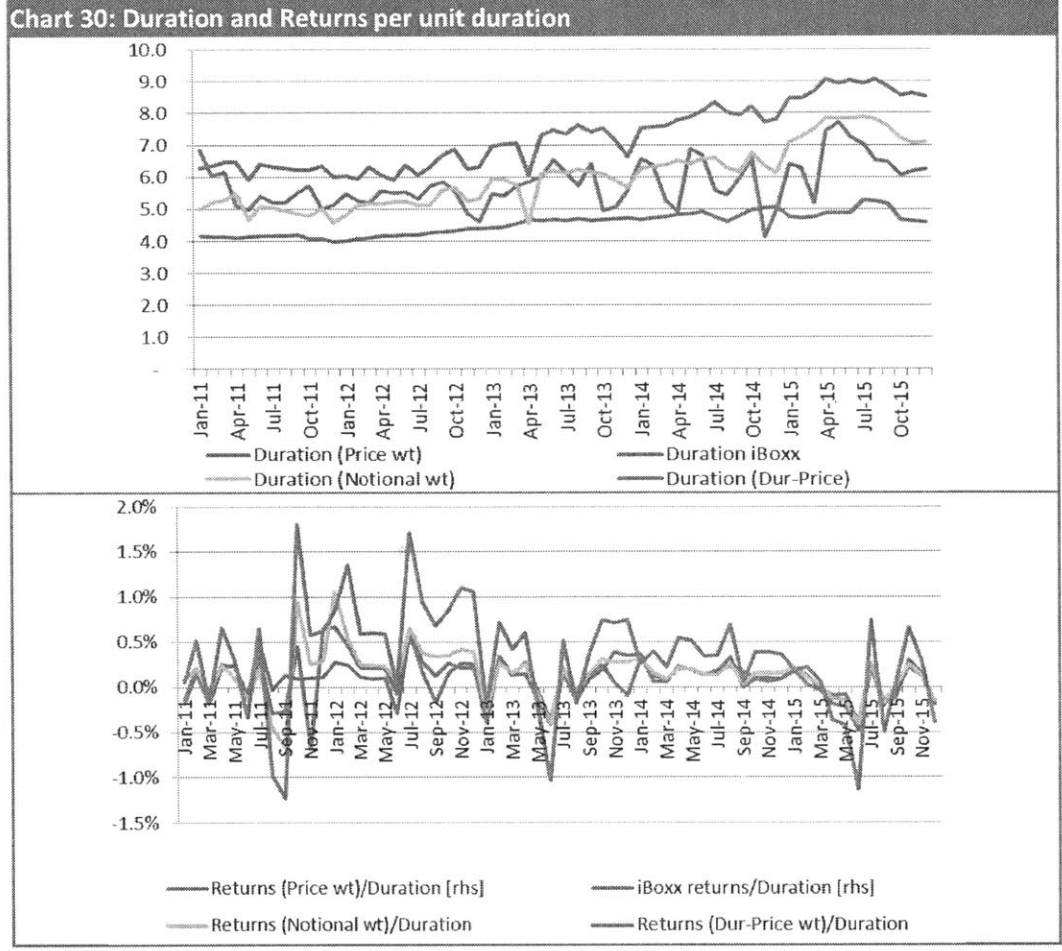
Source: Bloomberg, Markit iBoxx EUR index

*All custom indices except for active bond funds are penalized by 0.2% in portfolio value every month to account for trading costs.

V. Additional observations

- Exploring portfolio duration and returns

I also observe the portfolio duration and duration per unit returns against similar measures of the iBoxx.

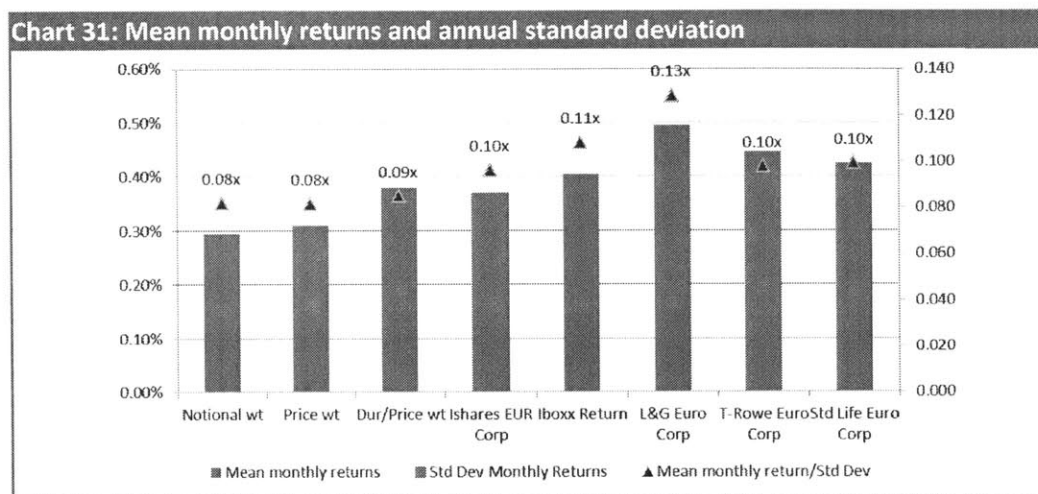


Source: Markit/Bloomberg
 * I did not have access to time series of duration values for commercially available indices

From the above chart, I observe duration for all the custom indices to be volatile and ahead of the duration for the iBoxx index. This implies that liquidity shifts between longer and shorter duration bonds, occurs over time. Further, return per unit duration for the duration-price weighted index also remains more volatile relative to the remaining indices.

- **Volatility of historical returns**
 I observe comparable returns volatility of the monthly returns for all of the custom indices relative to the volatilities of the monthly returns of all the remaining indices. Liquid bonds will show less volatile spreads and hence indices created using this strategy will be less volatile. Further benchmark, tracker indices also remain liquid due to investor interest in

broad market indices and hence reflect low volatility in returns. Additionally, active bond fund managers will generally be unable or unwilling to build sizable positions in illiquid credits.



Source: Bloomberg, Markit iBoxx EUR index; *All custom indices except for active bond funds are penalized by 0.2% in portfolio value every month to account for trading costs.

Table 17: 5-year mean monthly returns and standard deviation

	Notional wt	Price wt	Dur/Price wt	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Mean Monthly Return	0.29%	0.31%	0.38%	0.37%	0.40%	0.49%	0.45%	0.42%
Std Dev	0.036	0.038	0.045	0.039	0.037	0.039	0.046	0.043
Mean Monthly Return/Std Dev	0.08x	0.08x	0.09x	0.10x	0.11x	0.13x	0.10x	0.10x

*All custom indices are penalized by 0.2% in portfolio value every month to account for trading costs.

- **Correlation among returns**

I observe lower correlations of the historical returns for the custom indices with the returns of the T-Rowe EUR Fund and Std Life EUR fund. The remaining funds including the benchmark indices reflect modestly higher correlation.

Table 18: 5-year returns correlation table for custom index constructed from randomly selected bonds

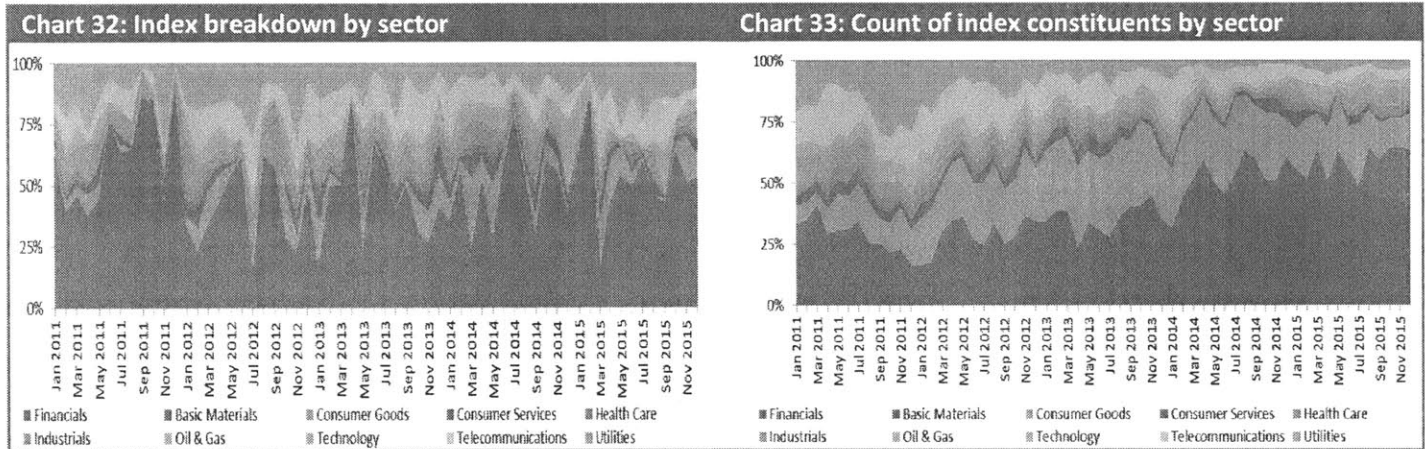
	Notional wt	Price wt	Dur/Price wt	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Notional wt	1.000	0.998	0.992	0.692	0.686	0.661	0.587	0.626
Price wt	-	1.000	0.996	0.690	0.688	0.664	0.590	0.628
Dur/Price wt	-	-	1.000	0.682	0.679	0.655	0.578	0.615

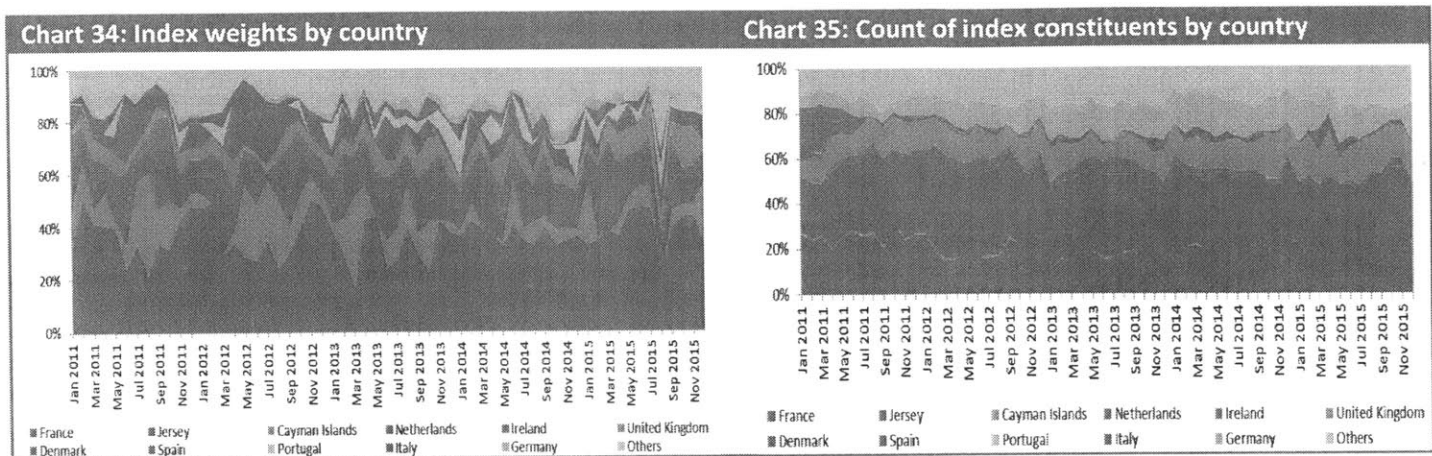
iShares EUR Corp	-	-	1.000	0.967	0.953	0.924	0.947
iBoxx Return	-	-	-	1.000	0.988	0.973	0.986
L&G Euro Corp	-	-	-	-	1.000	0.969	0.978
T-Rowe Euro Corp	-	-	-	-	-	1.000	0.987
Std Life Euro Corp	-	-	-	-	-	-	1.000

Source: Markit/Bloomberg

- **Industry/Geography analysis**

This strategy can also lead to excess concentration in particular industry segments because improved sentiment for particular segments or increased issuance can cause higher liquidity in these segments relative to others. Hence it can potentially lead to concentration build up in the proposed custom index. Therefore I explore if the source of the returns for the proposed custom index is be due to potential concentration in particular industries, issuer names or countries or other similar factors.

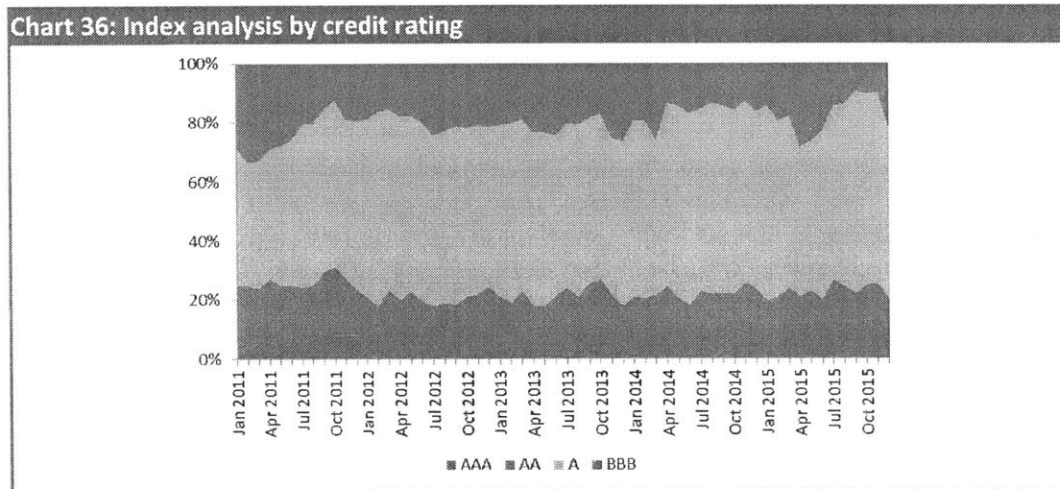




In the above graphs, I observe high and fluctuating concentration levels of the sector ‘Financials’ in the proposed index and a high concentration for western Europe dominating the issuers space. There are a lower number of financial issuers and sizable number of consumer goods firms. This implies a smaller number of western European financial issuers were able to issue new bonds that are liquid. This is expected as European financials have remained under stress and only major financials with potential backing of their respective national governments have been able to tap the capital markets. Hence these companies are over-represented in our custom index. I also see increasing number of consumer issues implying increased issues with smaller notional amounts. This is also expected as the region has faced recession and high employment over the past five years and hence credit spreads for consumer companies have widened. This is in contrast to the iBoxx index which has upper concentration ceiling levels for individual issuer names, countries, industry segments and other similar factors. Additionally, index trackers also tend to diversify so as to track the index and active bond fund managers tend to diversify to ensure pragmatic risk taking.

- **Breakdown of credit quality**

I also review the custom portfolio to observe if the source of returns is from concentration in particular credit ratings. I observe concentration in AA and A credits mainly due to higher weighting of national Financials.



Source: Markit/Bloomberg

CHAPTER 8

SELECTING CHEAPEST BONDS RELATIVE TO DEFAULT PROBABILITY FOR INDEX CONSTRUCTION

I. Introduction:

The iBoxx EUR Corporate index rebalances every month with a new selection of bonds. I select two hundred bonds every month from this new selection of bonds which have the highest OAS spreads relative to the 1 year probability of default and then use it to form custom indices. I then track the total return performance of these indices against the performance of commercially available indices over a five year period.

II. Rationale:

The main rationale behind this approach is that OAS spreads should account for the credit risk and any excess spread relative to the probability of default should imply a cheaper bond. Hence cheaper bonds should converge to their true value i.e. reflect spreads should tighten gradually. This will imply higher or excess returns relative to investing in other bonds. This method is especially useful when sector driven news causes indiscriminate trading and creates value buying/selling opportunities.

III. Methodology for bond selection

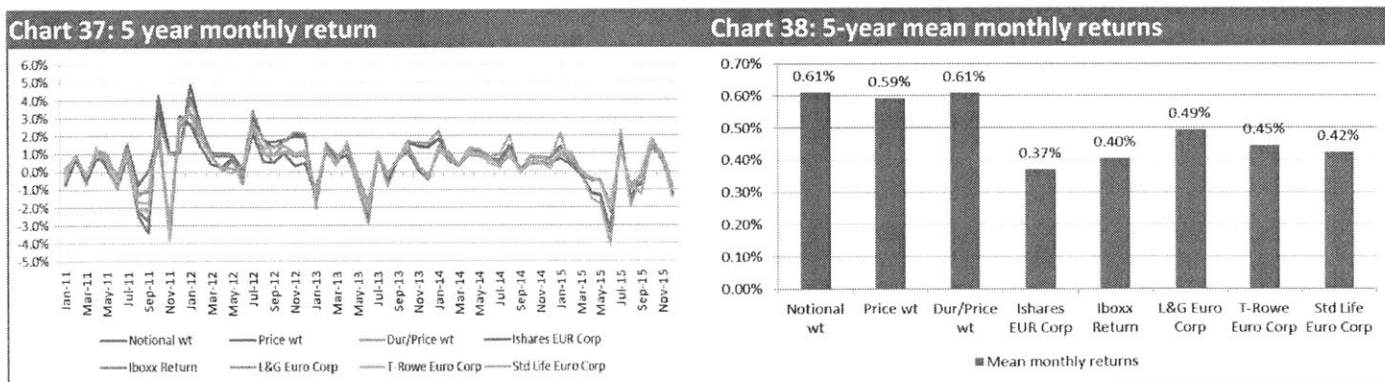
- Data selection

iBoxx EUR Corporate index consists of approximate 1500 bonds and is rebalanced monthly. Number of constituent bonds range between 1253 bonds to 1734 bonds for every month. I use this set of bonds to select top 200 most underpriced bonds at the beginning of the month relative to their PD.

To obtain the top most underpriced bonds relative to their credit risk, I obtain OAS (bid) spreads for each bond at the beginning of each month. I also obtain the 1 year probability of default for each issuer using the Bloomberg default risk model at the beginning of each month. PD can also be obtained from any KMV or any market price related model. Since iBoxx EUR index is the source of bonds for the proposed custom index and is an investment grade index hence majority of issuers included in the index are publicly traded entities and therefore it is easy to obtain PDs for the same. I do not consider bonds for which I am unable to obtain OAS-spreads or PD information. I then divide the OAS spread with the PD for all the bonds of each month. The bonds for each month are then ranked according to the resulting output and I select top 200 of these bonds. This process is done for all the months and the top 200 cheapest bonds relative to their credit risk are selected for each month.

IV. Comparison of the monthly return performance of custom indices vs the monthly return performance of all indices

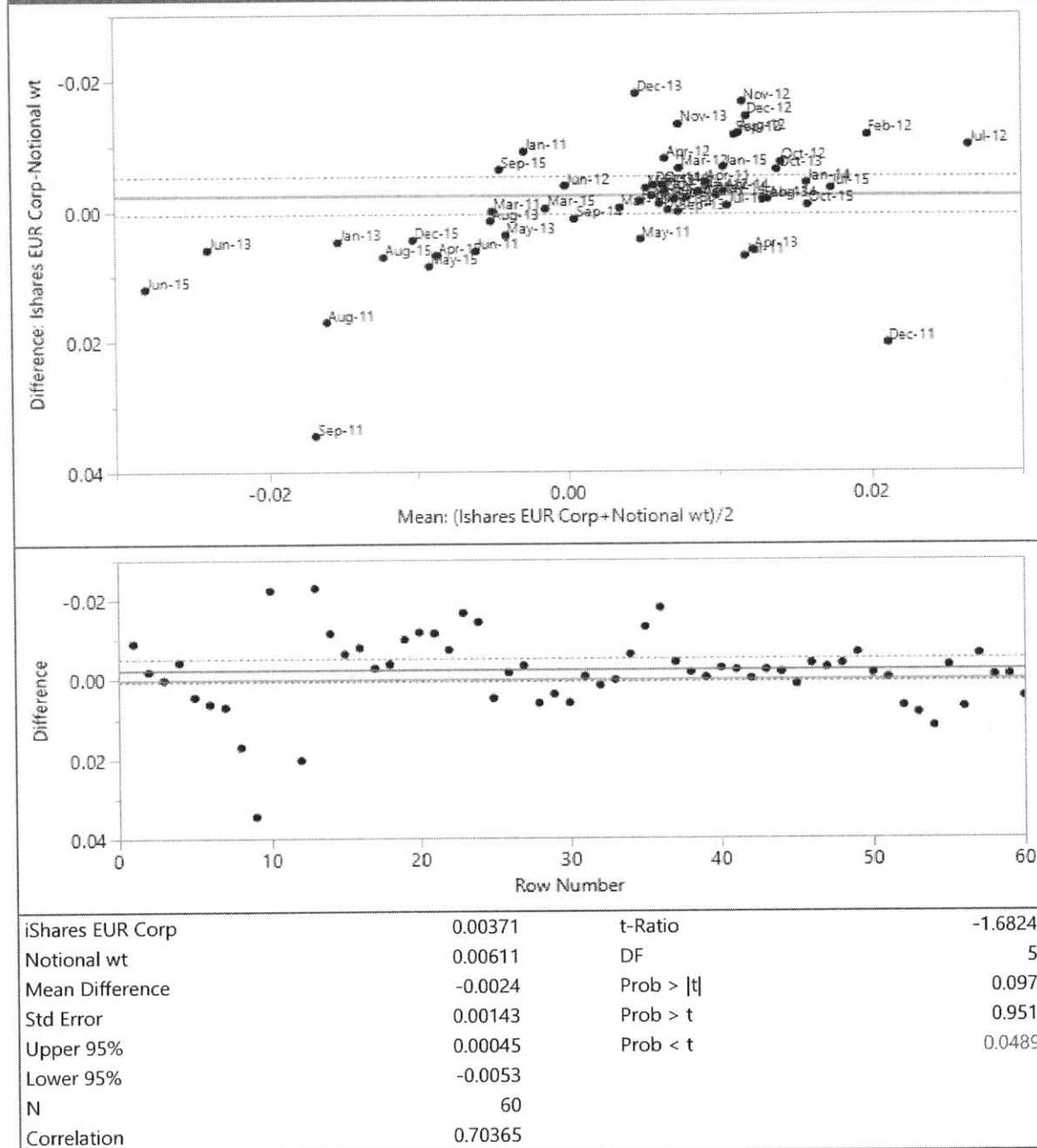
I calculate the monthly returns of the custom bond indices, the iBoxx index, benchmark tracker fund and commercial actively managed bond funds over a five year period. The mean monthly returns of the all three custom indices exceed the mean monthly returns of the benchmark, the benchmark tracker, and the active bond funds.



Source: Bloomberg, Markit iBoxx EUR index

*All custom indices are penalized by 0.2% in portfolio value every month to account for trading costs.

Chart 39: iShares EUR Corp-Notional wt



Although the mean of the historical monthly returns for the custom indices is above the mean of the monthly returns of all the indices considered in this thesis, I also check via statistical tests if these results are statistically significant (Please refer to Appendix J for all the results). I observe

the null hypothesis does not hold true in four different cases as detailed below. I observe that the mean of the monthly returns for all three custom indices is significantly higher than the mean of the monthly returns iShares index and mean of the monthly returns for the Price weighted index outperforming the iBoxx index. All statistical comparisons were done at 95% confidence interval level.

Prior to running this analysis; I also confirmed that the returns for all indices are normal or nearly normal. Please refer to Appendix E for confirmation on the normality of the returns for all indices including the custom indices.

This is a notable result because even after penalizing the monthly returns of the custom indices by 0.2% of portfolio value per month i.e. cumulative 2.4% of portfolio values per annum, the monthly returns of all the custom indices are statistically higher than the returns of the benchmark tracker. Furthermore, I do not observe significantly higher returns for the active bond funds relative to the returns of the custom indices. However, this strategy may be selecting for riskier investments that happened to perform relatively well over this 5-year period.

Table 19: Paired t-test for comparing difference of mean returns of custom indices vs commercial funds

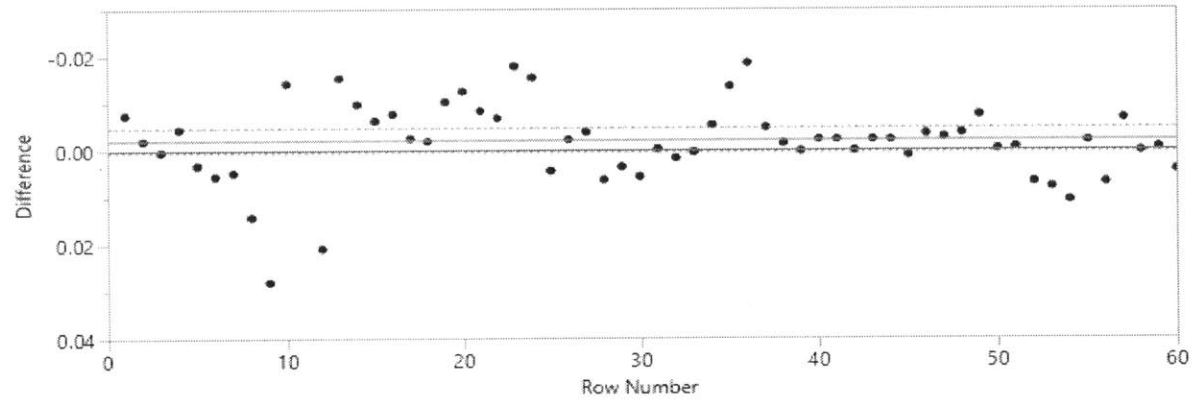
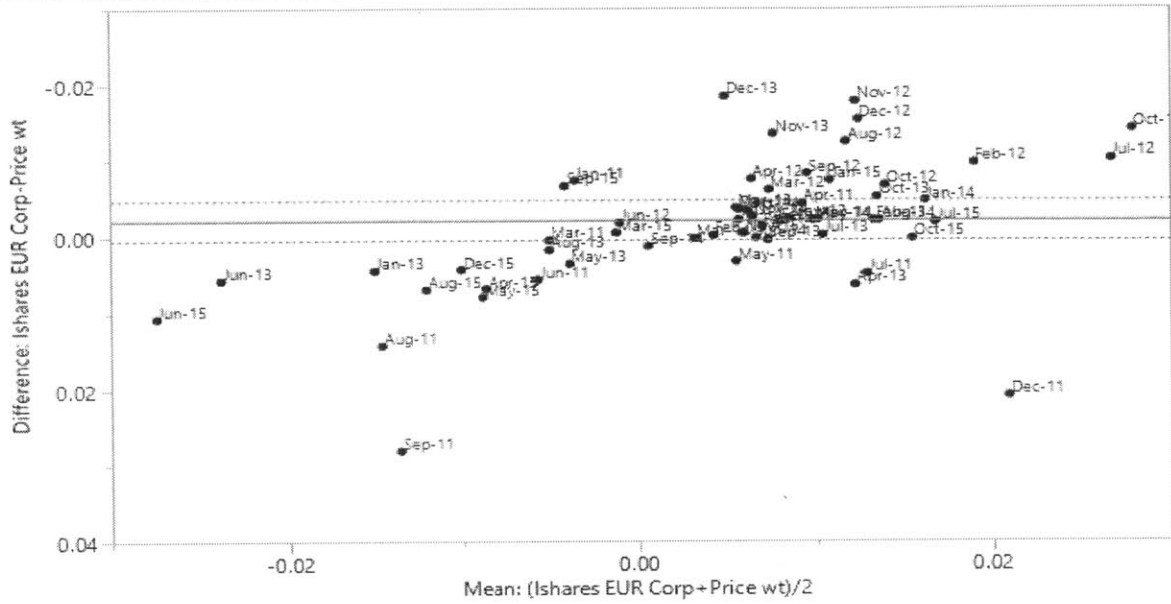
Null =	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Notional wt	FALSE	TRUE	TRUE	TRUE	TRUE
Price wt	FALSE	FALSE	TRUE	TRUE	TRUE
Dur/Price wt	FALSE	TRUE	TRUE	TRUE	TRUE

Null hypothesis: Difference in means is '0'; 95% confidence interval

Please refer to Appendix J for detailed charts on t-test comparisons

** Paired t-test done because of equal sample size implies that t-test will be robust even if sample variances differ*

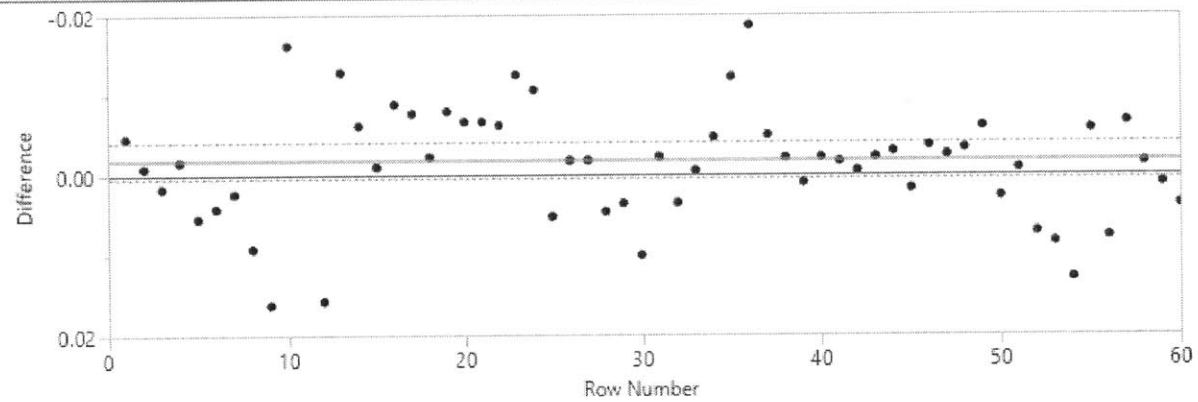
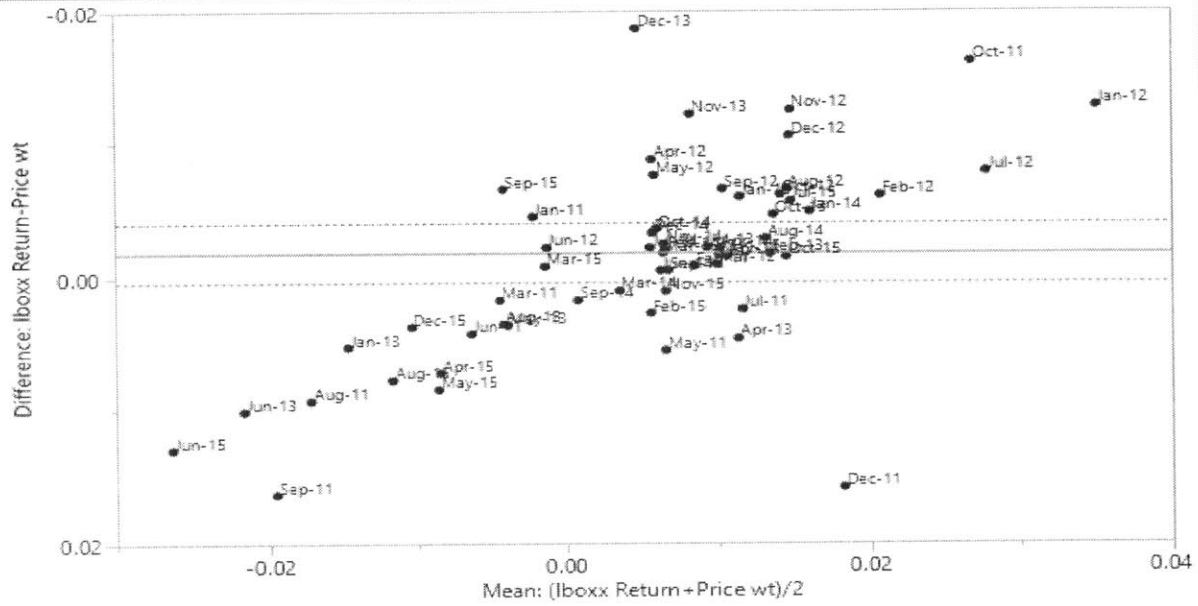
Chart 40: Difference: iShares EUR Corp – Price wt



iShares EUR Corp	0.00371	t-Ratio	-1.70593
Price wt	0.00592	DF	59
Mean Difference	-0.0022	Prob > t	0.0933
Std Error	0.0013	Prob > t	0.9534
Upper 95%	0.00038	Prob < t	0.0466*
Lower 95%	-0.0048		
N	60		
Correlation	0.71692		

* Paired t-test done because of equal sample size implies that t-test will be robust even if sample variances differ

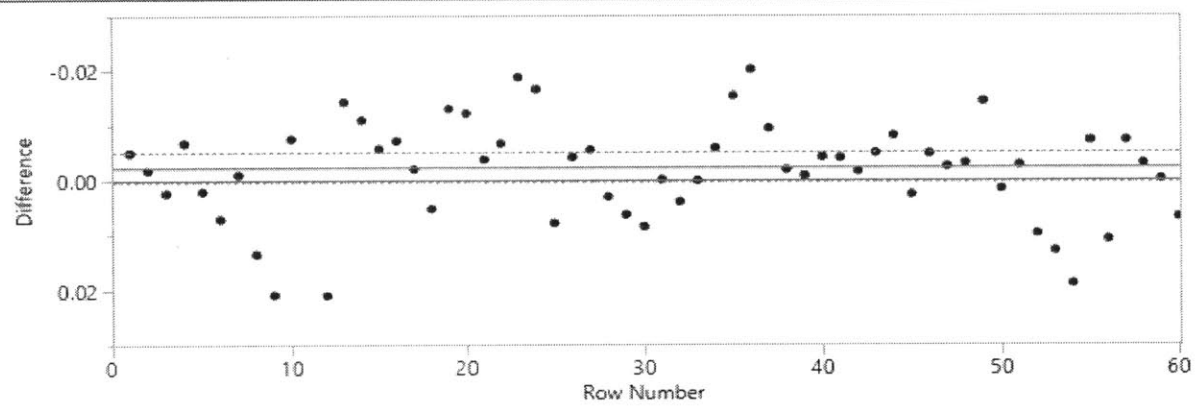
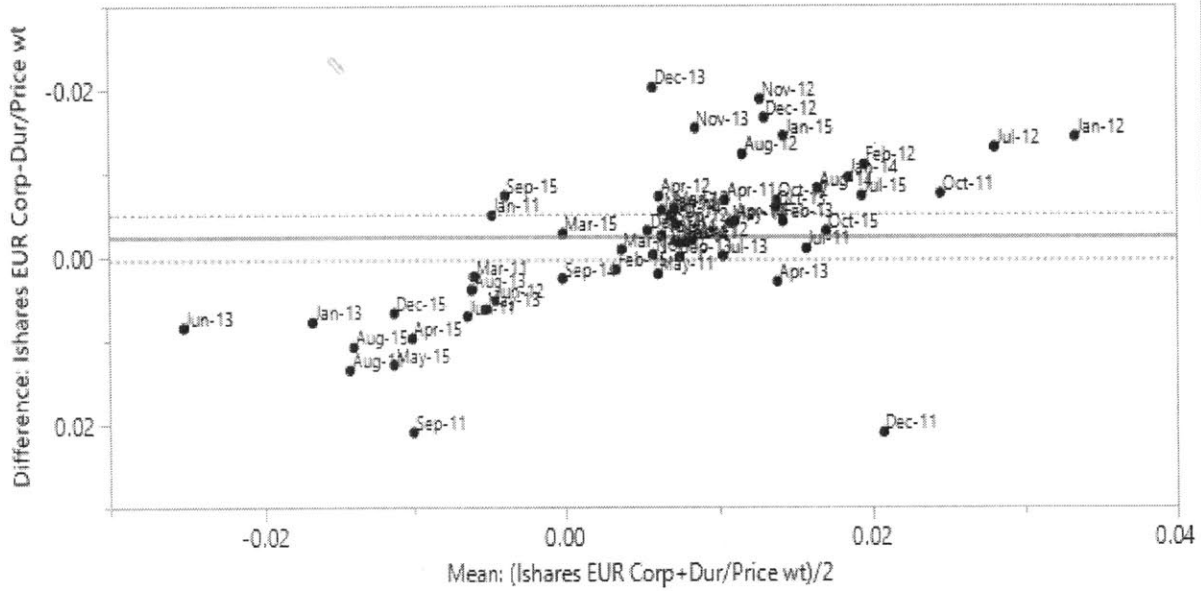
Chart 41: Difference: iBoxx Return-Price wt



iBoxx Return	0.00405	t-Ratio	-1.67203
Price wt	0.00592	DF	59
Mean Difference	-0.0019	Prob > t	0.0998
Std Error	0.00112	Prob > t	0.9501
Upper 95%	0.00037	Prob < t	0.0499*
Lower 95%	-0.0041		
N	60		
Correlation	0.79891		

* Paired t-test done because of equal sample size implies that t-test will be robust even if sample variances differ

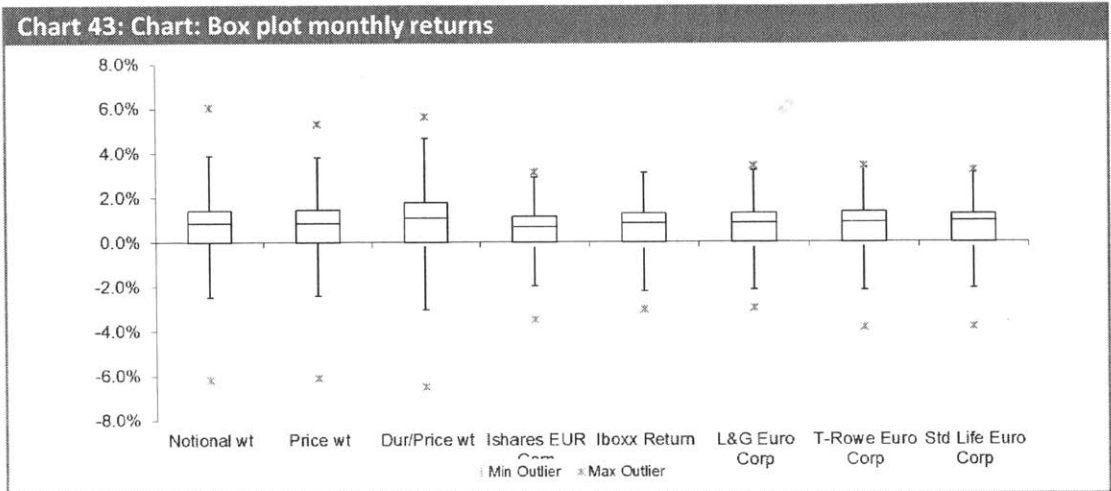
Chart 42: Difference: iShares EUR Corp – Dur/Price wt



iShares EUR Corp	0.00371	t-Ratio	-1.73496
Dur/Price wt	0.00609	DF	59
Mean Difference	-0.0024	Prob > t	0.0880
Std Error	0.00137	Prob > t	0.9560
Upper 95%	0.00036	Prob < t	0.0440*
Lower 95%	-0.0051		
N	60		
Correlation	0.7383		

* Paired t-test done because of equal sample size implies that t-test will be robust even if sample variances differ

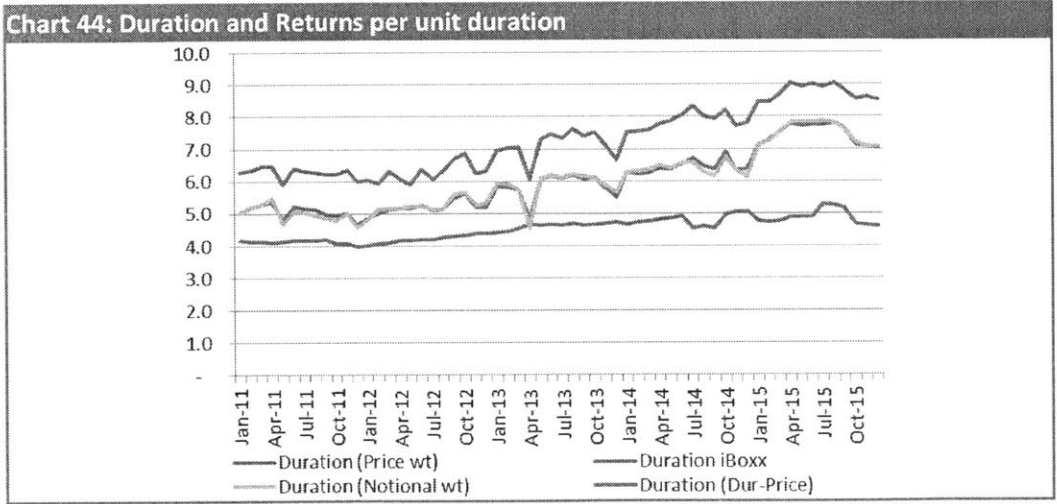
Additionally, on observing the box plots for this index, I again see a wider dispersion of monthly returns with wide outliers for all three custom indices relative to all other indices.

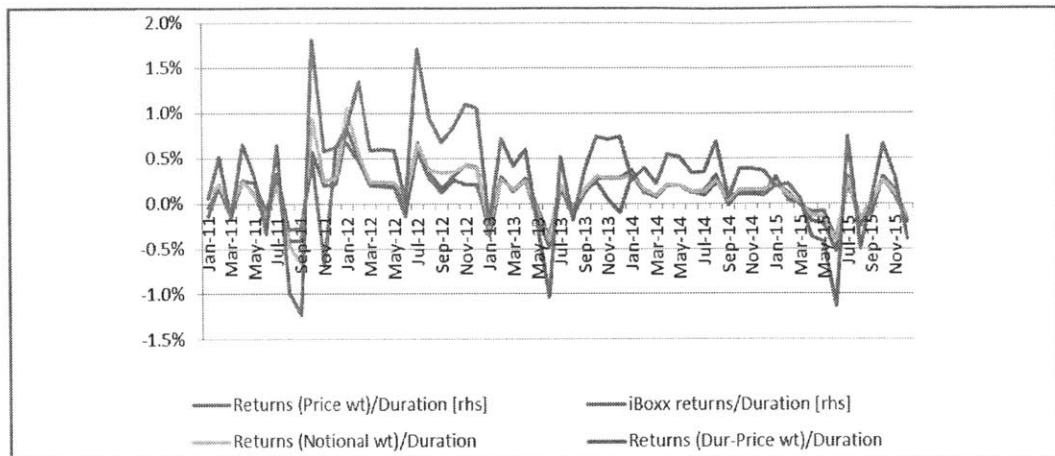


V. Additional observations

- **Exploring portfolio duration and returns**

I also observe the portfolio duration and duration per unit returns against similar measures of the iBoxx. From the chart below, I observe that duration for custom index indices remain above the duration of the iBoxx and trend upwards. Further, I note that return per unit of duration for the duration-price weighted index to be more volatile than all the other indices.



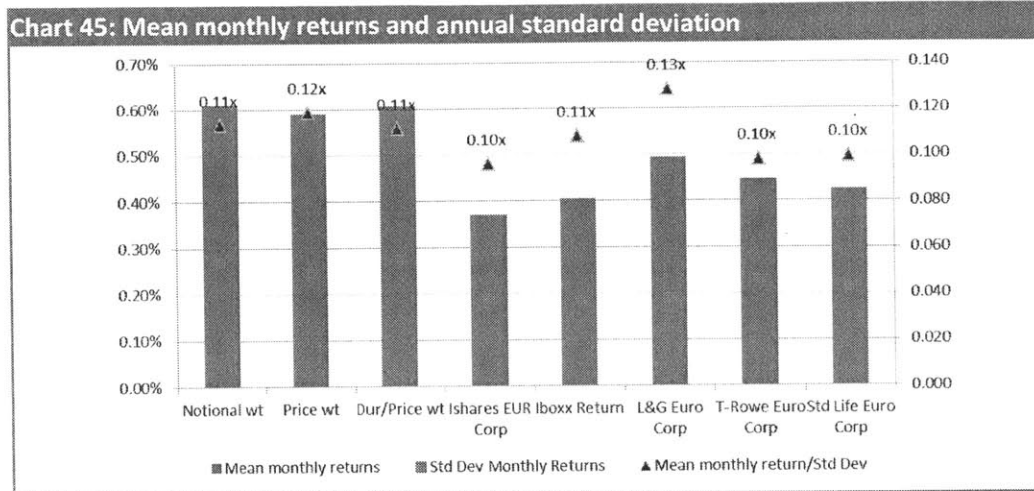


Source: Markit/Bloomberg

* I did not have access to time series of duration values for commercially available indices

- **Volatility as source of returns**

I observe significantly higher volatility across all time periods for the custom indices. EUR iBoxx index and related commercial trackers reflect relatively lower historical volatility of total returns across all time-periods versus the proposed custom index. These volatility figures are also expected as smaller number of bonds will typically have higher volatility than the index and index trackers. Further bonds which are cheap with respect to their credit risk are cheap due to adverse credit sentiment and hence reflect increased sensitivity to economic and sector news and therefore show increased spread volatility. Increased spread volatility is reflected in volatile returns. Over the past five years, return to standard deviation for the custom indices are nearly comparable with the benchmark and the active funds except the Legal & General Fund. The Legal & General fund outperforms all indices including the proposed custom indices on this measure.



Source: Bloomberg, Markit iBoxx EUR index; *All custom indices except for active bond funds are penalized by 0.2% in portfolio value every month to account for trading costs.

Table 20: 5-year mean monthly returns and standard deviation

	Notional wt	Price wt	Dur/Price wt	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
Mean Monthly Return	0.61%	0.59%	0.61%	0.37%	0.40%	0.49%	0.45%	0.42%
Std Dev	0.054	0.050	0.055	0.039	0.037	0.039	0.046	0.043
Mean Monthly Return/Std Dev	0.11x	0.12x	0.11x	0.10x	0.11x	0.13x	0.10x	0.10x

*All custom indices are penalized by 0.2% in portfolio value every month to account for trading costs.

- a. **Correlation among returns:** I further calculated the correlations among the historical returns across all three time periods for all the indices. I observe high correlation between the returns of the custom indices with the benchmark and the active bond funds.

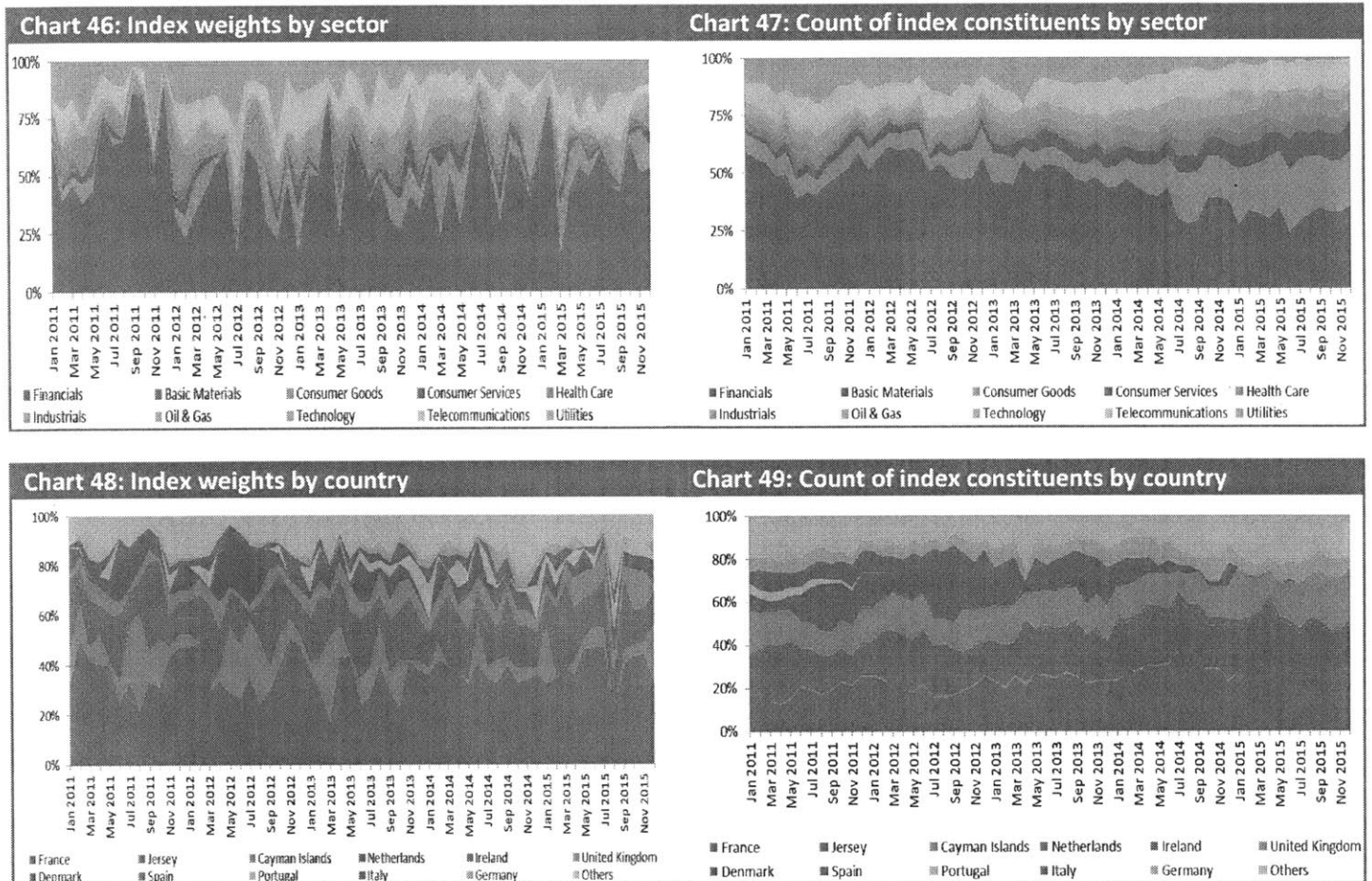
Table 21: 5-year Correlation of returns of custom index constructed from top 200 monthly cheapest bonds relative to credit risk

	Notional wt	Price wt	Dur/Price wt	iShares EUR Corp	iBoxx Return	L&G Euro Corp	T-Rowe Euro Corp	Std Life Euro Corp
5 YEAR								
Notional wt	1.000	0.995	0.962	0.789	0.799	0.806	0.812	0.785
Price wt		1.000	0.982	0.799	0.813	0.811	0.808	0.788
Dur/Price wt			1.000	0.801	0.819	0.806	0.782	0.774
iShares EUR Corp				1.000	0.991	0.988	0.973	0.986
iBoxx Return					1.000	0.980	0.955	0.975
L&G Euro Corp						1.000	0.969	0.978
T-Rowe Euro Corp							1.000	0.987
Std Life Euro Corp								1.000

Source: Markit/Bloomberg

- **Industry/Geographical Analysis:**

This strategy can also lead to excess concentration in particular industry segments because any economic news impacting particular segment more than others can cause over-trading i.e. oversold or over bought securities. This will create trading opportunities for the proposed strategy and can potentially add to concentration risk. Therefore I explore if the source of returns for the proposed custom index is due to potential concentration in particular industries, issuer names or countries or other similar factors.

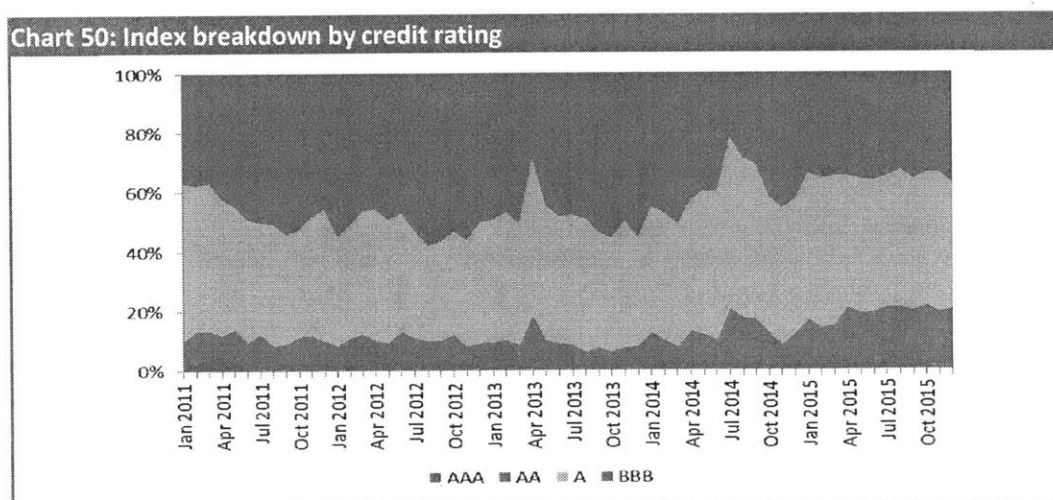


In the above graphs, I observe high concentration levels of the sector 'Financials' in the proposed index which declines towards 2015 and is replaced by issuers from the 'Consumer

Goods' segment. I also observe increasing number of consumer goods issues without their rising contribution to the index implying lower notional amount and duration of consumer goods issuers. High concentration of financials coupled with high exposure to Western Europe including UK, Netherlands and France (not Germany) is expected owing to sustained economic and regulatory pressure on financial institutions in the region. It also implies German financials were reasonably priced from the credit risk perspective. My proposed custom index with high concentration levels of specific industry segments and countries is in contrast to iBoxx index which has upper concentration ceiling levels for individual issuer names, countries, industry segments and other similar factors. Additionally, index trackers also tend to diversify so as to track the index and active bond fund managers also tend to diversify to ensure pragmatic risk taking.

- **Credit Rating analysis:**

I also review the custom portfolio to observe if the source of returns is from concentration in particular credit rating. I observe distribution in AA, A and BBB credits. The distribution remains relatively stable of across these credits.



Source: Markit/Bloomberg

CHAPTER 9

CONCLUSIONS

I. Active bond funds do not statistically outperform

In the above thesis, I propose indices prepared using a variety of strategies. I also impose a cost penalty of 0.2% of portfolio value per month representing trading costs. Despite these factors and with the active funds having support of institutional knowledge and resources, I observe no statistical difference between almost all of my custom indices with the active funds.

II. Returns for active bond funds – highly correlated with the returns of the benchmark index

I observe that the returns of the active bond funds have been highly correlated with the returns of the benchmark and benchmark tracker index over the past five years. This is unexpected given the active mandate for the commercial bond funds.

III. Notional weighted indices (Spread-Duration strategy) outperform the iShares index

I observe Notional weighted indices using the Spread-Duration selection strategy showing statistical outperformance relative to the iShares index. The indices for the Spread-Duration strategy and also remaining other strategies could reflect statistical outperformance relative to iBoxx index if the latter were to account for trading costs.

LIMITATIONS

One of the main limitations of the custom indices is the bond pricing and returns calculations. I use mid-price trade data to calculate potential returns for the proposed custom indices, as compared to the active bond funds which use actual trade data. This may not be practically feasible due to bond liquidity which will be reflected in wider bid-ask spreads. This issue is mitigated by the following factors:

- a. I am dealing with only investment grade euro corporate bonds which are generally liquid and are additionally part of the iBoxx index which adds to the liquidity.
- b. Furthermore, I am comparing returns with iBoxx index which is calculated on Bid prices only and hence ignores the trading costs. Therefore it is conservative to compare returns of the custom indices after accounting for the trading costs with the returns of the iBoxx index.
- c. Additionally, fund managers managing commercial indices/bond funds have access to institutional resources which enable them to trade individual securities at lower costs hence lower the liquidity costs. Applying similar costs to our custom index strategy will significantly lower the trading costs.
- d. As the index rebalances every month some bonds may continue over several months. Hence as an investor in custom index, I do not have to necessarily trade out of those bonds completely or I can use alternative strategies to significantly minimize trading costs.
- e. Lastly and most importantly, I impose a 0.2% of portfolio value representing trading costs every month.

NEXT STEPS

A key improvement to this report could be repeating the above documented investment strategies and index construction methodologies over multiple time periods. The past five years has seen severe economic stress and unprecedented policy responses by the ECB and the European governments. Hence the results may be different under more normal economic circumstances.

Additional improvements can be made to the process by using Bid-Ask prices for every bond and optimizing the rebalancing portfolio every month based on the trading costs. We can then remove the 0.2% trading costs every month when implementing this method. This will help us obtain a better comparison between the performances of the custom indices with the active bond funds.

Further, controlling for industry sector and credit rating concentrations in the proposed index would allow for better comparison with the index and index tracker.

CHAPTER 10

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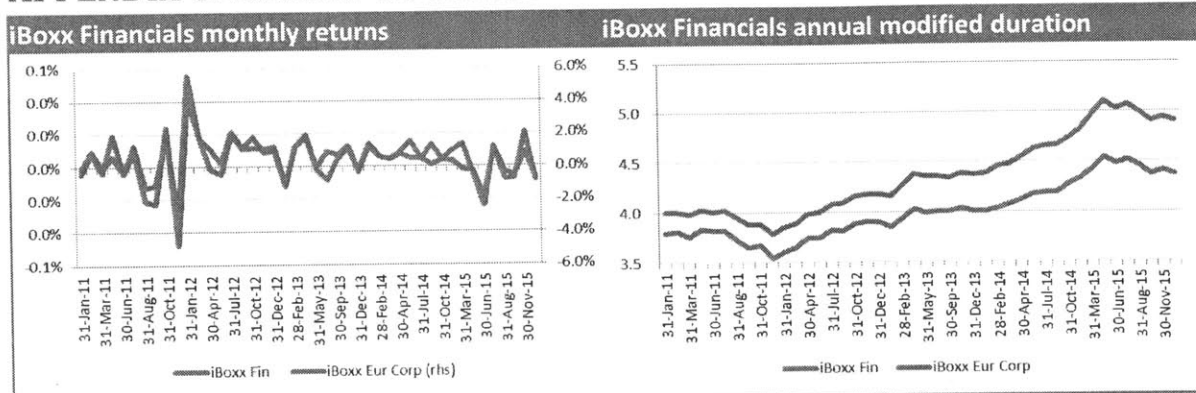
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APPENDIX B: LIST OF CHARTS

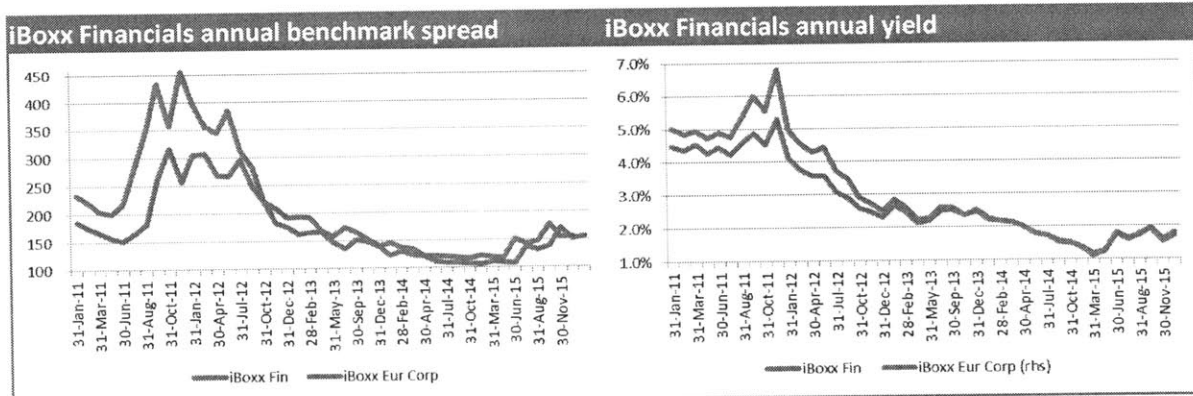
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APPENDIX C: MARKIT € FINANCIALS INDEX DE0006301591]



Source: Markit



Source: Markit

APPENDIX D: REFERENCES

Markit iBoxx Pricing Rules March 2013]

Markit iBoxx Bond Index Calculus May 2015]

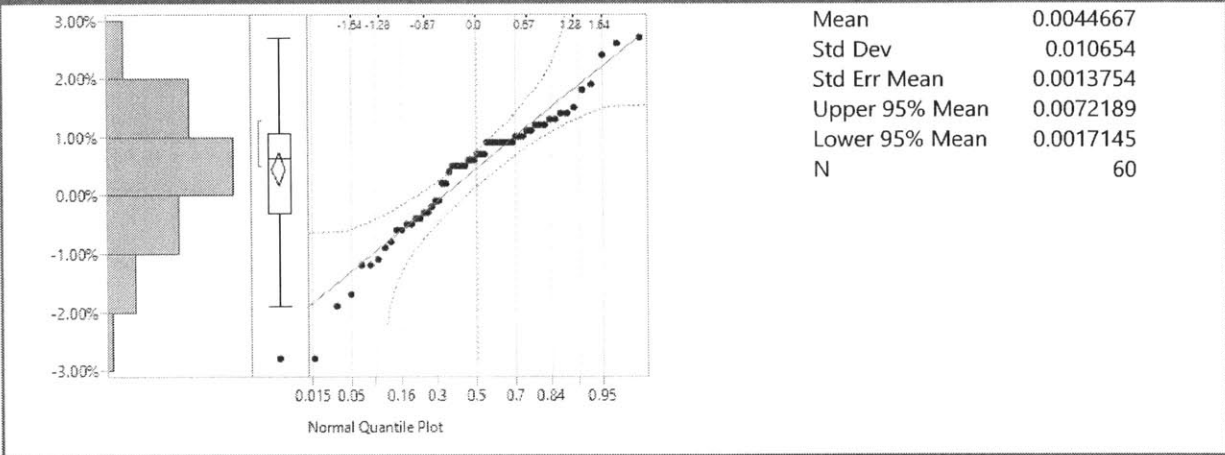
L&G Euro Corporate Bond Fund Fact sheet: used to provide description of the active bond fund

T-Rowe Euro Corporate Bond Fund Fact sheet: used to provide description of the active bond fund

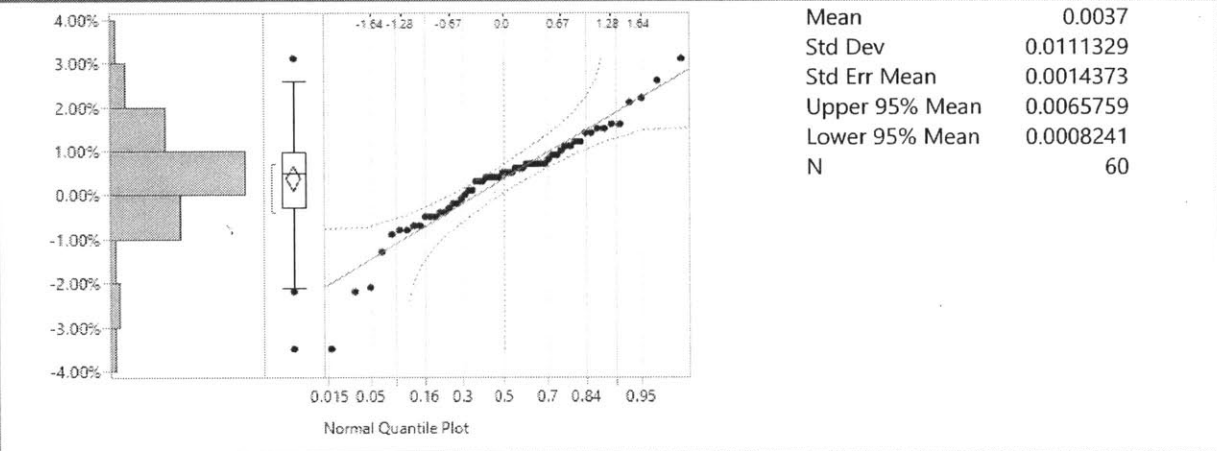
Standard Life Euro Corporate Bond Fund Fact sheet: used to provide description of the active bond fund

APPENDIX E: NORMALITY CHARTS

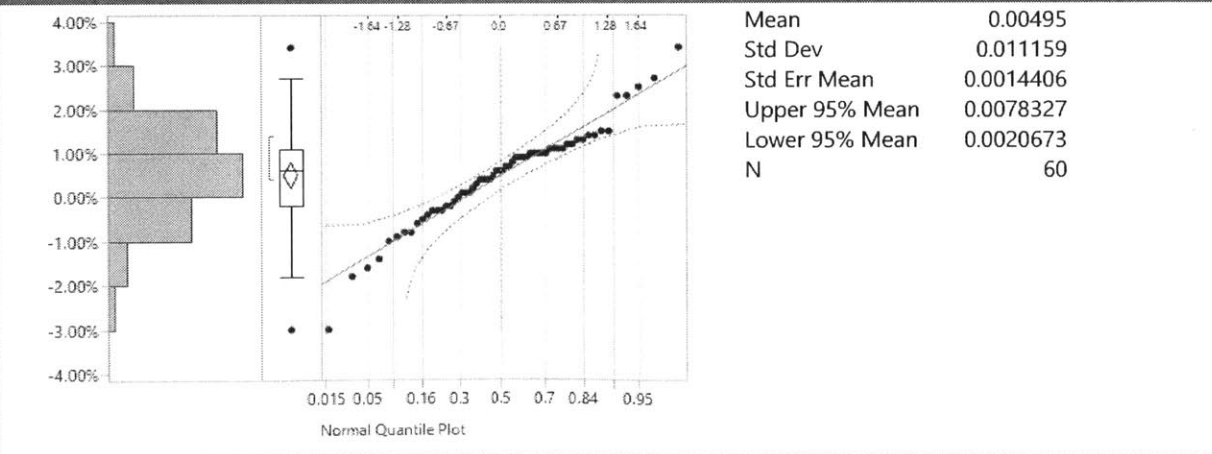
iBoxx Index: Normal Quantile Plot



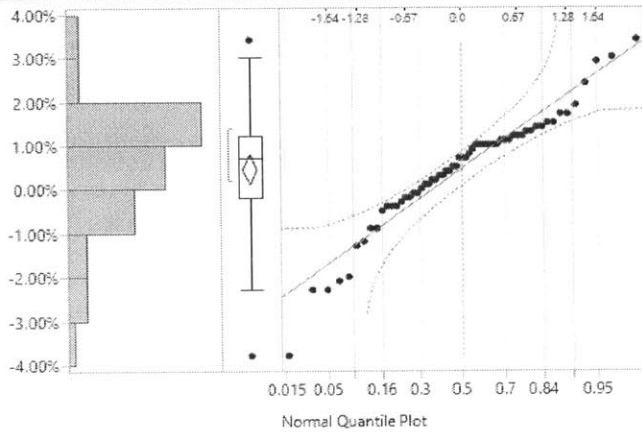
iShares EUR Corp: Normal Quantile Plot



L&G EUR Corp: Normal Quantile Plot

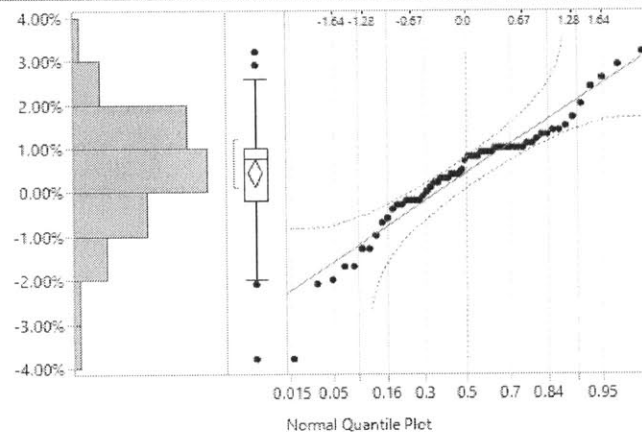


T-Rowe EUR Corp: Normal Quantile Plot



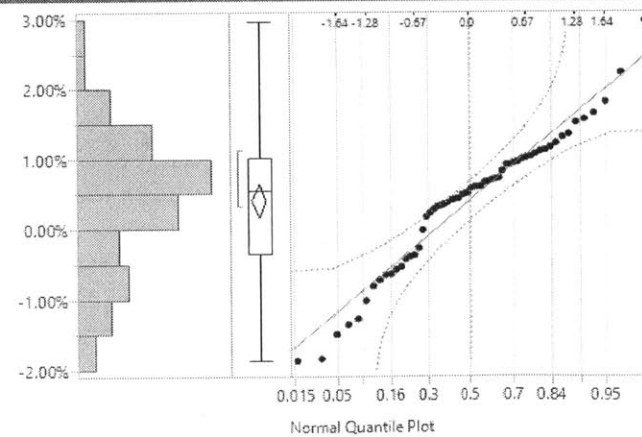
Mean	0.00445
Std Dev	0.0131554
Std Err Mean	0.0016984
Upper 95% Mean	0.0078484
Lower 95% Mean	0.0010516
N	60

Standard Life EUR Corp: Normal Quantile Plot



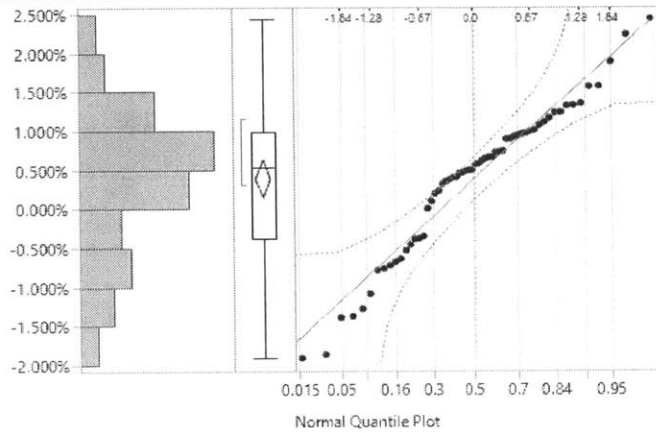
Mean	0.0042667
Std Dev	0.0123712
Std Err Mean	0.0015971
Upper 95% Mean	0.0074625
Lower 95% Mean	0.0010708
N	60

Notional weighted index: Normal Quantile Plot (Random Selection)



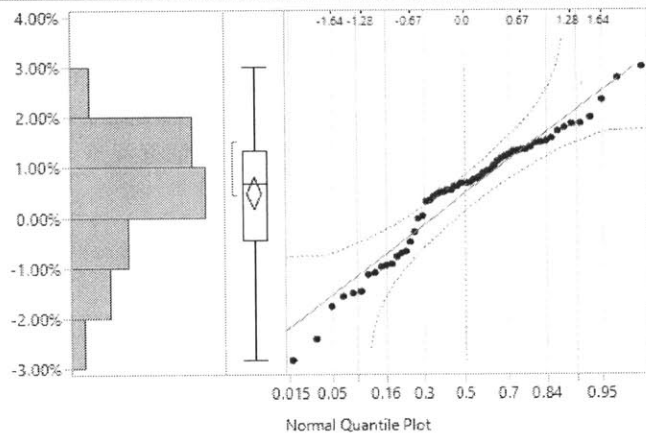
Mean	0.0039702
Std Dev	0.0096219
Std Err Mean	0.0012422
Upper 95% Mean	0.0064558
Lower 95% Mean	0.0014846
N	60

Price weighted index: Normal Quantile Plot (Random Selection)



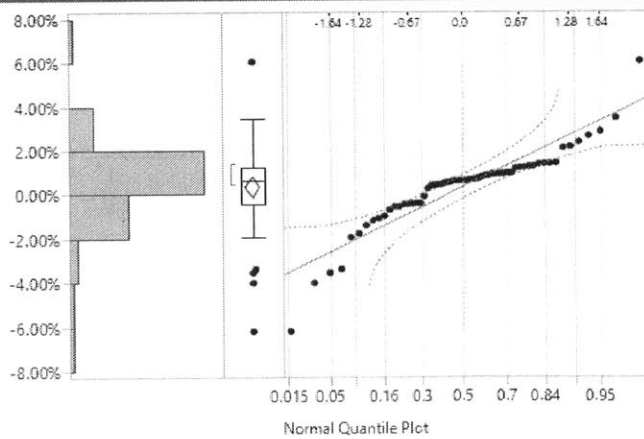
Mean	0.003797
Std Dev	0.009459
Std Err Mean	0.0012211
Upper 95% Mean	0.0062405
Lower 95% Mean	0.0013535
N	60

Dur-Price weighted index: Normal Quantile Plot (Random Selection)



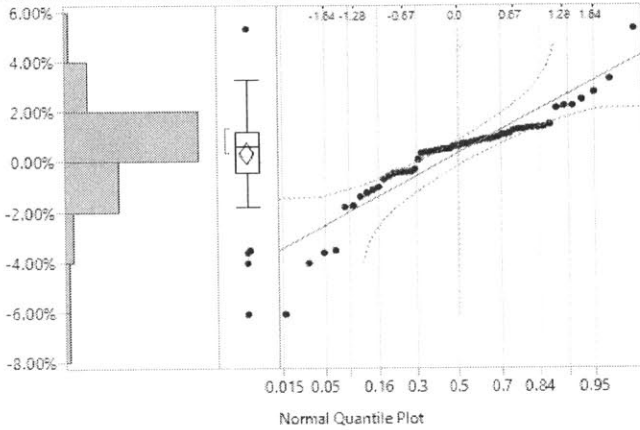
Mean	0.0046977
Std Dev	0.0123377
Std Err Mean	0.0015928
Upper 95% Mean	0.0078849
Lower 95% Mean	0.0015106
N	60

Notional weighted index: Normal Quantile Plot (1 month underperforming)



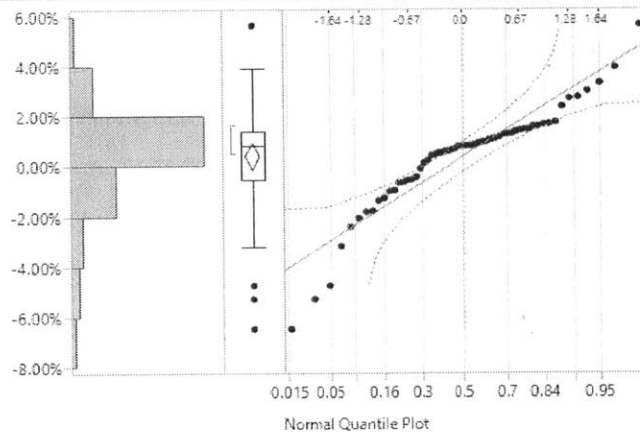
Mean	0.0033726
Std Dev	0.0180566
Std Err Mean	0.0023311
Upper 95% Mean	0.0080371
Lower 95% Mean	-0.001292
N	60

Price weighted index: Normal Quantile Plot (1 Month underperforming)



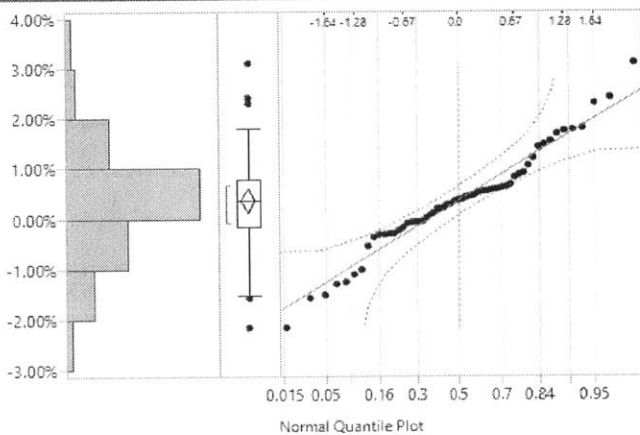
Mean	0.0030677
Std Dev	0.0175675
Std Err Mean	0.002268
Upper 95% Mean	0.0076058
Lower 95% Mean	-0.001471
N	60

Dur-Price weighted index: Normal Quantile Plot (1 Month underperforming)



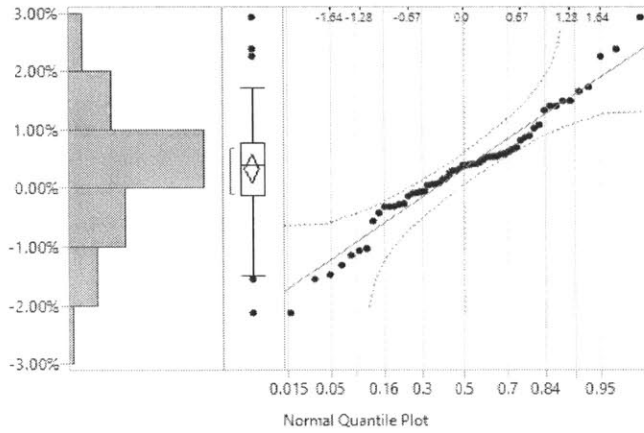
Mean	0.0036369
Std Dev	0.0204228
Std Err Mean	0.0026366
Upper 95% Mean	0.0089127
Lower 95% Mean	-0.001639
N	60

Notional weighted index: Normal Quantile Plot (Spread-Duration)



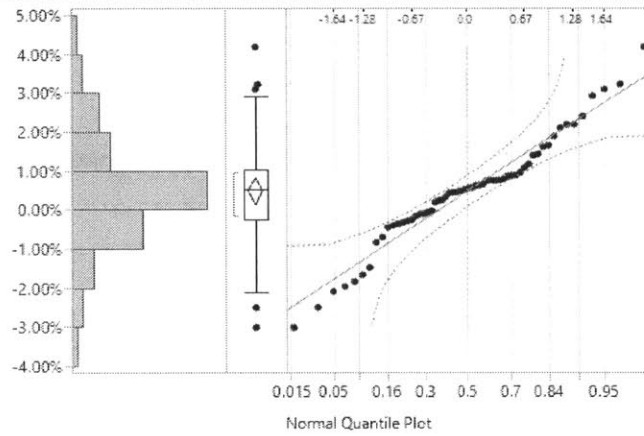
Mean	0.0034687
Std Dev	0.009879
Std Err Mean	0.0012754
Upper 95% Mean	0.0060207
Lower 95% Mean	0.0009167
N	60

Price weighted index: Normal Quantile Plot (Spread-Duration)



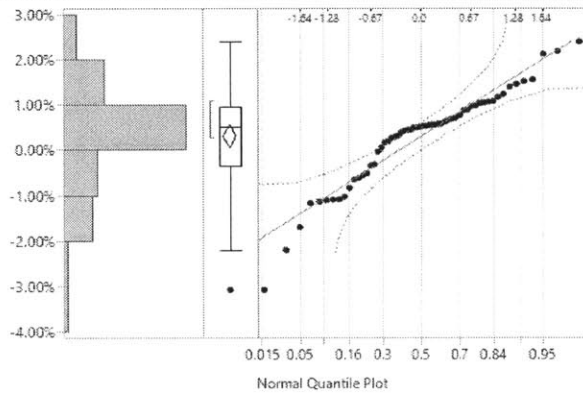
Mean	0.0032851
Std Dev	0.0094843
Std Err Mean	0.0012244
Upper 95% Mean	0.0057352
Lower 95% Mean	0.0008351
N	60

Dur-Price weighted index: Normal Quantile Plot (Spread-Duration)



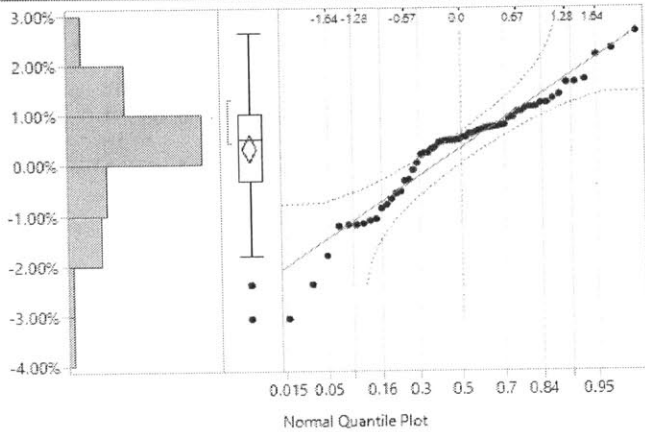
Mean	0.0047109
Std Dev	0.0137046
Std Err Mean	0.0017693
Upper 95% Mean	0.0082511
Lower 95% Mean	0.0011706
N	60

Notional weighted index: Normal Quantile Plot (Liquid Strategy)



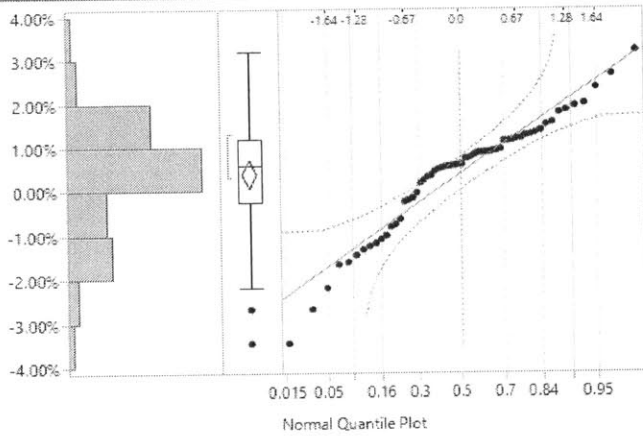
Mean	0.0029371
Std Dev	0.0103279
Std Err Mean	0.0013333
Upper 95% Mean	0.0056051
Lower 95% Mean	0.0002691
N	60

Price weighted index: Normal Quantile Plot (Liquid Strategy)



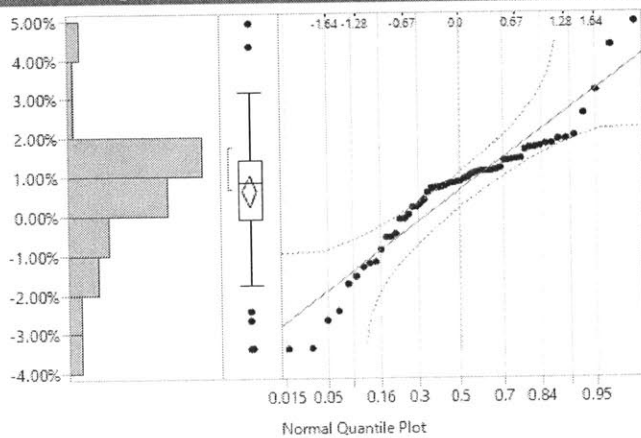
Mean	0.0030935
Std Dev	0.0109351
Std Err Mean	0.0014117
Upper 95% Mean	0.0059183
Lower 95% Mean	0.0002687
N	60

Dur-Price weighted index: Normal Quantile Plot (Liquid Strategy)



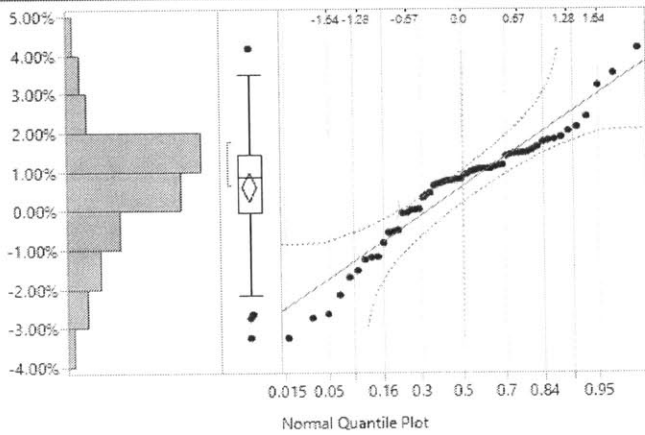
Mean	0.0037917
Std Dev	0.0128536
Std Err Mean	0.0016594
Upper 95% Mean	0.0071122
Lower 95% Mean	0.0004713
N	60

Notional weighted index: Normal Quantile Plot (Spread-PD Strategy)



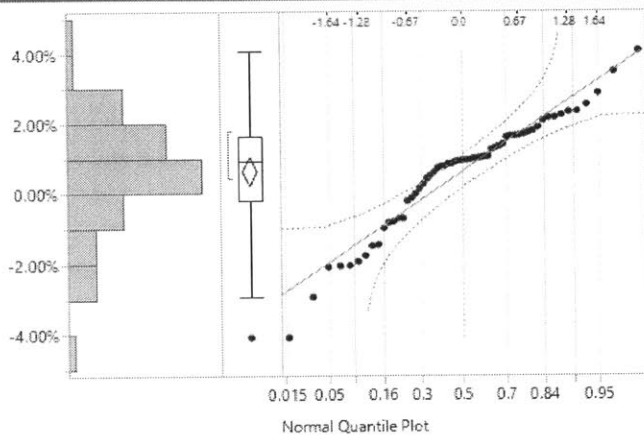
Mean	0.0061064
Std Dev	0.0155483
Std Err Mean	0.0020073
Upper 95% Mean	0.010123
Lower 95% Mean	0.0020899
N	60

Price weighted index: Normal Quantile Plot (Spread-PD Strategy)



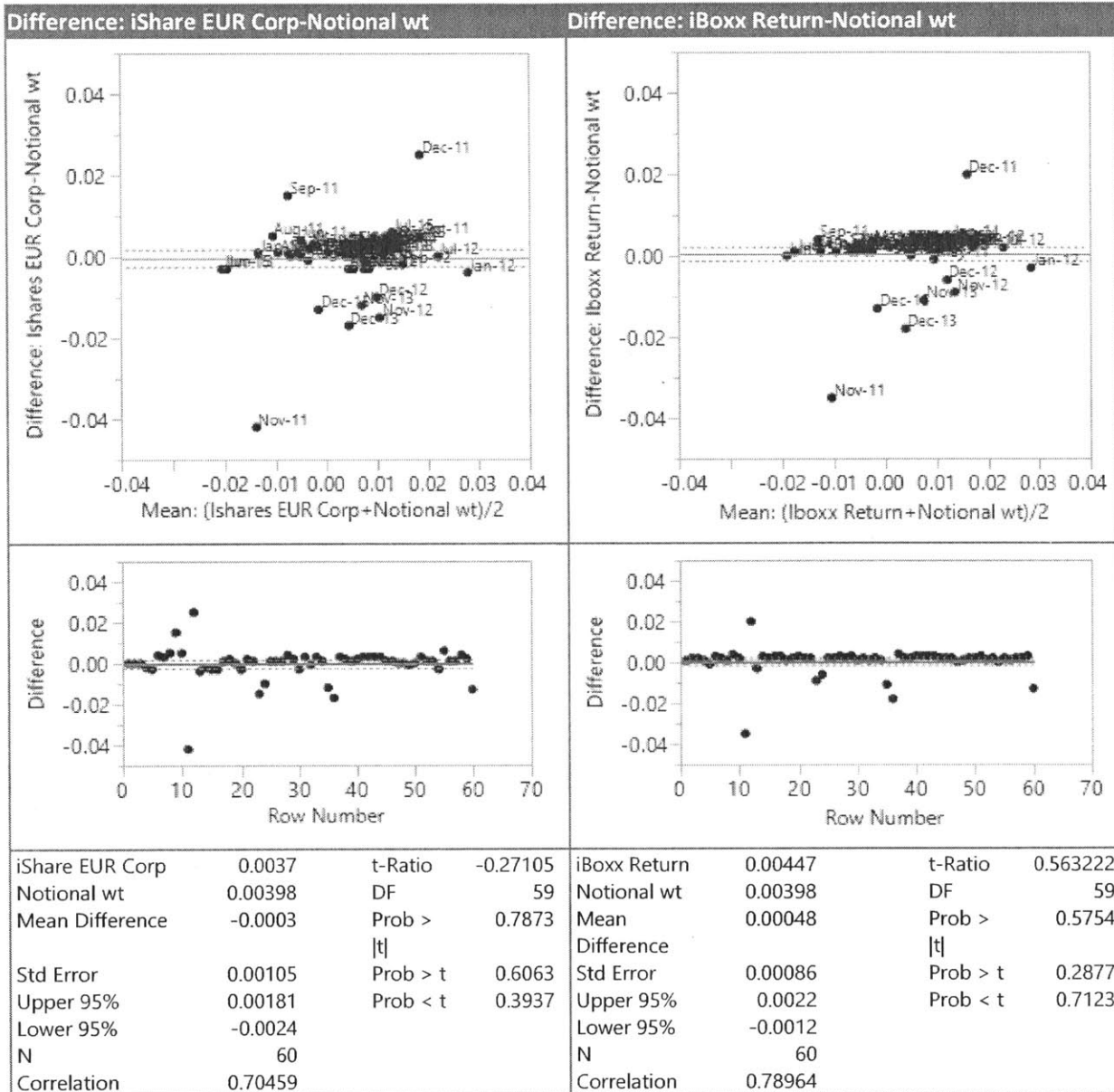
Mean	0.0059241
Std Dev	0.0143963
Std Err Mean	0.0018586
Upper 95% Mean	0.009643
Lower 95% Mean	0.0022051
N	60

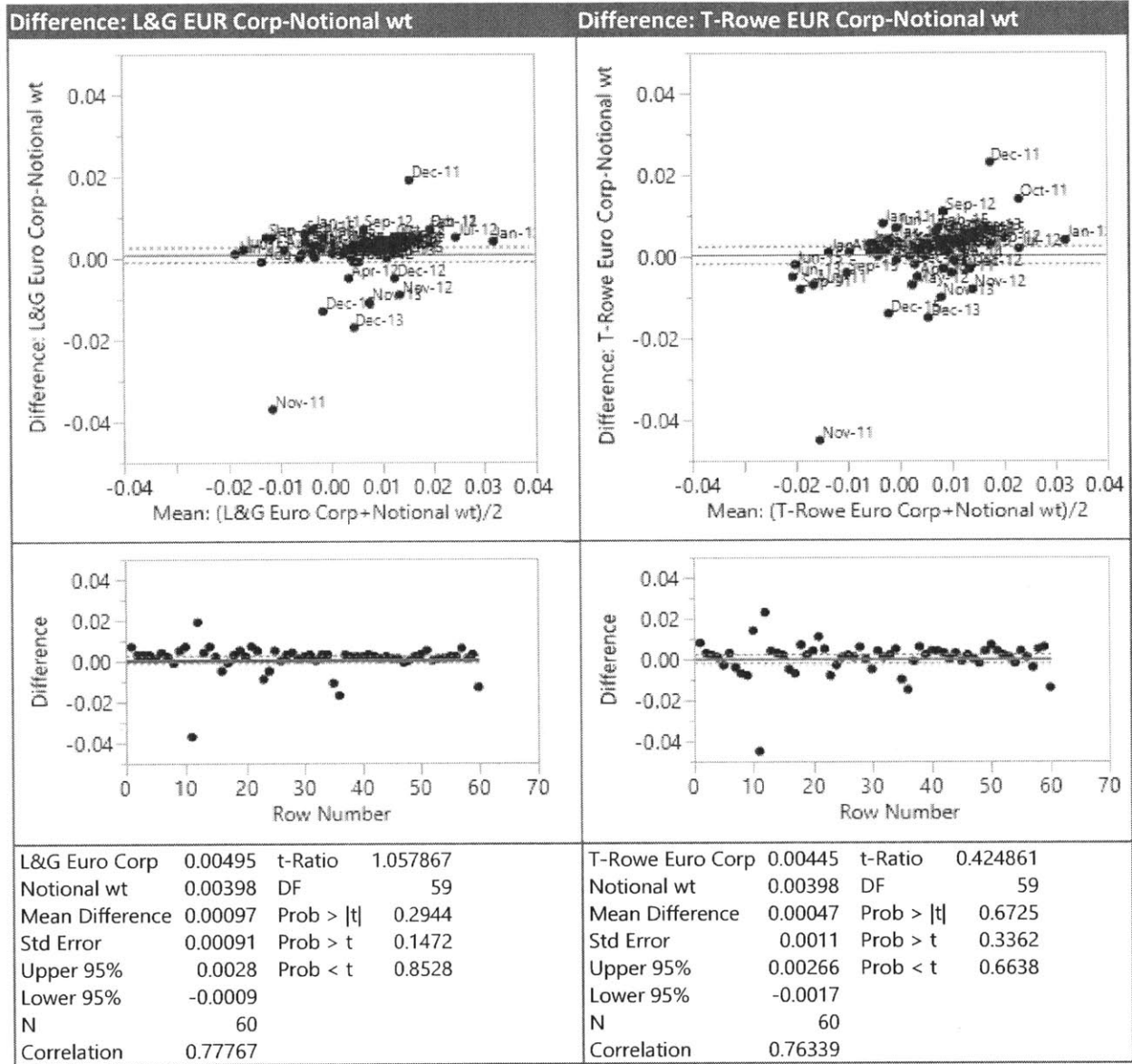
Dur-Price weighted index: Normal Quantile Plot (Spread-PD Strategy)



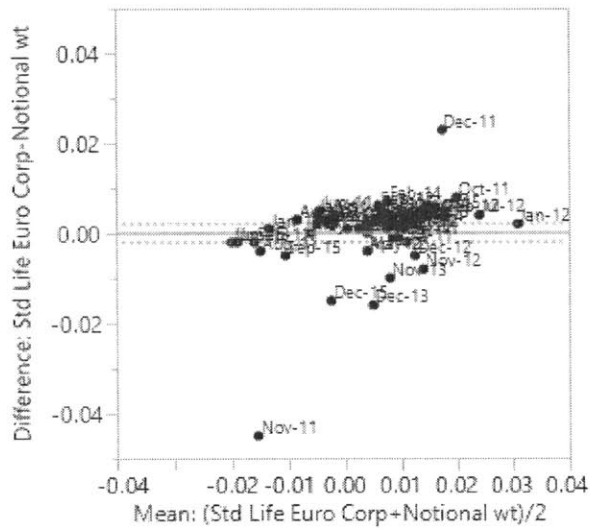
Mean	0.006086
Std Dev	0.015734
Std Err Mean	0.0020312
Upper 95% Mean	0.0101505
Lower 95% Mean	0.0020214
N	60

APPENDIX F: RANDOM SELECTION STRATEGY: PAIRED T-TESTS

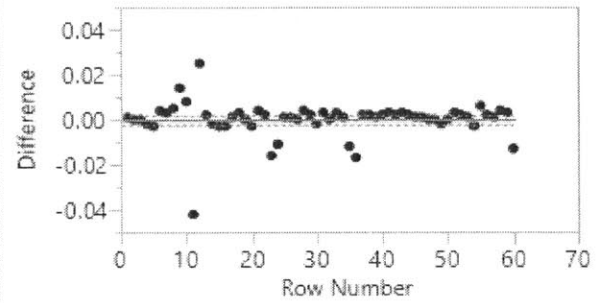
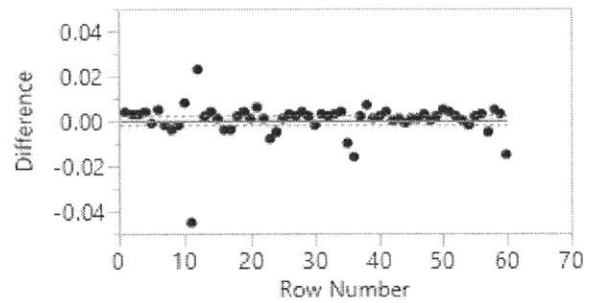
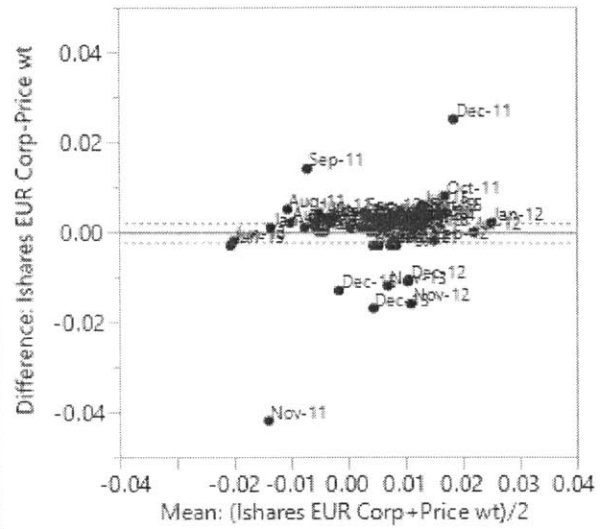




Difference: Std Life EUR Corp-Notional wt



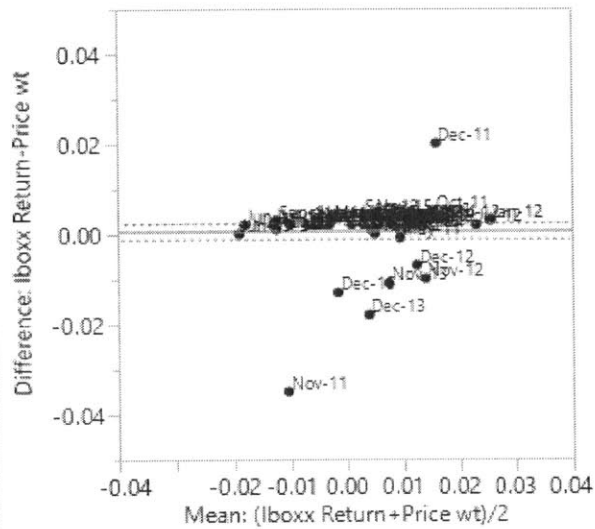
Difference: iShares EUR Corp – Price wt



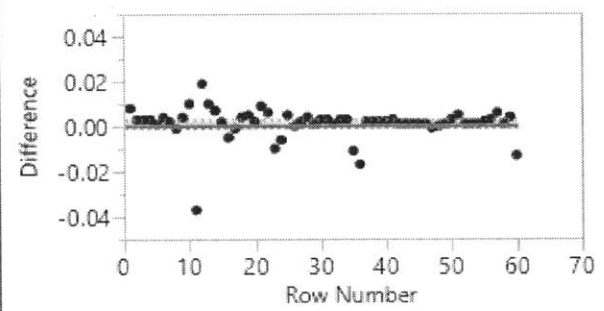
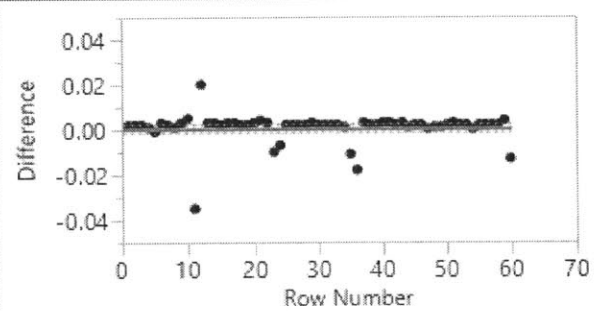
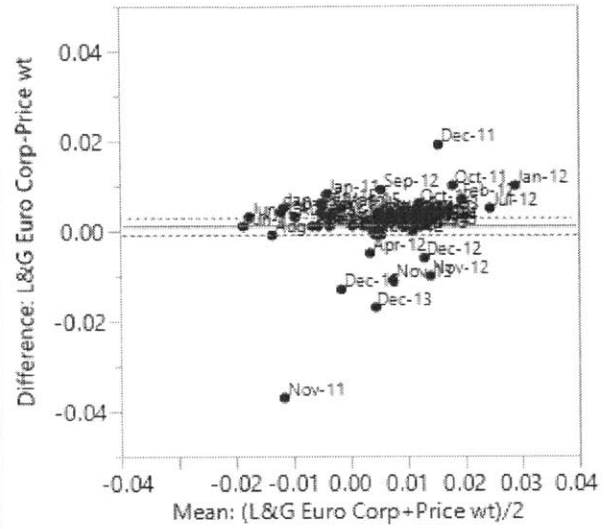
Std Life Euro Corp	0.00427	t-Ratio	0.274112
Notional wt	0.00398	DF	59
Mean Difference	0.00028	Prob > t	0.7850
Std Error	0.00103	Prob > t	0.3925
Upper 95%	0.00235	Prob < t	0.6075
Lower 95%	-0.0018		
N	60		
Correlation	0.76247		

iShare EUR Corp	0.0037	t-Ratio	-0.09484
Price wt	0.0038	DF	59
Mean Difference	-0.0001	Prob > t	0.9248
Std Error	0.00105	Prob > t	0.5376
Upper 95%	0.00201	Prob < t	0.4624
Lower 95%	-0.0022		
N	60		
Correlation	0.69714		

Difference: iBoxx Return-Price wt



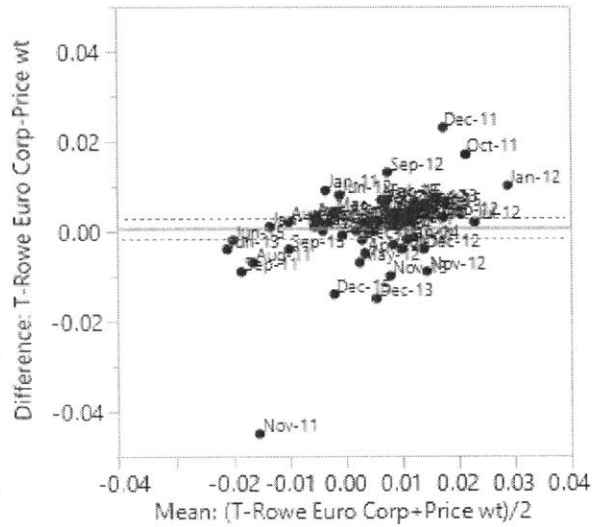
Difference: L&G EUR Corp - Price wt



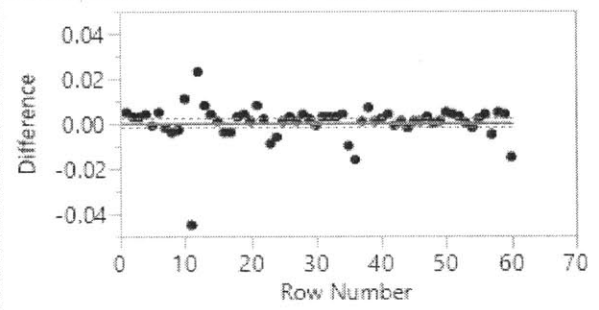
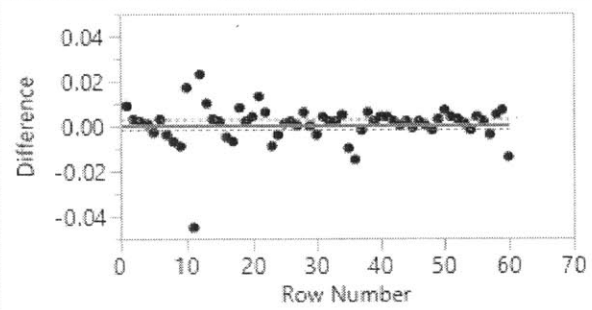
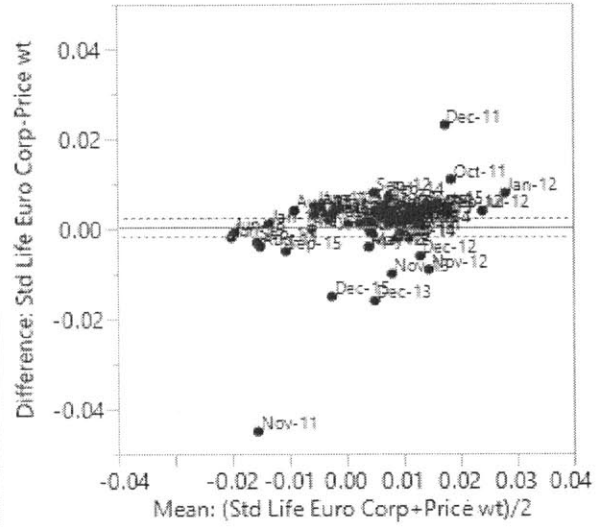
iBoxx Return	0.00447	t-Ratio	0.769173
Price wt	0.0038	DF	59
Mean Difference	0.00067	Prob > t	0.4449
Std Error	0.00087	Prob > t	0.2224
Upper 95%	0.0024	Prob < t	0.7776
Lower 95%	-0.0011		
N	60		
Correlation	0.78382		

L&G Euro Corp	0.00495	t-Ratio	1.218408
Price wt	0.0038	DF	59
Mean Difference	0.00115	Prob > t	0.2279
Std Error	0.00094	Prob > t	0.1140
Upper 95%	0.00304	Prob < t	0.8860
Lower 95%	-0.0007		
N	60		
Correlation	0.7608		

Difference: T-Rowe EUR Return-Price wt



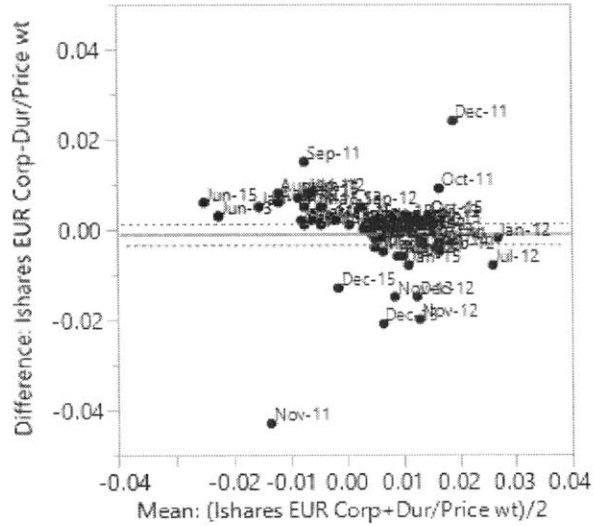
Difference: Std Life EUR Corp – Price wt



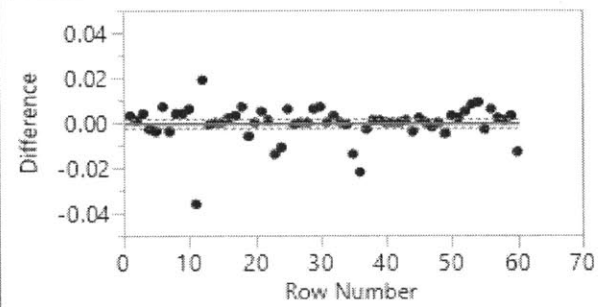
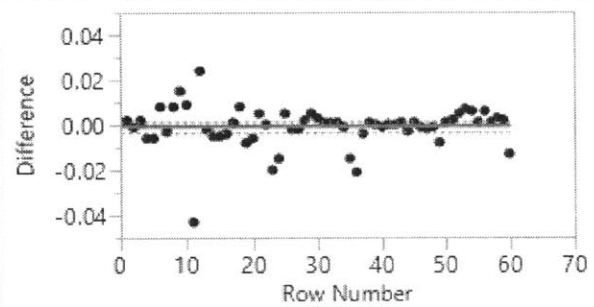
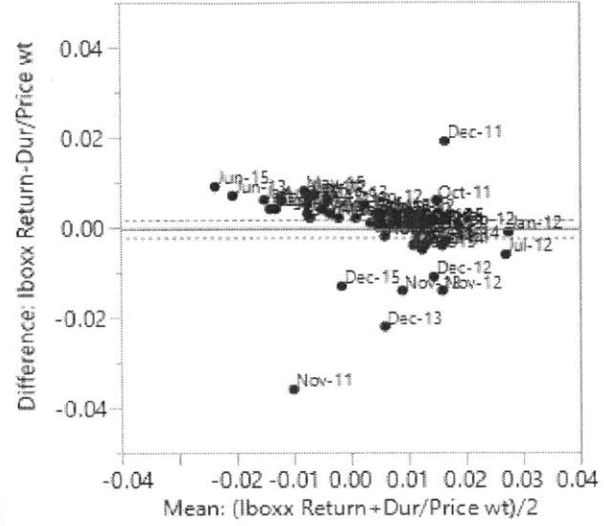
T-Rowe Euro Corp	0.00445	t-Ratio	0.572227
Price wt	0.0038	DF	59
Mean Difference	0.00065	Prob > t	0.5693
Std Error	0.00114	Prob > t	0.2847
Upper 95%	0.00292	Prob < t	0.7153
Lower 95%	-0.0016		
N	60		
Correlation	0.74375		

Std Life Euro Corp	0.00427	t-Ratio	0.439843
Price wt	0.0038	DF	59
Mean Difference	0.00047	Prob > t	0.6617
Std Error	0.00106	Prob > t	0.3308
Upper 95%	0.00259	Prob < t	0.6692
Lower 95%	-0.0017		
N	60		
Correlation	0.74771		

Difference: iShares EUR Corp – Dur/Price wt



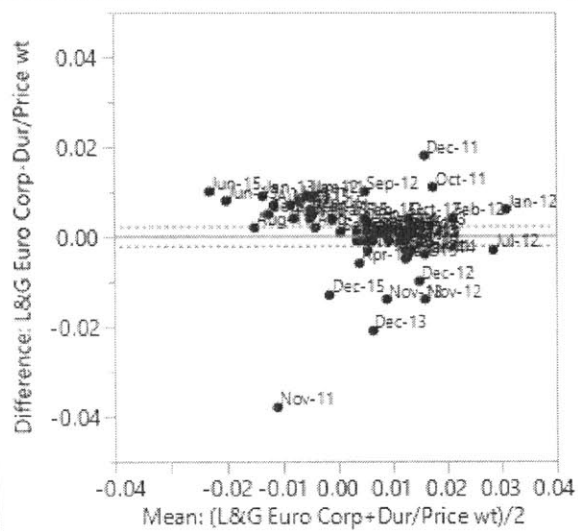
Difference: iBoxx return–Dur/ Price wt



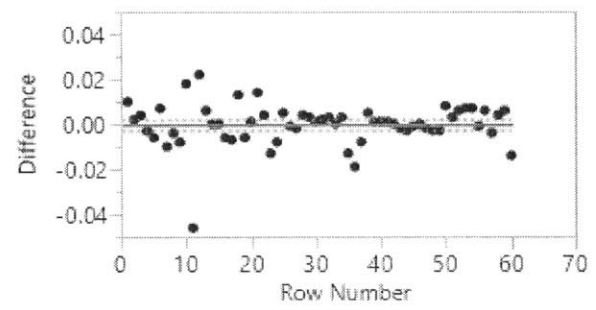
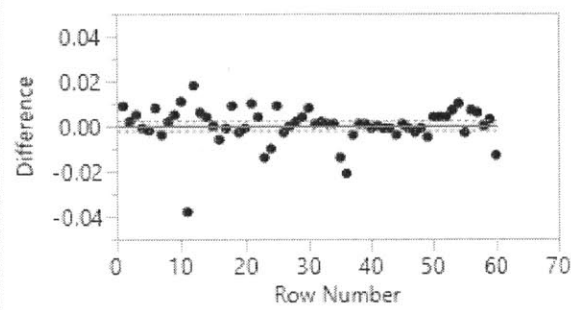
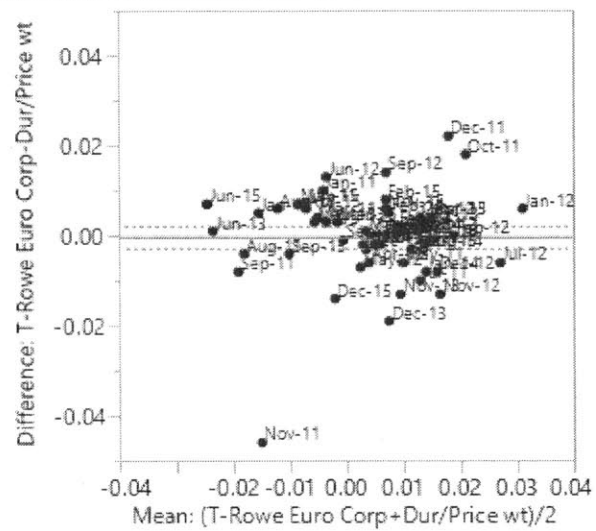
iShare EUR Corp	0.0037	t-Ratio	-0.86002
Dur/Price wt	0.00472	DF	59
Mean Difference	-0.001	Prob > t	0.3933
Std Error	0.00118	Prob > t	0.8034
Upper 95%	0.00135	Prob < t	0.1966
Lower 95%	-0.0034		
N	60		
Correlation	0.70055		

iBoxx Return	0.00447	t-Ratio	-0.24918
Dur/Price wt	0.00472	DF	59
Mean Difference	-0.0002	Prob > t	0.8041
Std Error	0.001	Prob > t	0.5980
Upper 95%	0.00176	Prob < t	0.4020
Lower 95%	-0.0023		
N	60		
Correlation	0.7815		

Difference: L&G EUR Corp – Dur/Price wt



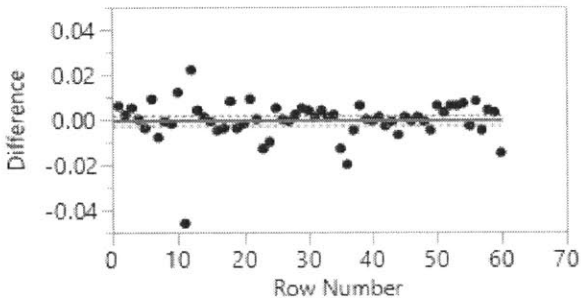
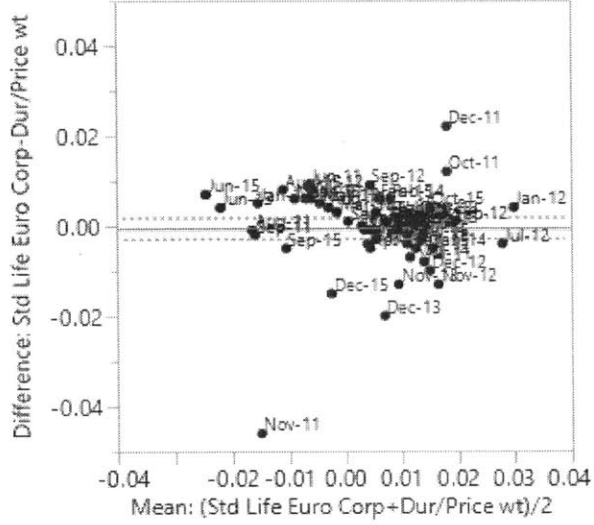
Difference: T-Rowe EUR Corp–Dur/ Price wt



L&G Euro Corp	0.00495	t-Ratio	0.217806
Dur/Price wt	0.00472	DF	59
Mean Difference	0.00023	Prob > t	0.8283
Std Error	0.00107	Prob > t	0.4142
Upper 95%	0.00238	Prob < t	0.5858
Lower 95%	-0.0019		
N	60		
Correlation	0.75538		

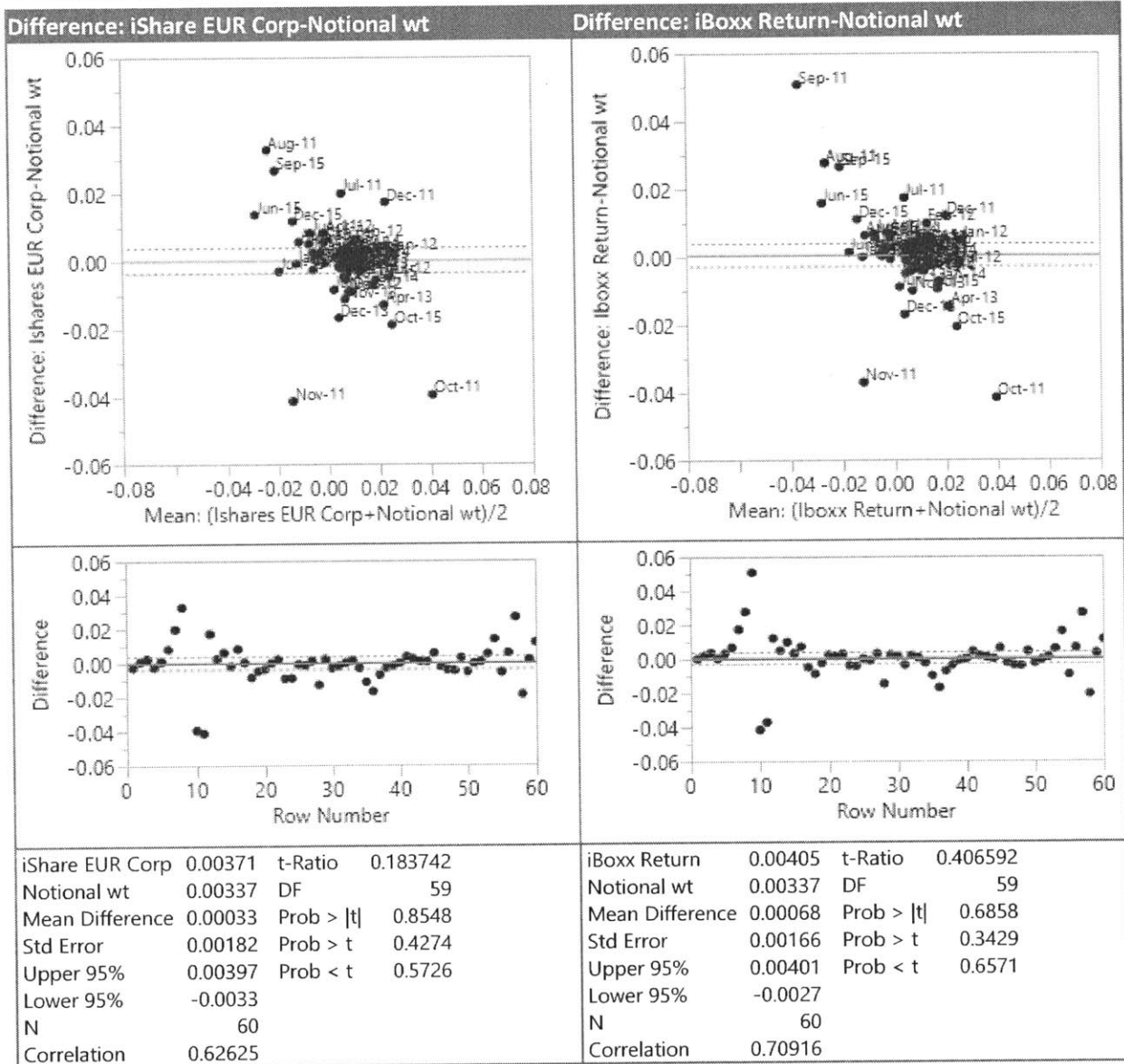
T-Rowe Euro Corp	0.00445	t-Ratio	-0.21733
Dur/Price wt	0.00472	DF	59
Mean Difference	-0.0003	Prob > t	0.8287
Std Error	0.00123	Prob > t	0.5856
Upper 95%	0.00219	Prob < t	0.4144
Lower 95%	-0.0027		
N	60		
Correlation	0.72403		

Difference: Std Life EUR Corp – Dur/Price wt

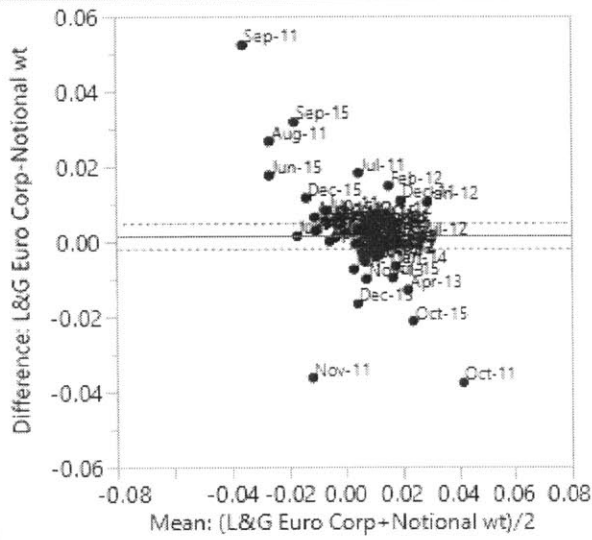


Std Life Euro Corp	0.00427	t-Ratio	-0.38714
Dur/Price wt	0.00472	DF	59
Mean Difference	-0.0005	Prob > t	0.7000
Std Error	0.00116	Prob > t	0.6500
Upper 95%	0.00188	Prob < t	0.3500
Lower 95%	-0.0028		
N	60		
Correlation	0.73476		

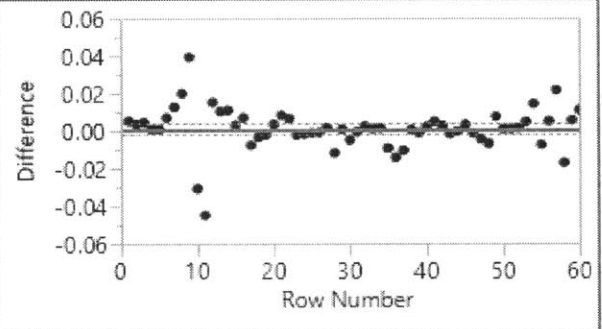
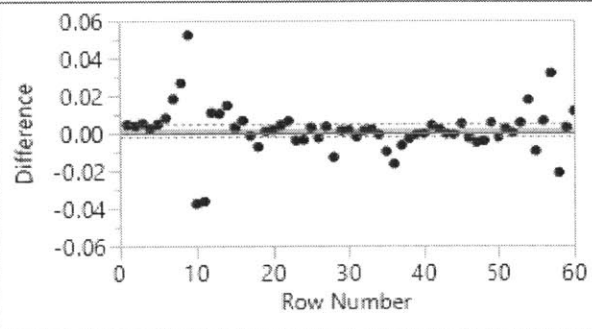
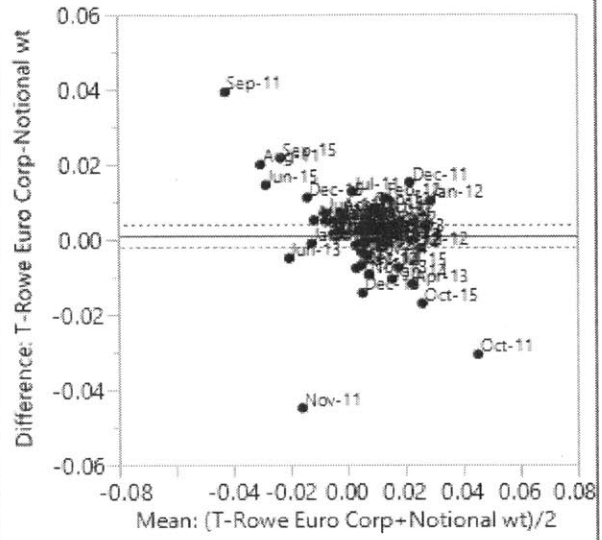
APPENDIX G: ONE MONTH UNDERPERFORMING SELECTION STRATEGY: PAIRED T-TESTS



Difference: L&G EUR Corp-Notional wt

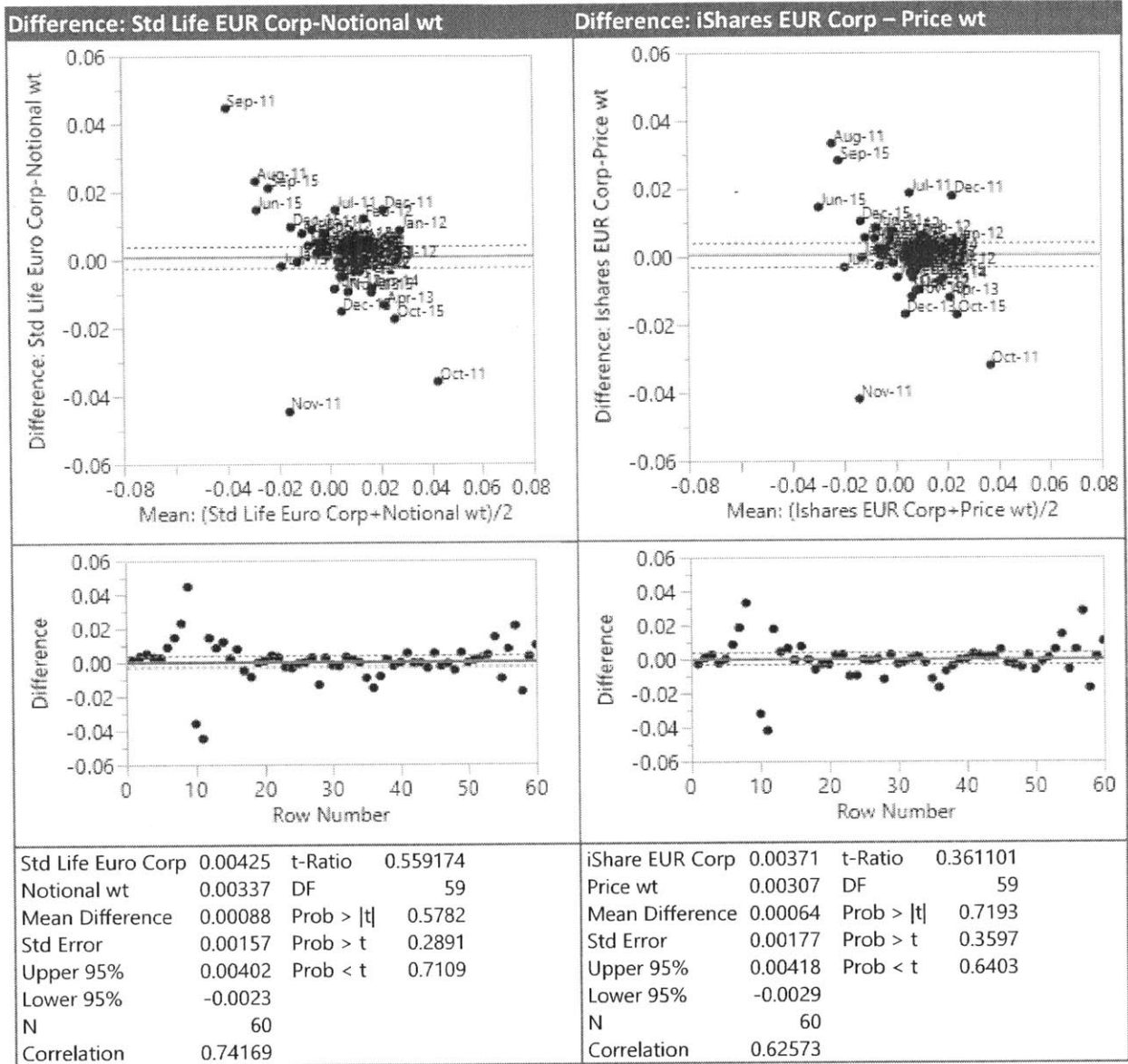


Difference: T-Rowe EUR Corp-Notional wt

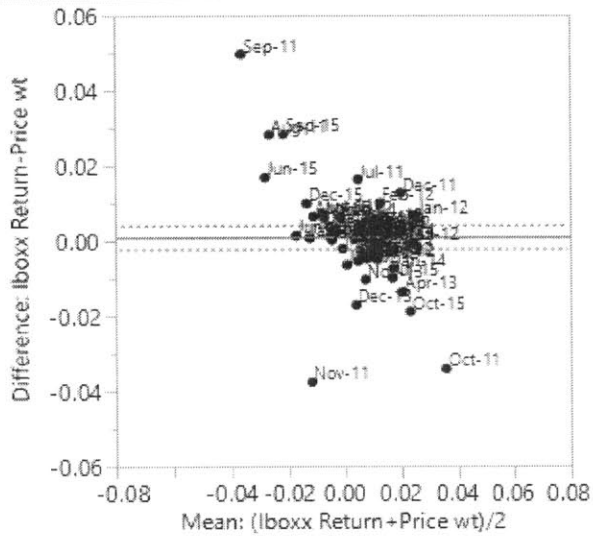


L&G Euro Corp	0.00495	t-Ratio	0.935543
Notional wt	0.00337	DF	59
Mean Difference	0.00157	Prob > t	0.3533
Std Error	0.00168	Prob > t	0.1767
Upper 95%	0.00494	Prob < t	0.8233
Lower 95%	-0.0018		
N	60		
Correlation	0.69735		

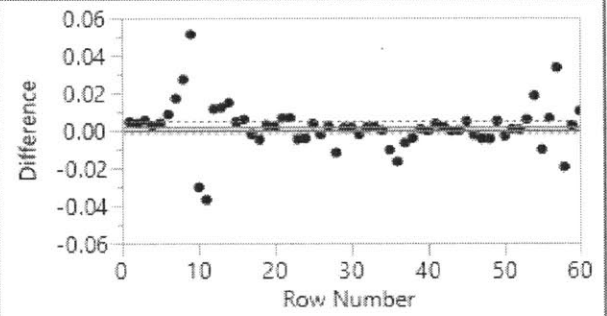
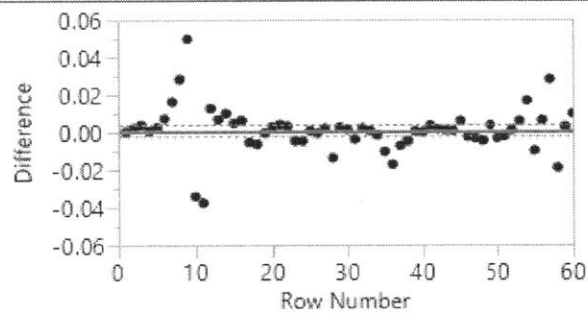
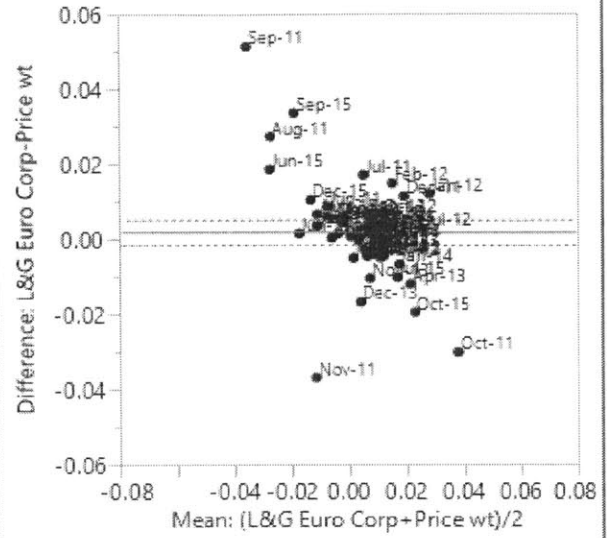
T-Rowe Euro Corp	0.00446	t-Ratio	0.735405
Notional wt	0.00337	DF	59
Mean Difference	0.00109	Prob > t	0.4650
Std Error	0.00148	Prob > t	0.2325
Upper 95%	0.00406	Prob < t	0.7675
Lower 95%	-0.0019		
N	60		
Correlation	0.7726		



Difference: iBoxx Return-Price wt

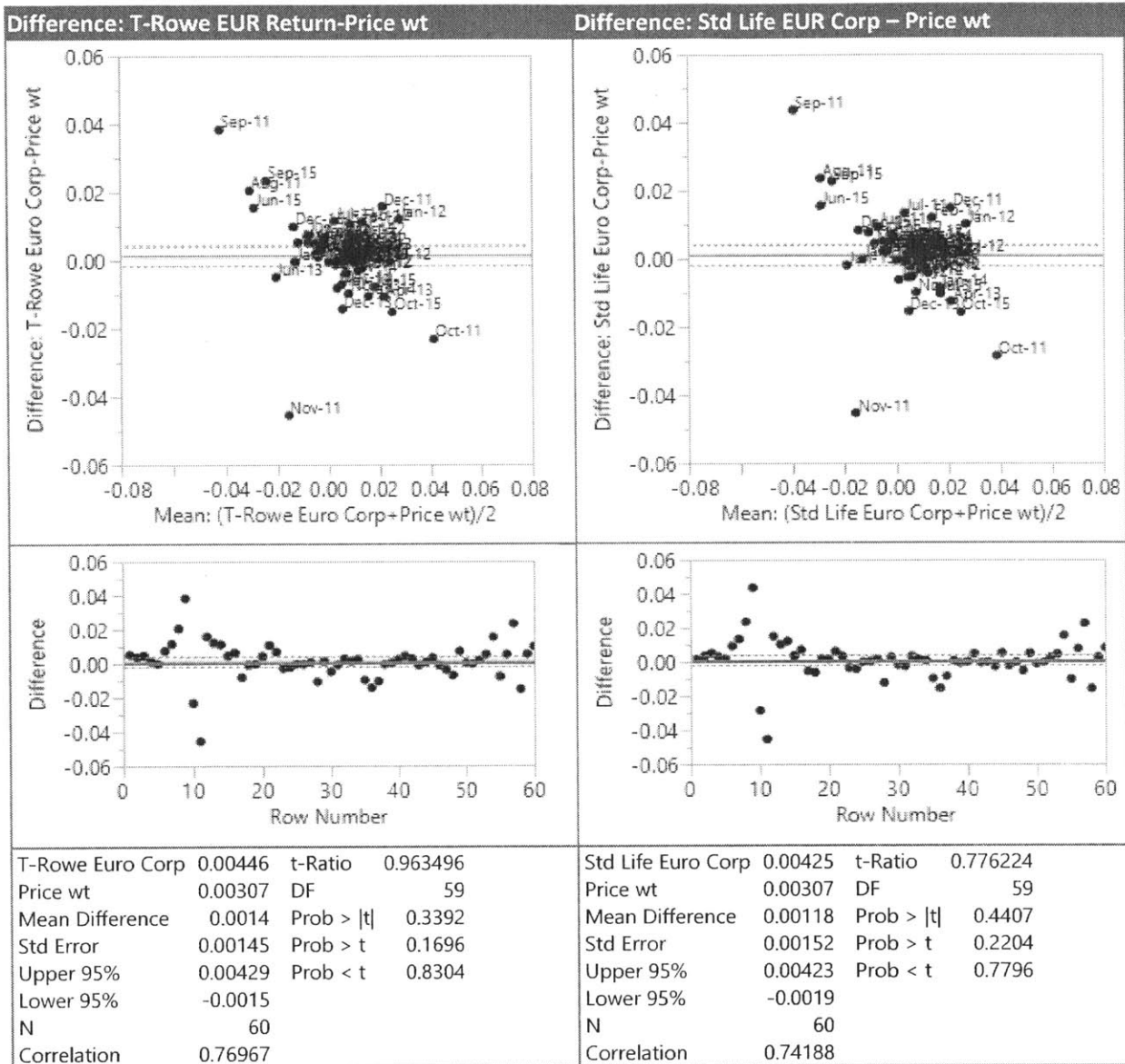


Difference: L&G EUR Corp – Price wt

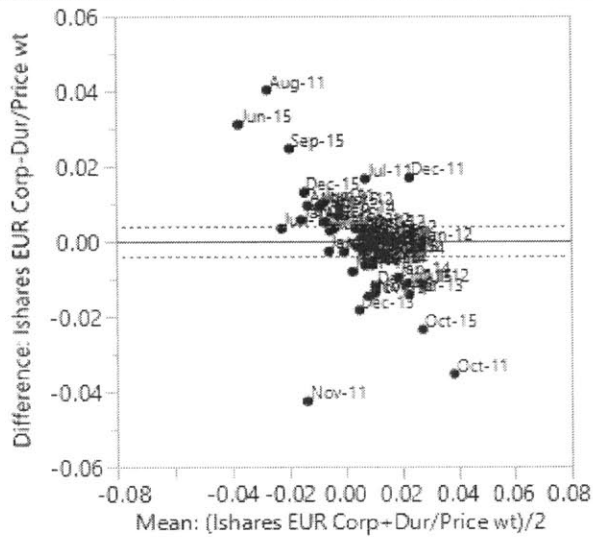


iBoxx Return	0.00405	t-Ratio	0.609192
Price wt	0.00307	DF	59
Mean Difference	0.00098	Prob > t	0.5447
Std Error	0.00161	Prob > t	0.2724
Upper 95%	0.0042	Prob < t	0.7276
Lower 95%	-0.0022		
N	60		
Correlation	0.71034		

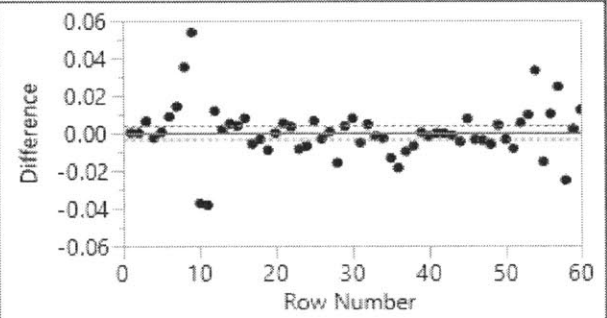
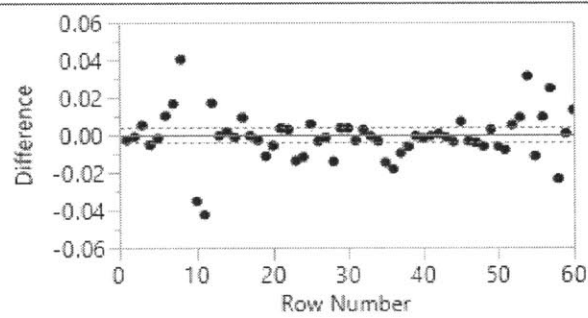
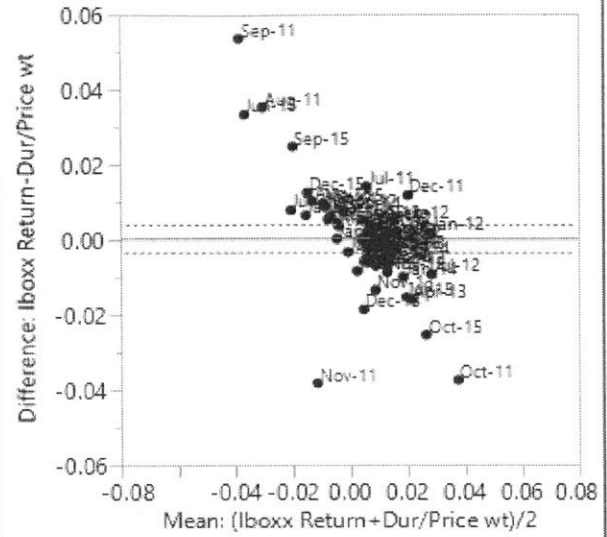
L&G Euro Corp	0.00495	t-Ratio	1.14797
Price wt	0.00307	DF	59
Mean Difference	0.00188	Prob > t	0.2556
Std Error	0.00164	Prob > t	0.1278
Upper 95%	0.00515	Prob < t	0.8722
Lower 95%	-0.0014		
N	60		
Correlation	0.69538		



Difference: iShares EUR Corp – Dur/Price wt



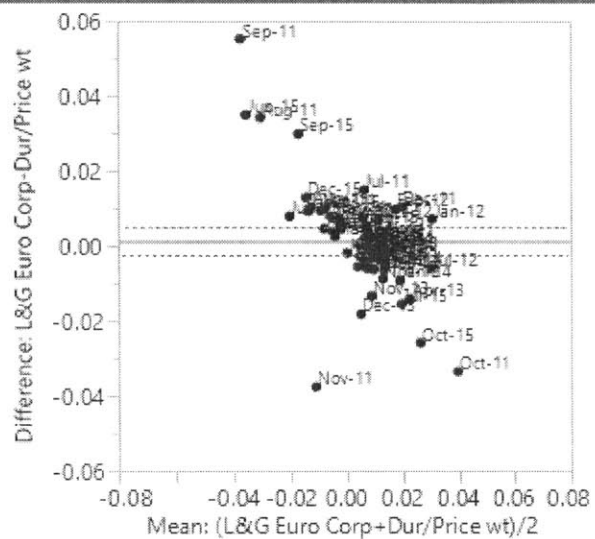
Difference: iBoxx return–Dur/ Price wt



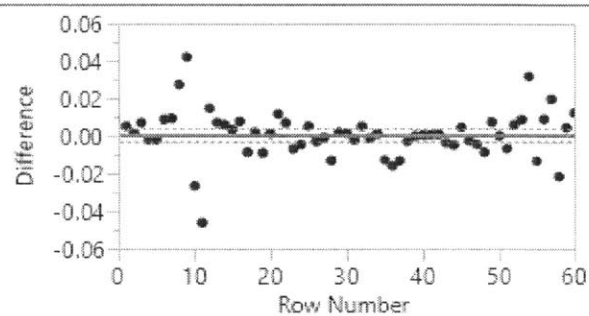
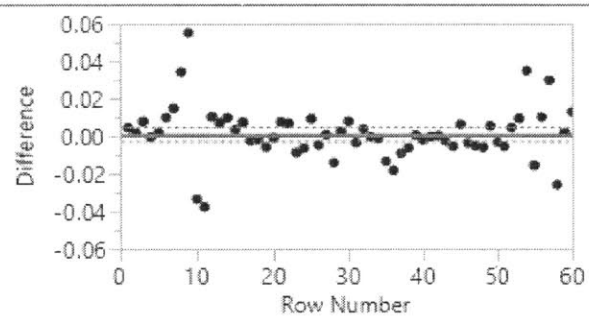
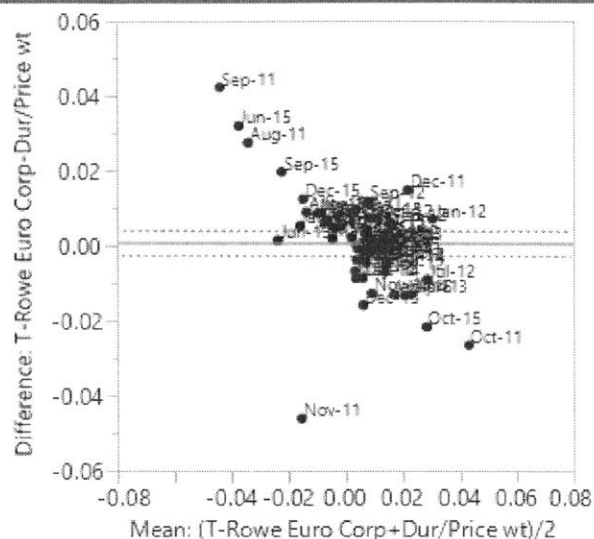
iShare EUR Corp	0.00371	t-Ratio	0.034792
Dur/Price wt	0.00364	DF	59
Mean Difference	0.00007	Prob > t	0.9724
Std Error	0.002	Prob > t	0.4862
Upper 95%	0.00407	Prob < t	0.5138
Lower 95%	-0.0039		
N	60		
Correlation	0.66185		

iBoxx Return	0.00405	t-Ratio	0.22229
Dur/Price wt	0.00364	DF	59
Mean Difference	0.00041	Prob > t	0.8249
Std Error	0.00185	Prob > t	0.4124
Upper 95%	0.00412	Prob < t	0.5876
Lower 95%	-0.0033		
N	60		
Correlation	0.74239		

Difference: L&G EUR Corp – Dur/Price wt



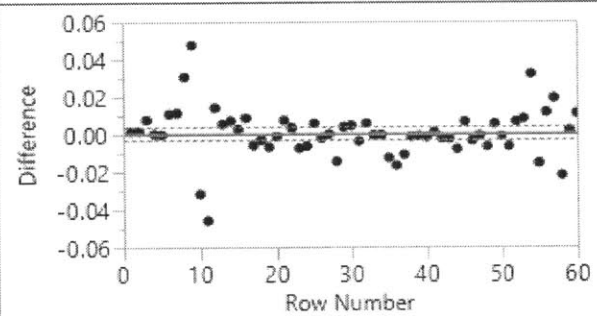
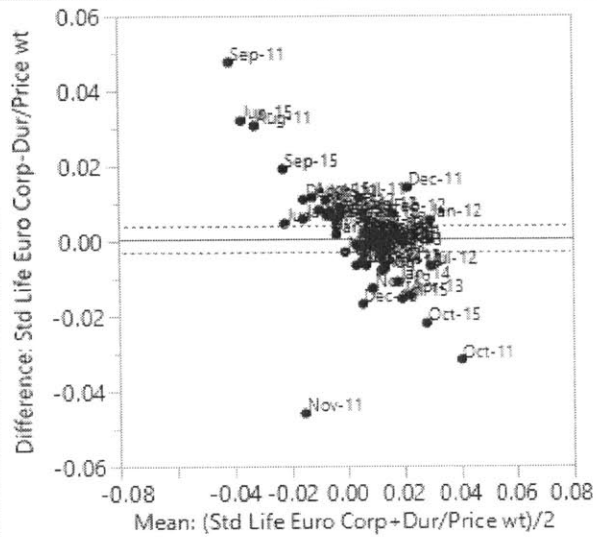
Difference: T-Rowe EUR Corp–Dur/ Price wt



L&G Euro Corp	0.00495	t-Ratio	0.701046
Dur/Price wt	0.00364	DF	59
Mean Difference	0.00131	Prob > t	0.4860
Std Error	0.00187	Prob > t	0.2430
Upper 95%	0.00504	Prob < t	0.7570
Lower 95%	-0.0024		
N	60		
Correlation	0.73014		

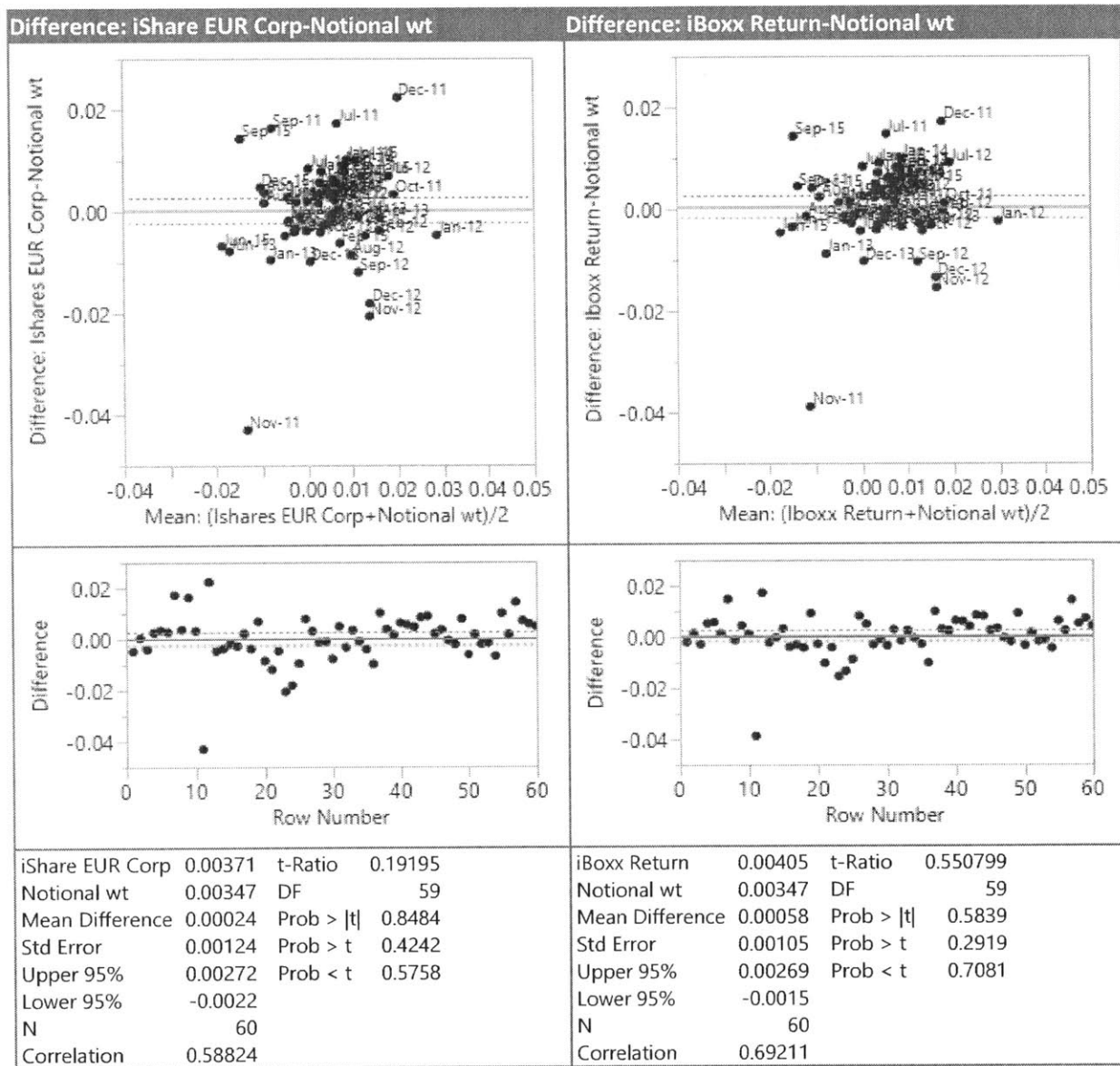
T-Rowe Euro Corp	0.00446	t-Ratio	0.494484
Dur/Price wt	0.00364	DF	59
Mean Difference	0.00083	Prob > t	0.6228
Std Error	0.00167	Prob > t	0.3114
Upper 95%	0.00417	Prob < t	0.6886
Lower 95%	-0.0025		
N	60		
Correlation	0.78606		

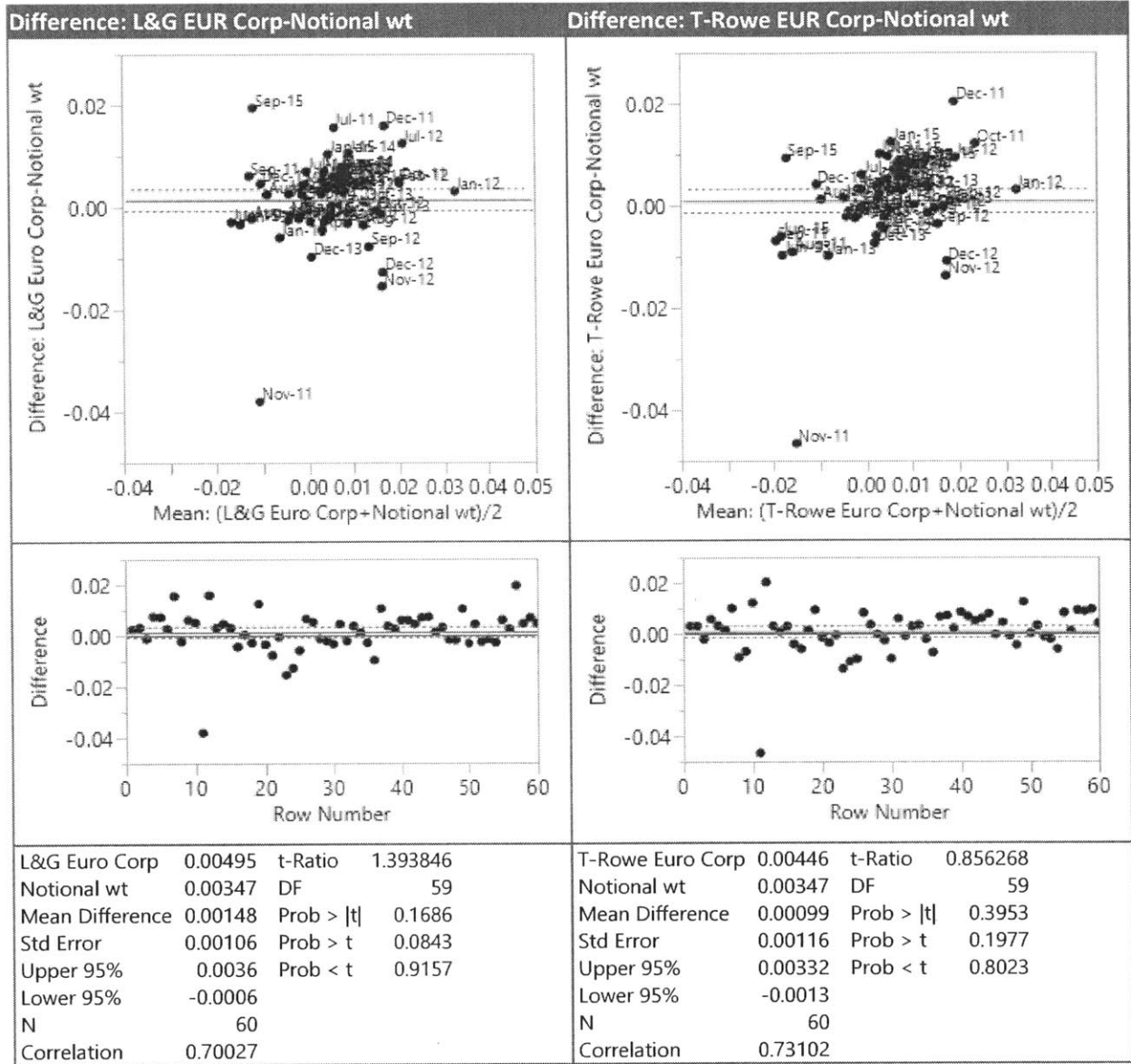
Difference: Std Life EUR Corp – Dur/Price wt



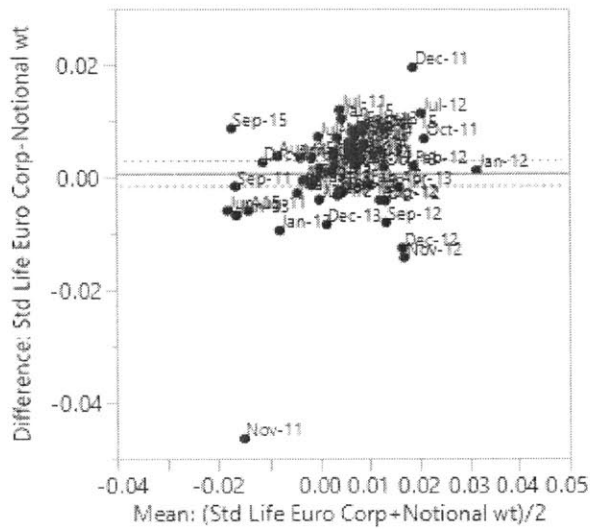
Std Life Euro Corp	0.00425	t-Ratio	0.350024
Dur/Price wt	0.00364	DF	59
Mean Difference	0.00061	Prob > t	0.7276
Std Error	0.00175	Prob > t	0.3638
Upper 95%	0.00412	Prob < t	0.6362
Lower 95%	-0.0029		
N	60		
Correlation	0.76407		

APPENDIX H: SPREAD-DURATION SELECTION STRATEGY: PAIRED T-TESTS

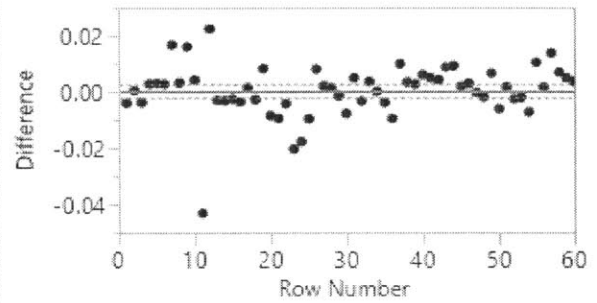
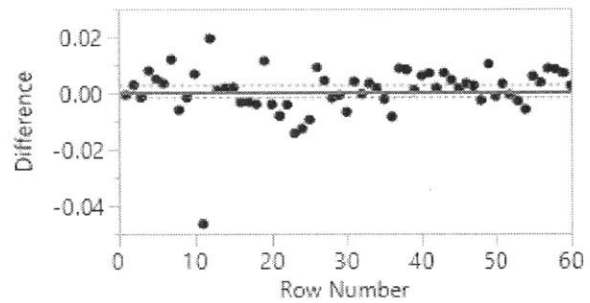
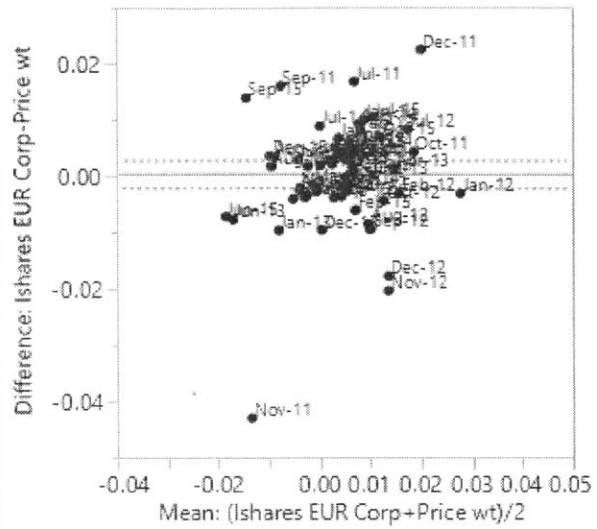




Difference: Std Life EUR Corp-Notional wt



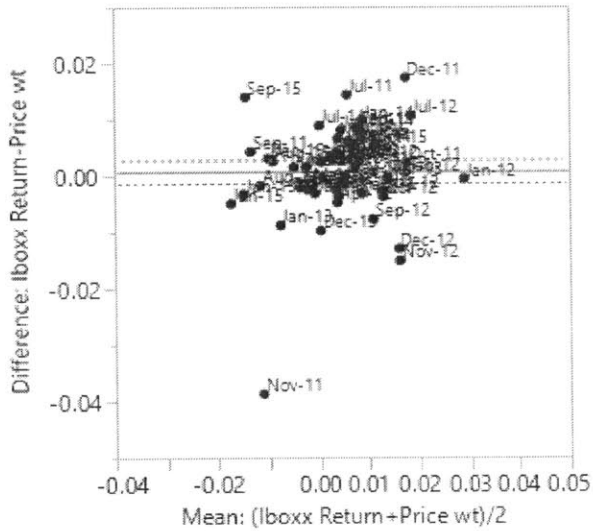
Difference: iShares EUR Corp – Price wt



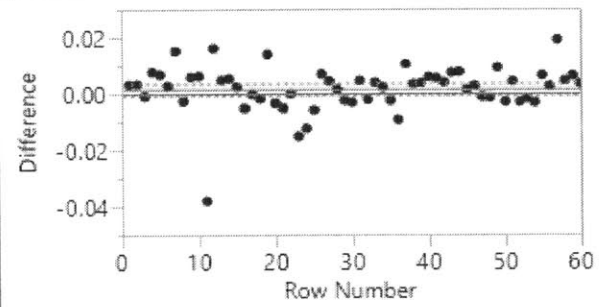
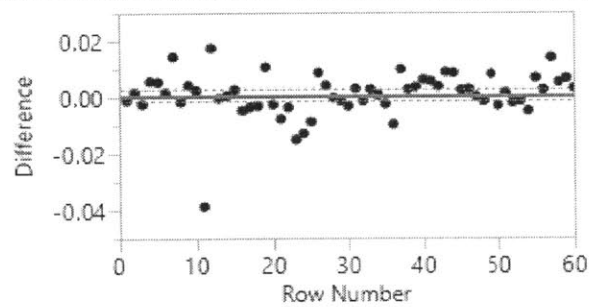
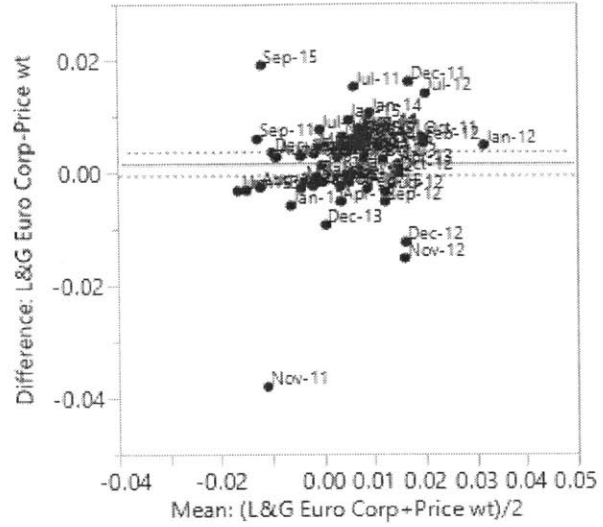
Std Life Euro Corp	0.00425	t-Ratio	0.686836
Notional wt	0.00347	DF	59
Mean Difference	0.00078	Prob > t	0.4949
Std Error	0.00114	Prob > t	0.2474
Upper 95%	0.00306	Prob < t	0.7526
Lower 95%	-0.0015		
N	60		
Correlation	0.70772		

iShare EUR Corp	0.00371	t-Ratio	0.344675
Price wt	0.00329	DF	59
Mean Difference	0.00042	Prob > t	0.7316
Std Error	0.00122	Prob > t	0.3658
Upper 95%	0.00287	Prob < t	0.6342
Lower 95%	-0.002		
N	60		
Correlation	0.58794		

Difference: iBoxx Return-Price wt



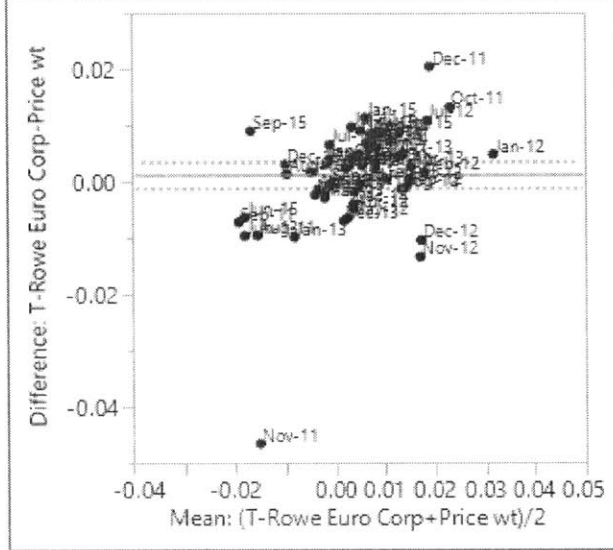
Difference: L&G EUR Corp – Price wt



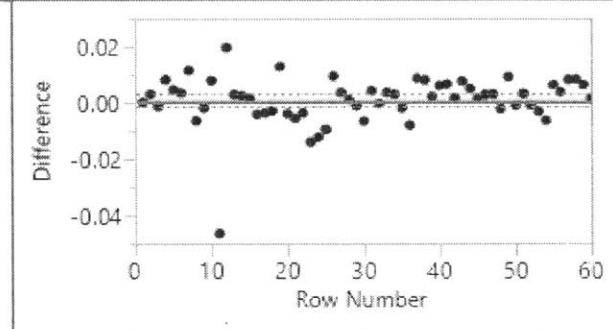
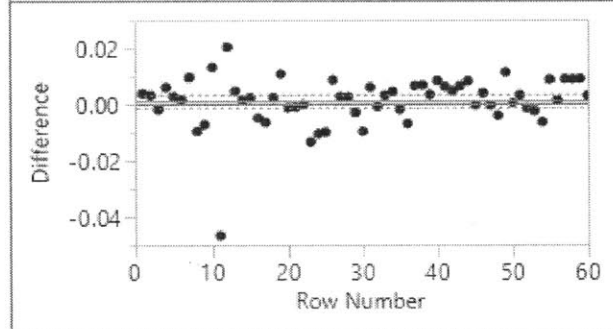
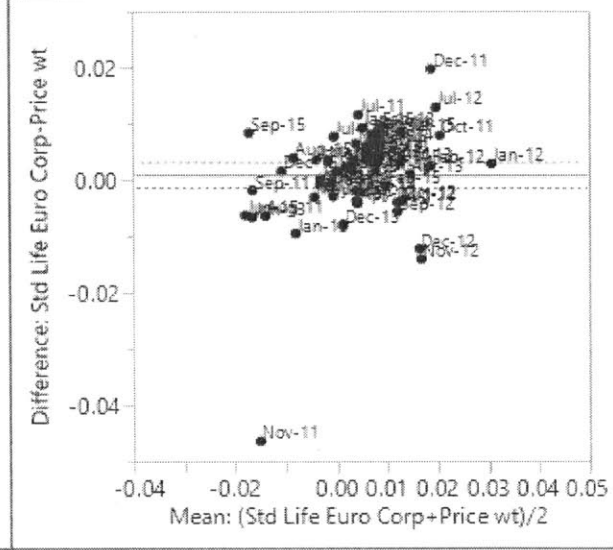
iBoxx Return	0.00405	t-Ratio	0.736136
Price wt	0.00329	DF	59
Mean Difference	0.00076	Prob > t	0.4646
Std Error	0.00104	Prob > t	0.2323
Upper 95%	0.00284	Prob < t	0.7677
Lower 95%	-0.0013		
N	60		
Correlation	0.69334		

L&G Euro Corp	0.00495	t-Ratio	1.580195
Price wt	0.00329	DF	59
Mean Difference	0.00166	Prob > t	0.1194
Std Error	0.00105	Prob > t	0.0597
Upper 95%	0.00376	Prob < t	0.9403
Lower 95%	-0.0004		
N	60		
Correlation	0.69844		

Difference: T-Rowe EUR Return-Price wt

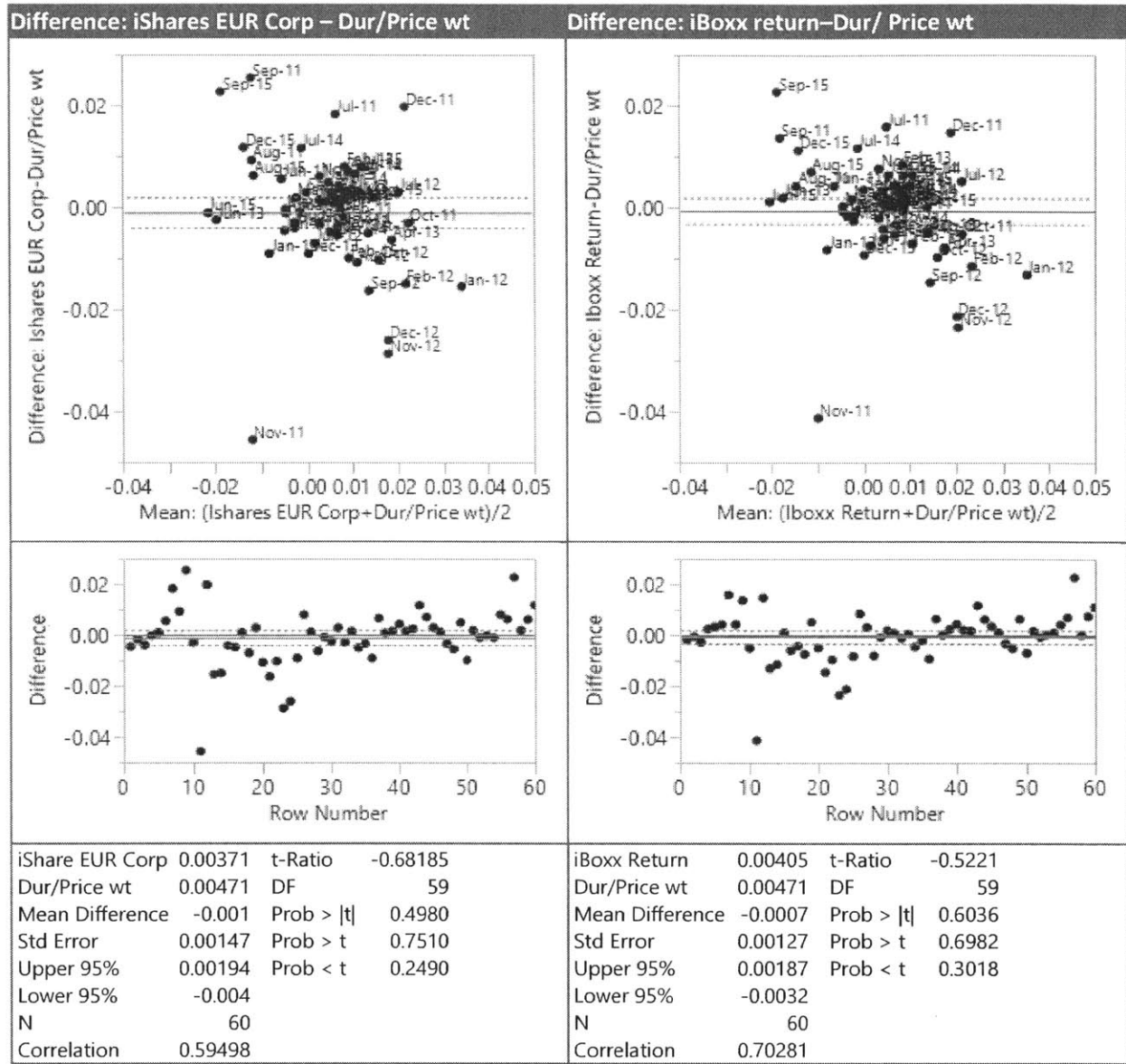


Difference: Std Life EUR Corp – Price wt

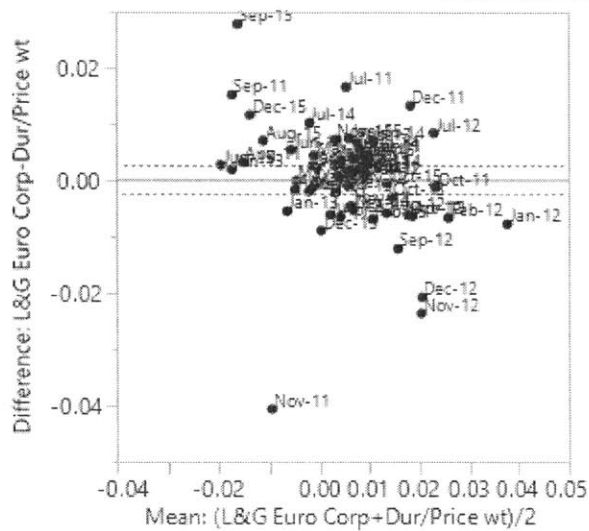


T-Rowe Euro Corp	0.00446	t-Ratio	1.011738
Price wt	0.00329	DF	59
Mean Difference	0.00118	Prob > t	0.3158
Std Error	0.00116	Prob > t	0.1579
Upper 95%	0.00351	Prob < t	0.8421
Lower 95%	-0.0012		
N	60		
Correlation	0.72924		

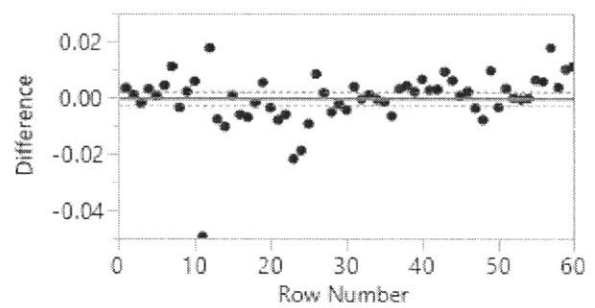
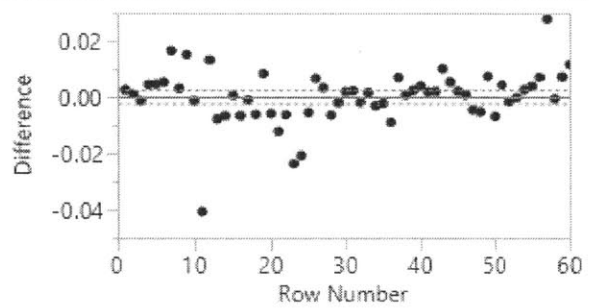
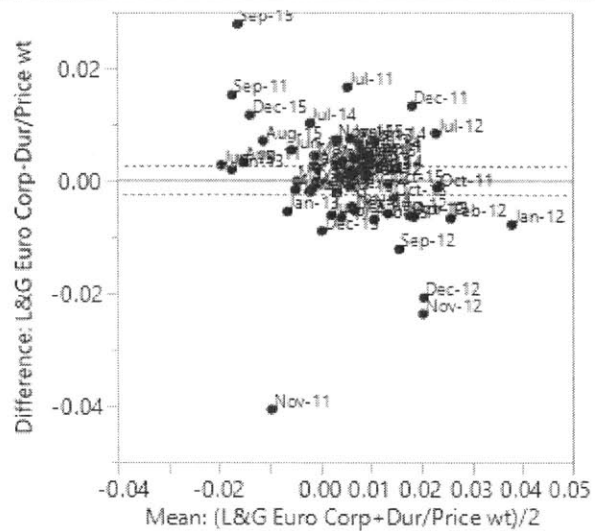
Std Life Euro Corp	0.00425	t-Ratio	0.852126
Price wt	0.00329	DF	59
Mean Difference	0.00096	Prob > t	0.3976
Std Error	0.00113	Prob > t	0.1988
Upper 95%	0.00323	Prob < t	0.8012
Lower 95%	-0.0013		
N	60		
Correlation	0.70762		



Difference: L&G EUR Corp – Dur/Price wt



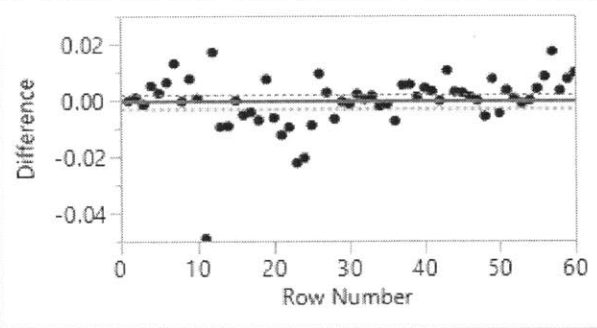
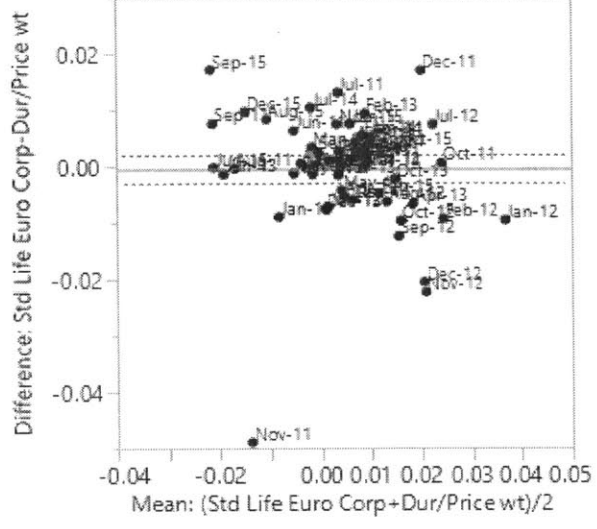
Difference: T-Rowe EUR Corp–Dur/ Price wt



L&G Euro Corp	0.00495	t-Ratio	0.18748
Dur/Price wt	0.00471	DF	59
Mean Difference	0.00023	Prob > t	0.8519
Std Error	0.00125	Prob > t	0.4260
Upper 95%	0.00274	Prob < t	0.5740
Lower 95%	-0.0023		
N	60		
Correlation	0.71288		

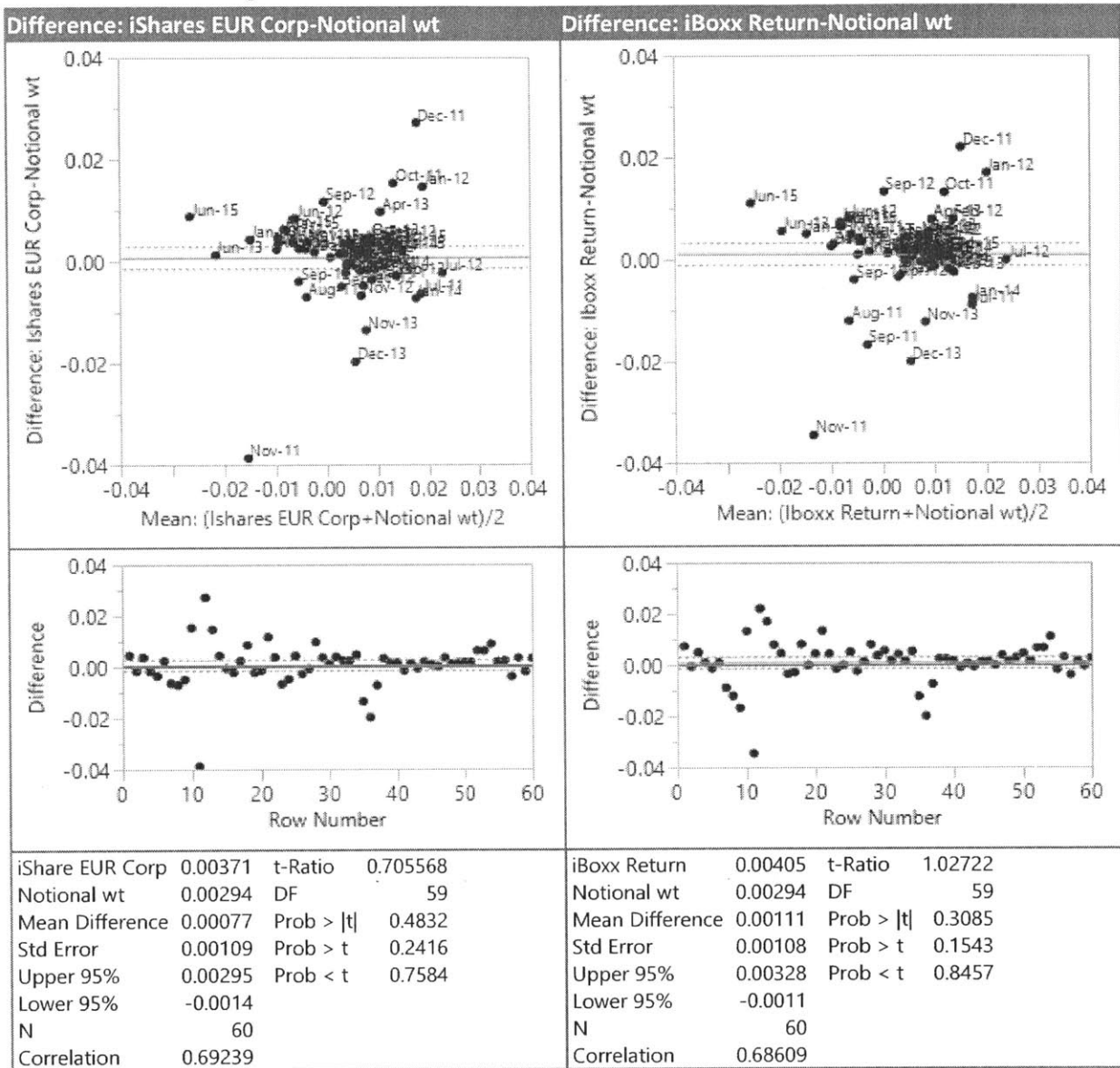
T-Rowe Euro Corp	0.00446	t-Ratio	-0.19889
Dur/Price wt	0.00471	DF	59
Mean Difference	-0.0002	Prob > t	0.8430
Std Error	0.00124	Prob > t	0.5785
Upper 95%	0.00224	Prob < t	0.4215
Lower 95%	-0.0027		
N	60		
Correlation	0.74372		

Difference: Std Life EUR Corp – Dur/Price wt

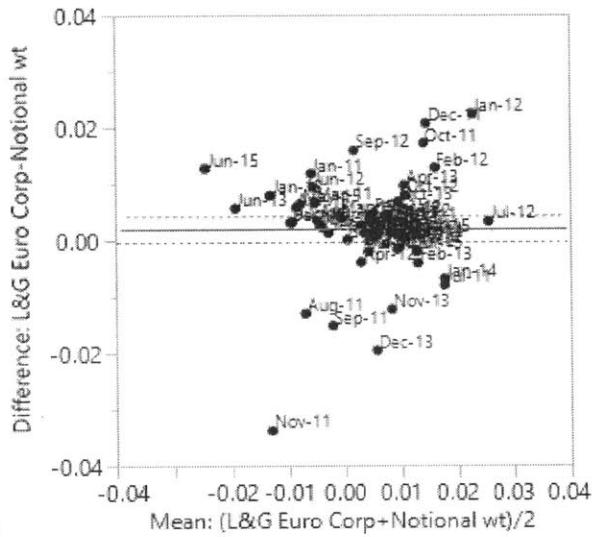


Std Life Euro Corp	0.00425	t-Ratio	-0.36357
Dur/Price wt	0.00471	DF	59
Mean Difference	-0.0005	Prob > t	0.7175
Std Error	0.00127	Prob > t	0.6413
Upper 95%	0.00208	Prob < t	0.3587
Lower 95%	-0.003		
N	60		
Correlation	0.72087		

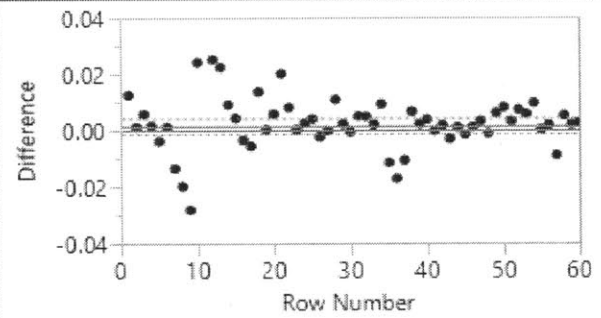
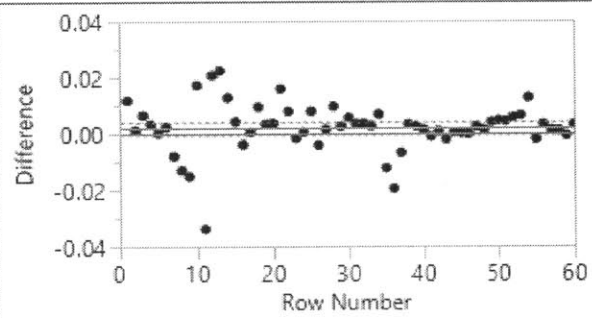
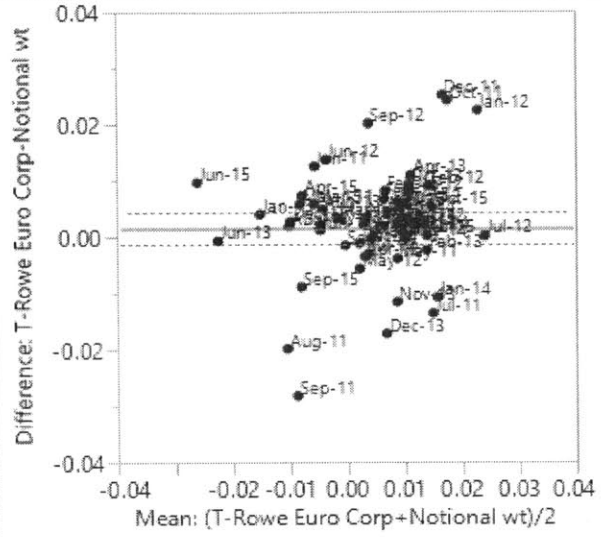
APPENDIX I: LIQUID BOND SELECTION STRATEGY: PAIRED T-TESTS



Difference: L&G EUR Corp-Notional wt



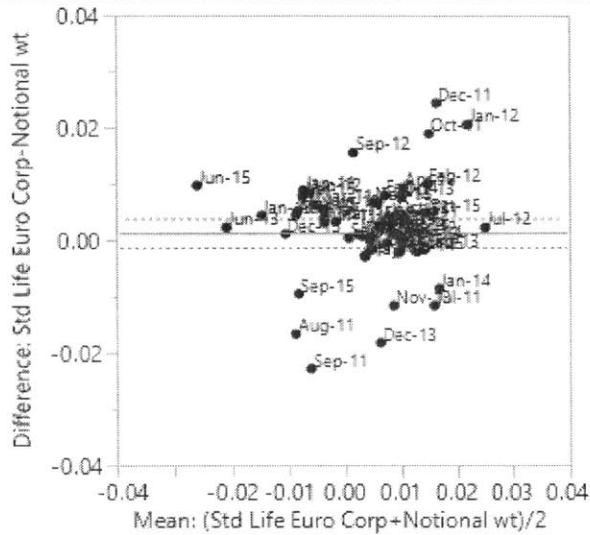
Difference: T-Rowe EUR Corp-Notional wt



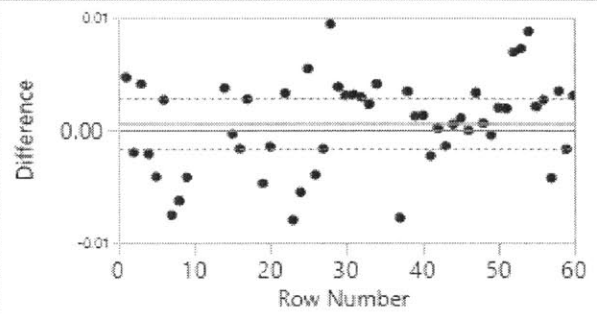
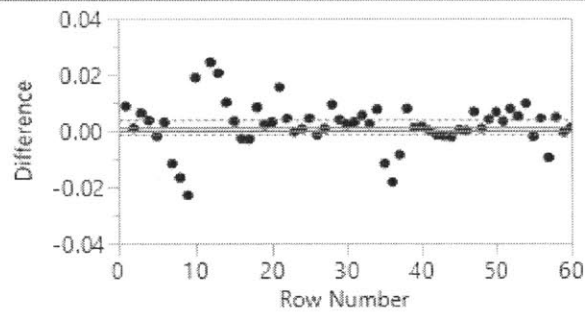
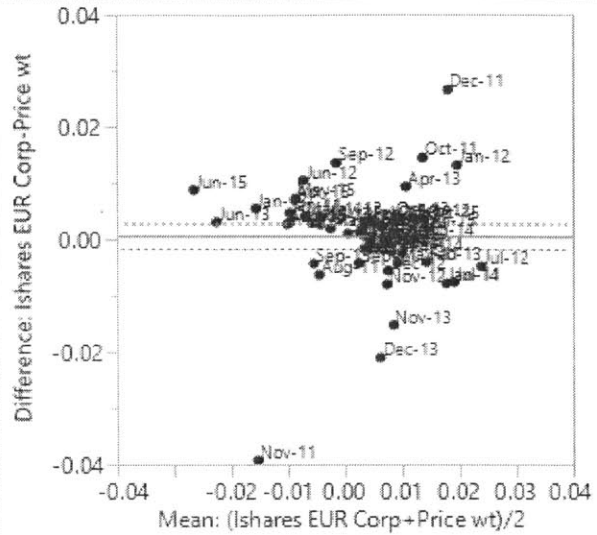
L&G Euro Corp	0.00495	t-Ratio	1.755092
Notional wt	0.00294	DF	59
Mean Difference	0.00201	Prob > t	0.0844
Std Error	0.00114	Prob > t	0.0422*
Upper 95%	0.0043	Prob < t	0.9578
Lower 95%	-0.0003		
N	60		
Correlation	0.66051		

T-Rowe Euro Corp	0.00446	t-Ratio	1.076699
Notional wt	0.00294	DF	59
Mean Difference	0.00153	Prob > t	0.2860
Std Error	0.00142	Prob > t	0.1430
Upper 95%	0.00436	Prob < t	0.8570
Lower 95%	-0.0013		
N	60		
Correlation	0.58713		

Difference: Std Life EUR Corp-Notional wt

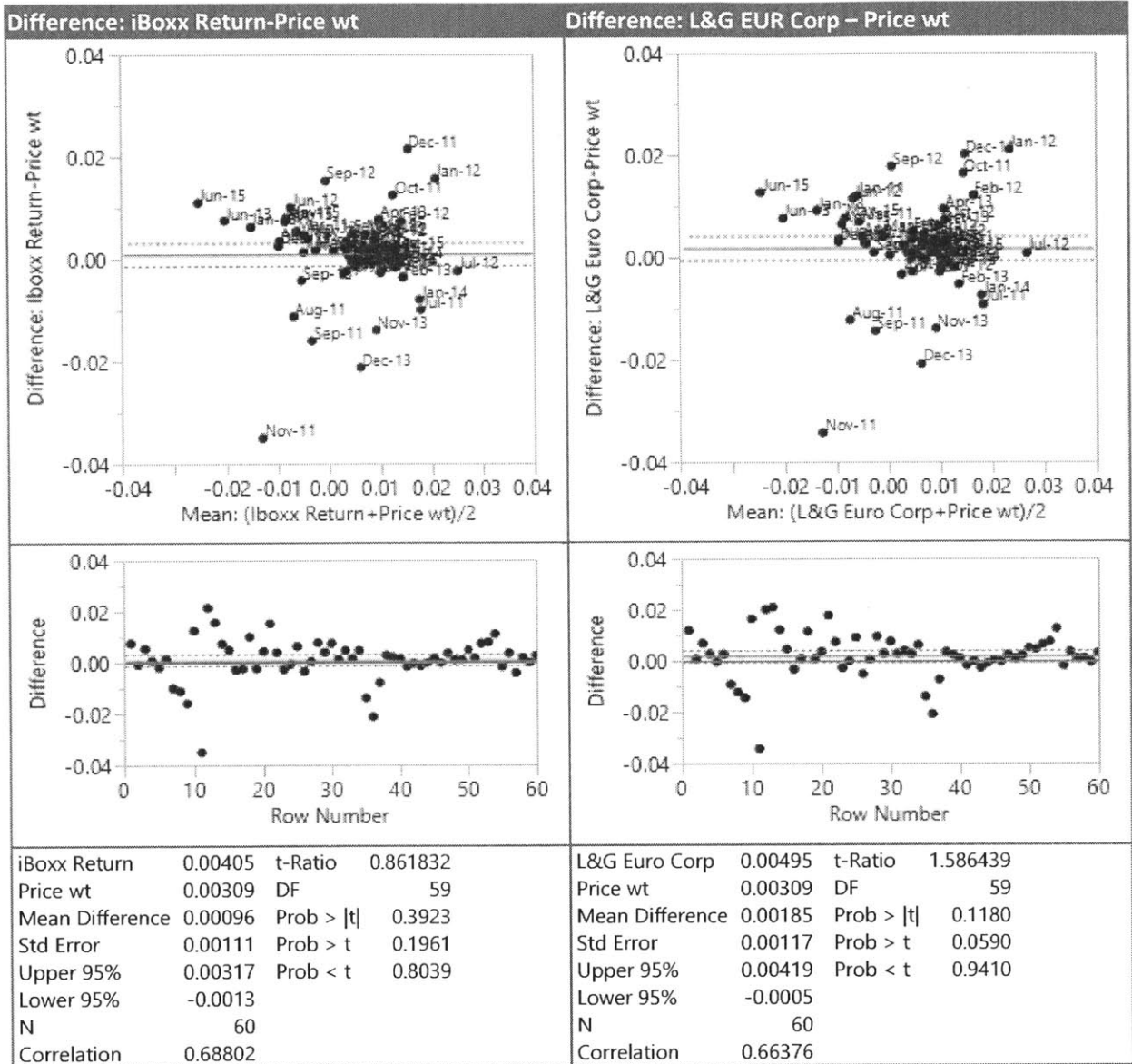


Difference: iShares EUR Corp – Price wt

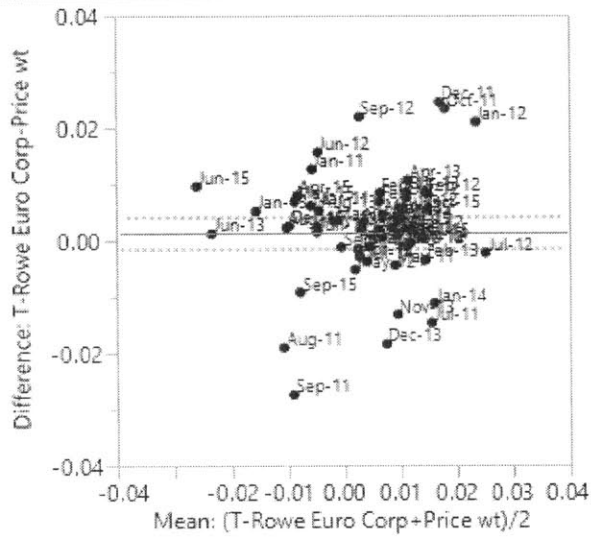


Std Life Euro Corp	0.00425	t-Ratio	1.017813
Notional wt	0.00294	DF	59
Mean Difference	0.00131	Prob > t	0.3129
Std Error	0.00129	Prob > t	0.1565
Upper 95%	0.00389	Prob < t	0.8435
Lower 95%	-0.0013		
N	60		
Correlation	0.62559		

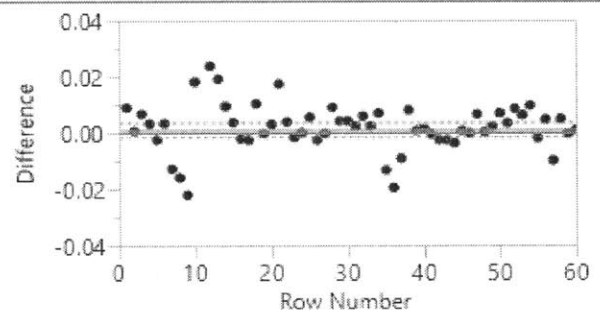
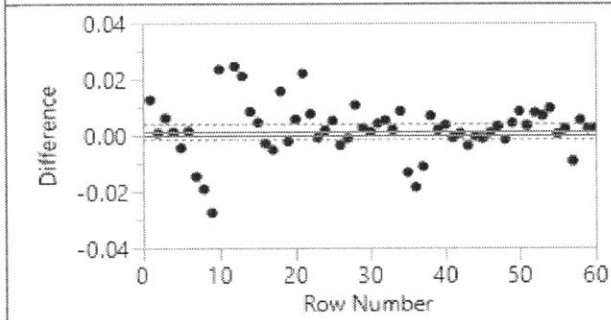
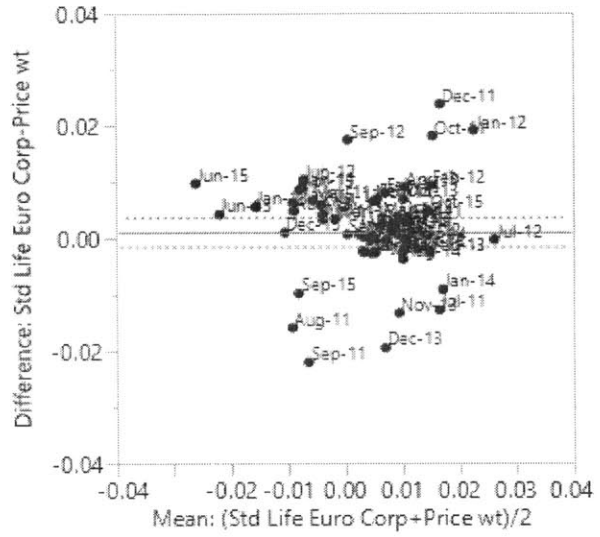
iShare EUR Corp	0.00371	t-Ratio	0.546645
Price wt	0.00309	DF	59
Mean Difference	0.00061	Prob > t	0.5867
Std Error	0.00112	Prob > t	0.2933
Upper 95%	0.00286	Prob < t	0.7067
Lower 95%	-0.0016		
N	60		
Correlation	0.69013		



Difference: T-Rowe EUR Return-Price wt

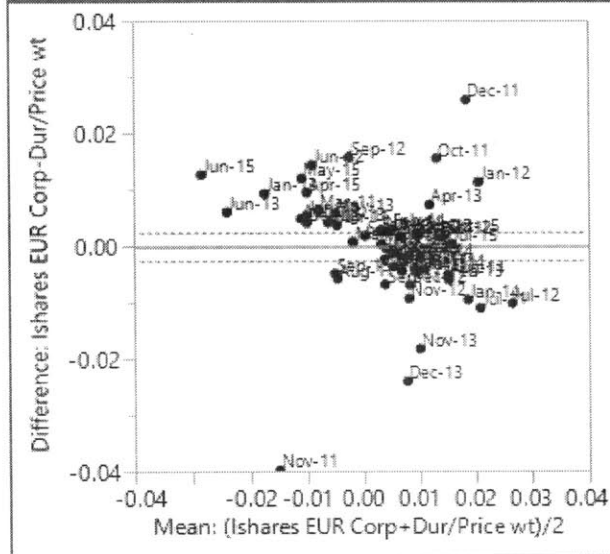


Difference: Std Life EUR Corp – Price wt

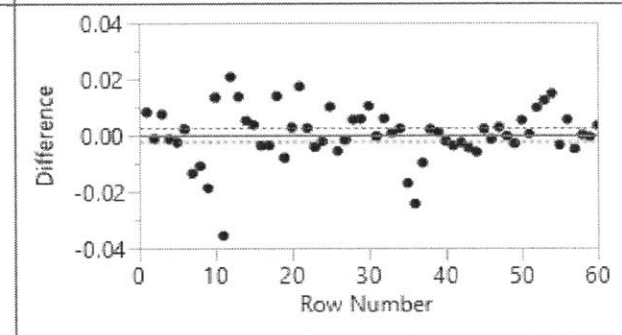
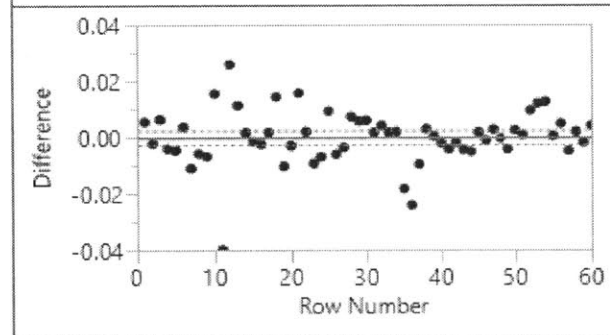
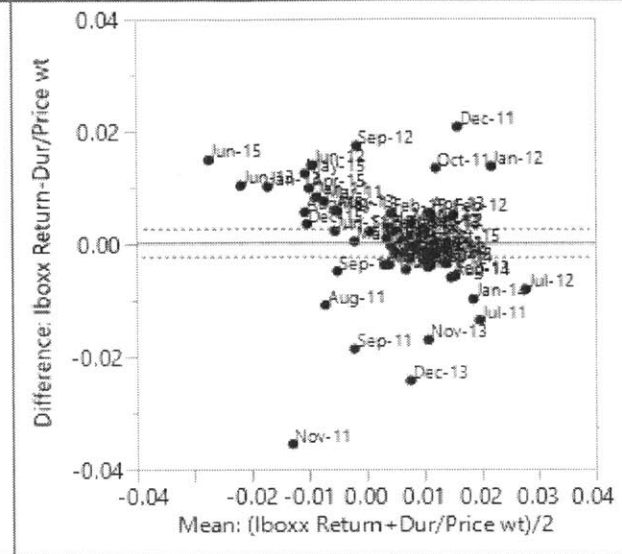


T-Rowe Euro Corp	0.00446	t-Ratio	0.955176	Std Life Euro Corp	0.00425	t-Ratio	0.883848
Price wt	0.00309	DF	59	Price wt	0.00309	DF	59
Mean Difference	0.00137	Prob > t	0.3410	Mean Difference	0.00116	Prob > t	0.3804
Std Error	0.00143	Prob > t	0.8216	Std Error	0.00131	Prob > t	0.1902
Upper 95%	0.00424	Prob < t	0.8289	Upper 95%	0.00377	Prob < t	0.8098
Lower 95%	-0.0015			Lower 95%	-0.0015		
N	60			N	60		
Correlation	0.59012			Correlation	0.62788		

Difference: iShares EUR Corp – Dur/Price wt



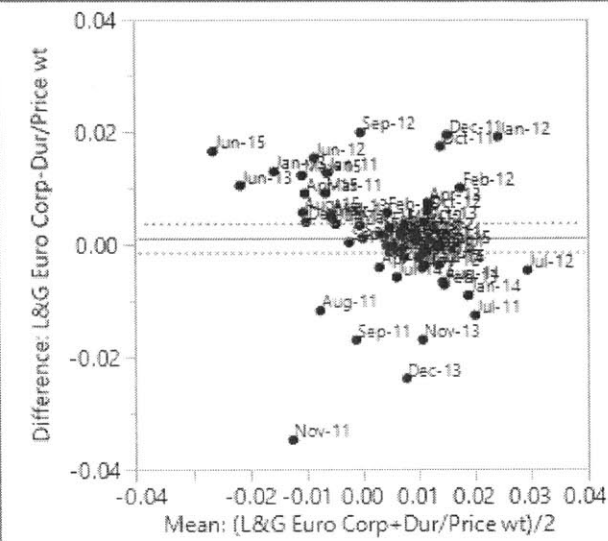
Difference: iBoxx return–Dur/ Price wt



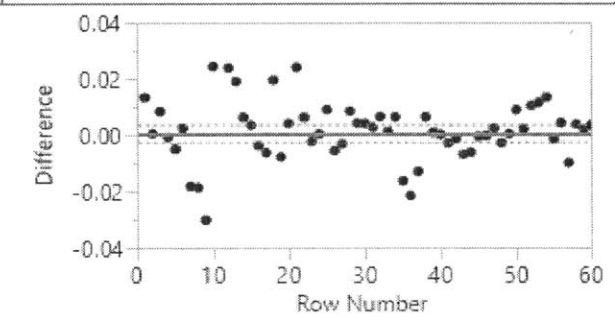
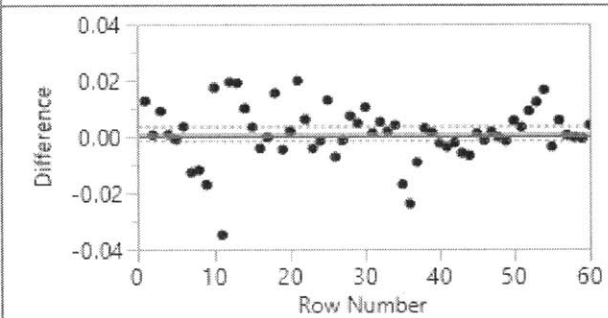
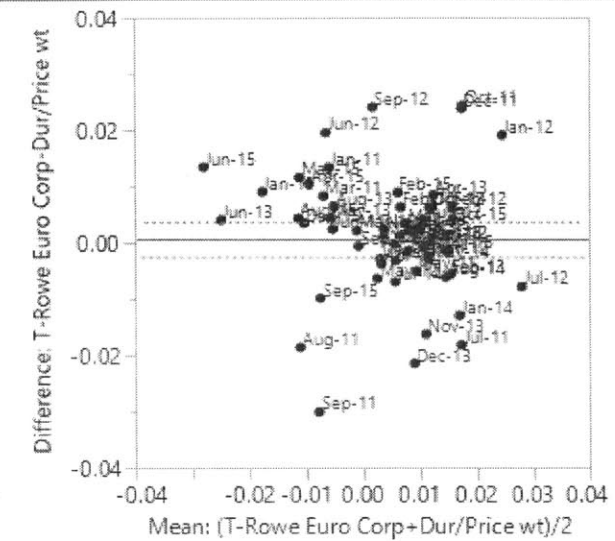
iShare EUR Corp	0.00371	t-Ratio	-0.06814
Dur/Price wt	0.00379	DF	59
Mean Difference	-0.0001	Prob > t	0.9459
Std Error	0.00125	Prob > t	0.5270
Upper 95%	0.00242	Prob < t	0.4730
Lower 95%	-0.0026		
N	60		
Correlation	0.68244		

iBoxx Return	0.00405	t-Ratio	0.206096
Dur/Price wt	0.00379	DF	59
Mean Difference	0.00026	Prob > t	0.8374
Std Error	0.00125	Prob > t	0.4187
Upper 95%	0.00276	Prob < t	0.5813
Lower 95%	-0.0022		
N	60		
Correlation	0.67854		

Difference: L&G EUR Corp – Dur/Price wt

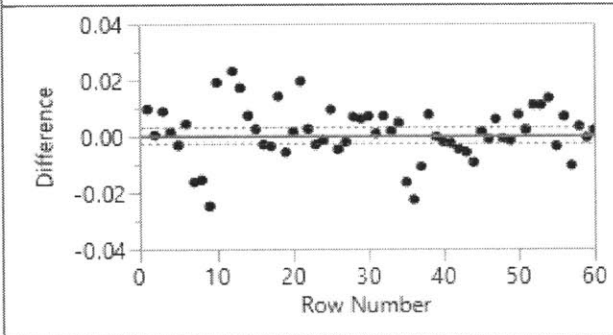
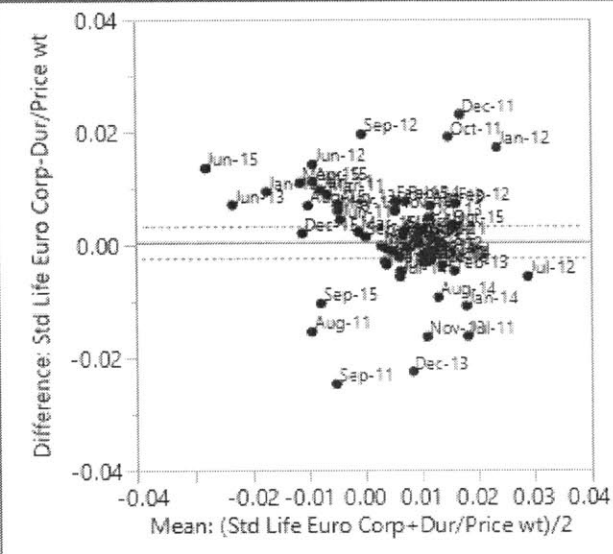


Difference: T-Rowe EUR Corp–Dur/ Price wt



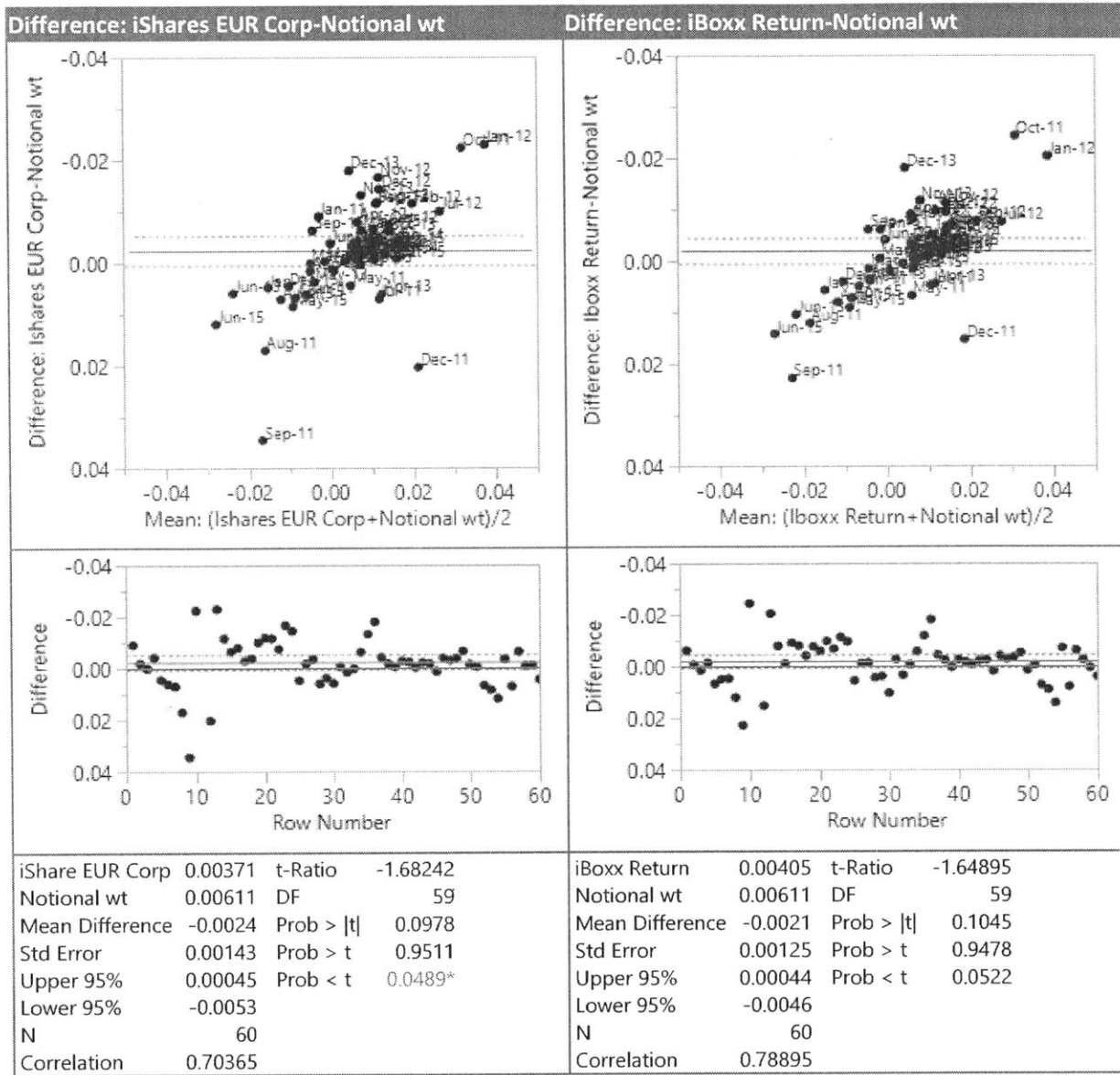
L&G Euro Corp	0.00495	t-Ratio	0.86855	T-Rowe Euro Corp	0.00446	t-Ratio	0.434728
Dur/Price wt	0.00379	DF	59	Dur/Price wt	0.00379	DF	59
Mean Difference	0.00115	Prob > t	0.7788	Mean Difference	0.00067	Prob > t	0.6653
Std Error	0.0013	Prob > t	0.8399	Std Error	0.00155	Prob > t	0.3327
Upper 95%	0.00376	Prob < t	0.1106	Upper 95%	0.00376	Prob < t	0.6673
Lower 95%	-0.0014			Lower 95%	-0.0024		
N	60			N	60		
Correlation	0.65508			Correlation	0.57766		

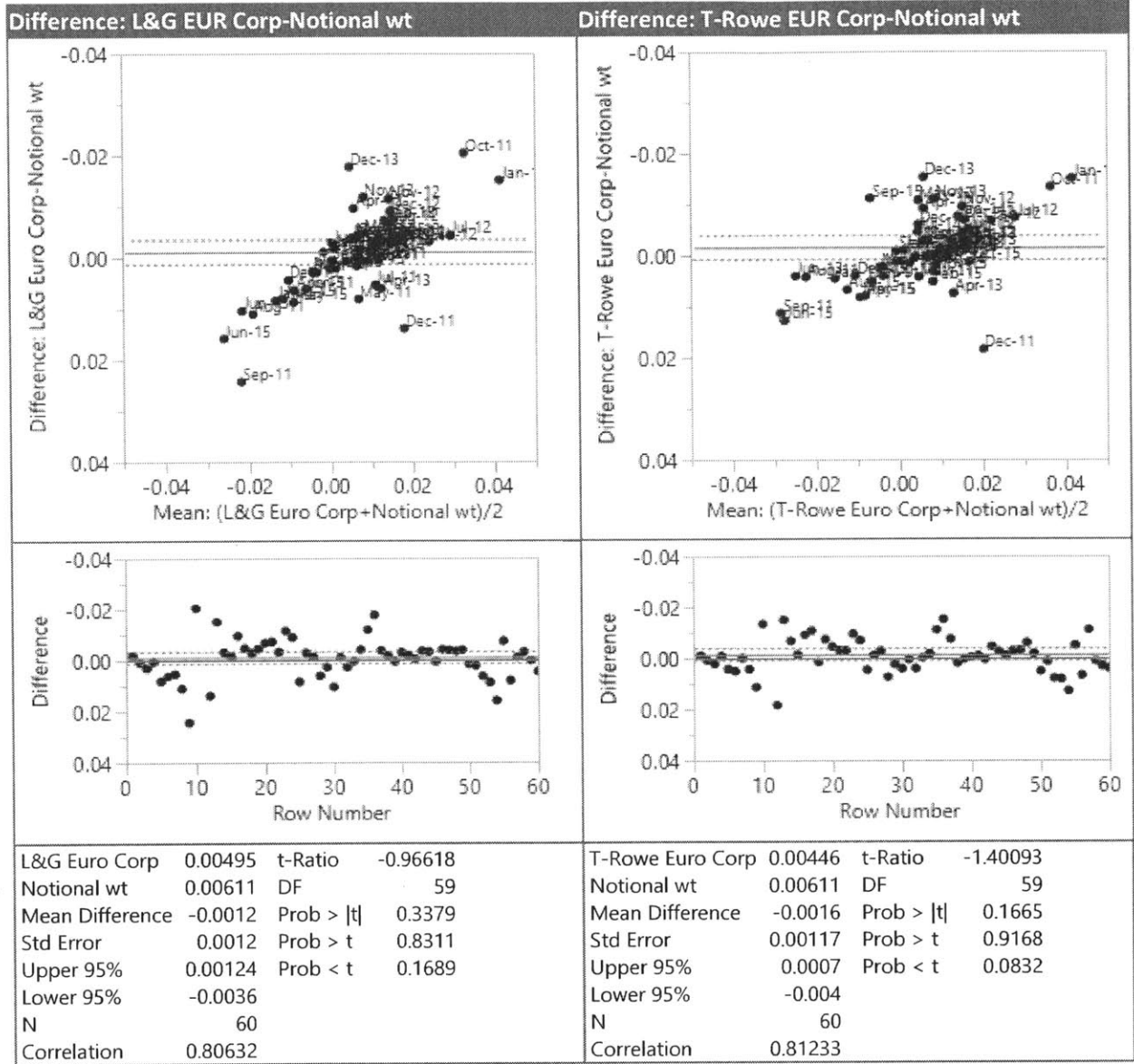
Difference: Std Life EUR Corp – Dur/Price wt



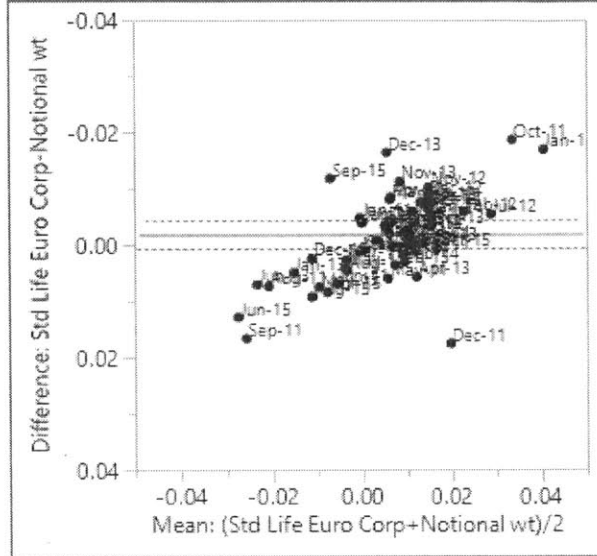
Std Life Euro Corp	0.00425	t-Ratio	0.320599
Dur/Price wt	0.00379	DF	59
Mean Difference	0.00046	Prob > t	0.7496
Std Error	0.00143	Prob > t	0.3748
Upper 95%	0.00332	Prob < t	0.6252
Lower 95%	-0.0024		
N	60		
Correlation	0.61524		

APPENDIX J: SPREAD-PD SELECTION STRATEGY: PAIRED T-TESTS

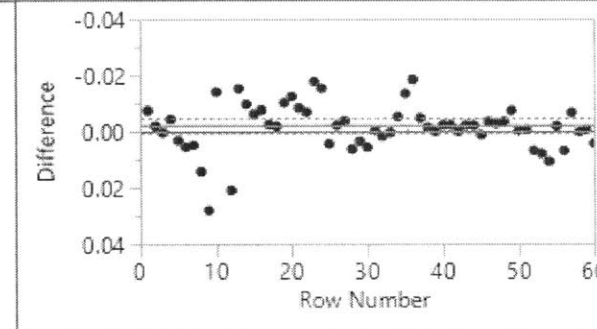
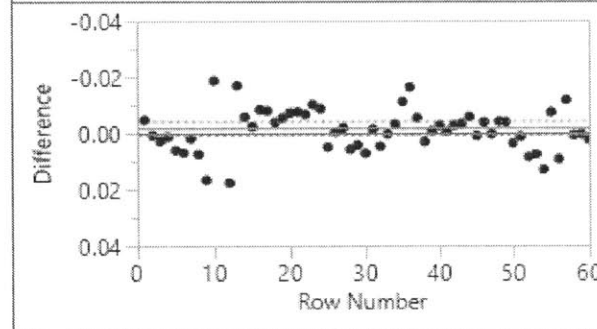
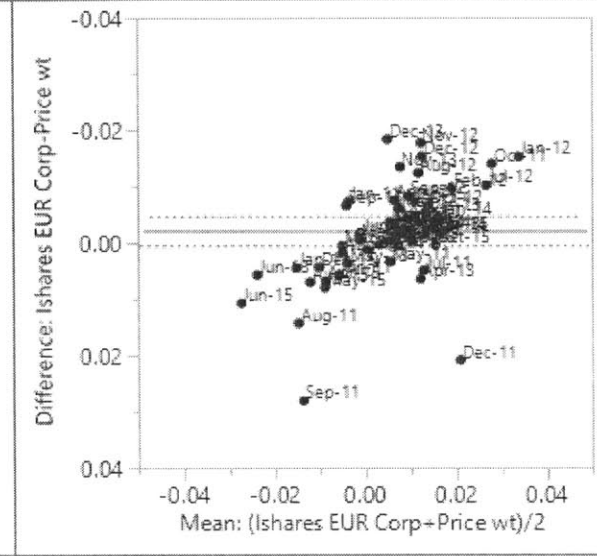




Difference: Std Life EUR Corp-Notional wt

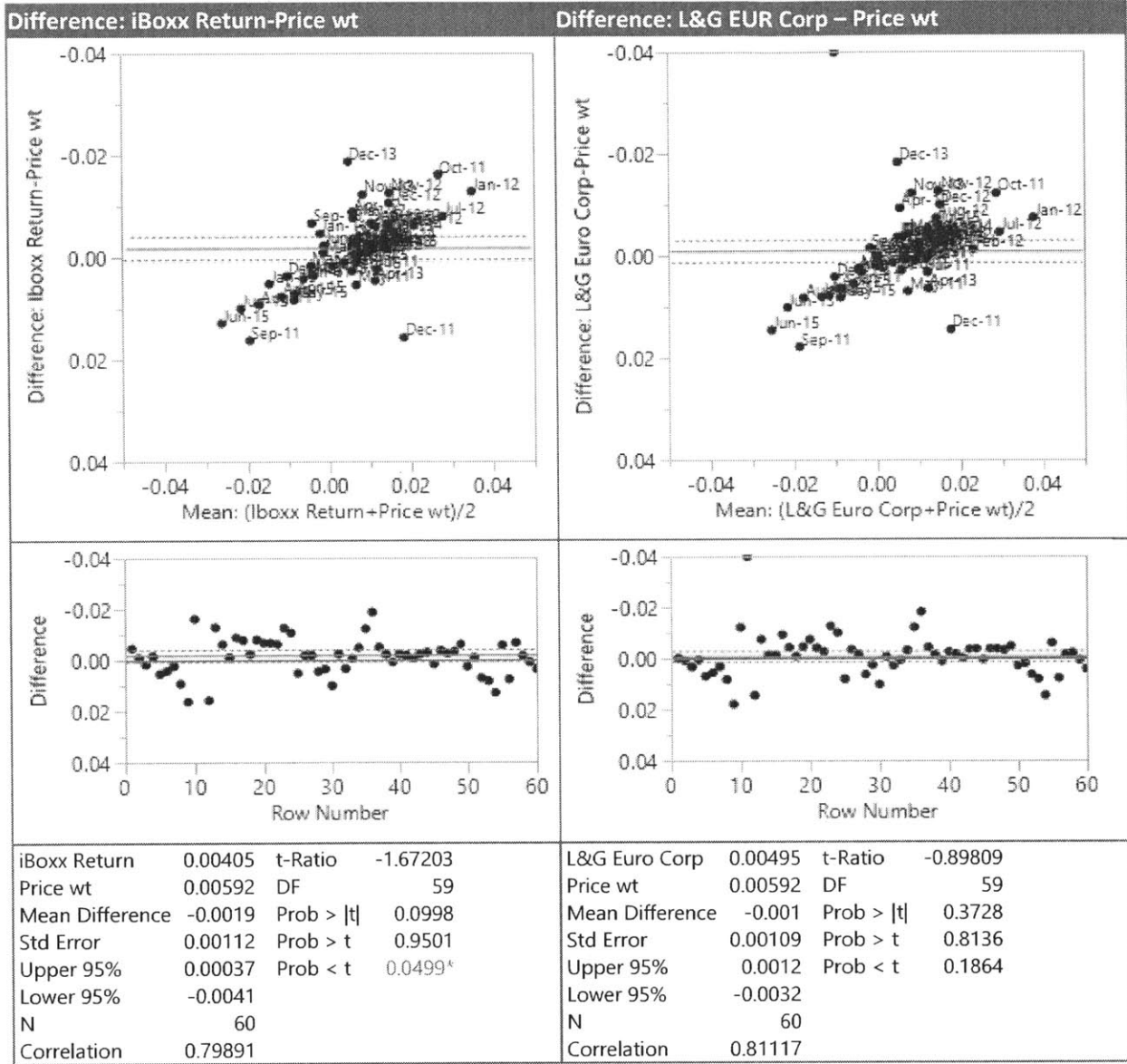


Difference: iShares EUR Corp – Price wt

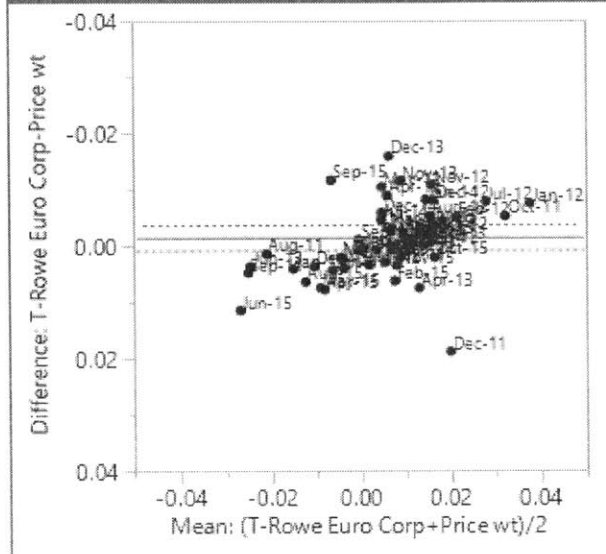


Std Life Euro Corp	0.00425	t-Ratio	-1.49418
Notional wt	0.00611	DF	59
Mean Difference	-0.0019	Prob > t	0.1405
Std Error	0.00124	Prob > t	0.9298
Upper 95%	0.00063	Prob < t	0.0702
Lower 95%	-0.0043		
N	60		
Correlation	0.78547		

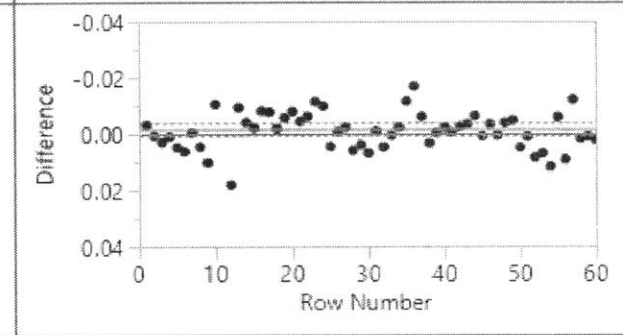
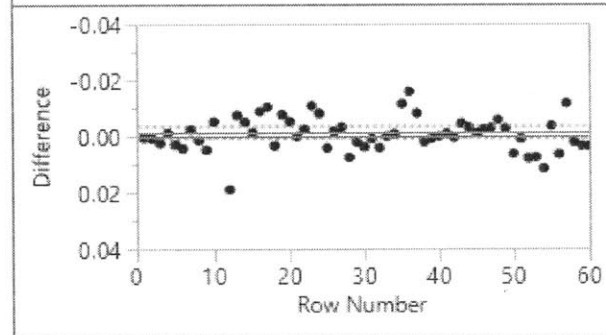
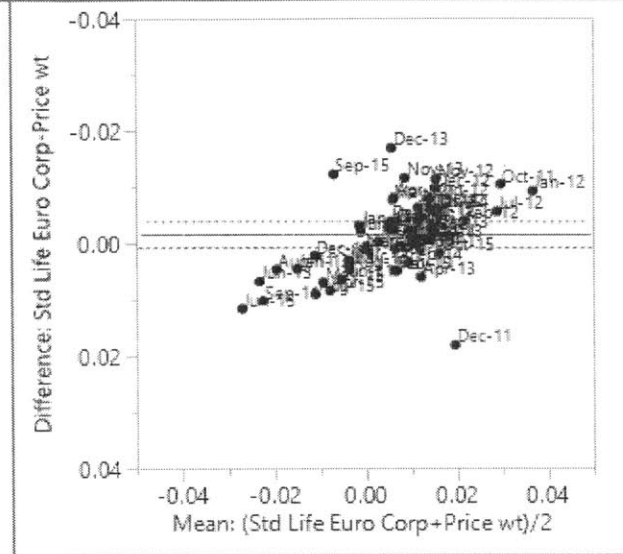
iShare EUR Corp	0.00371	t-Ratio	-1.70593
Price wt	0.00592	DF	59
Mean Difference	-0.0022	Prob > t	0.0933
Std Error	0.0013	Prob > t	0.9534
Upper 95%	0.00038	Prob < t	0.0466*
Lower 95%	-0.0048		
N	60		
Correlation	0.71692		



Difference: T-Rowe EUR Return-Price wt

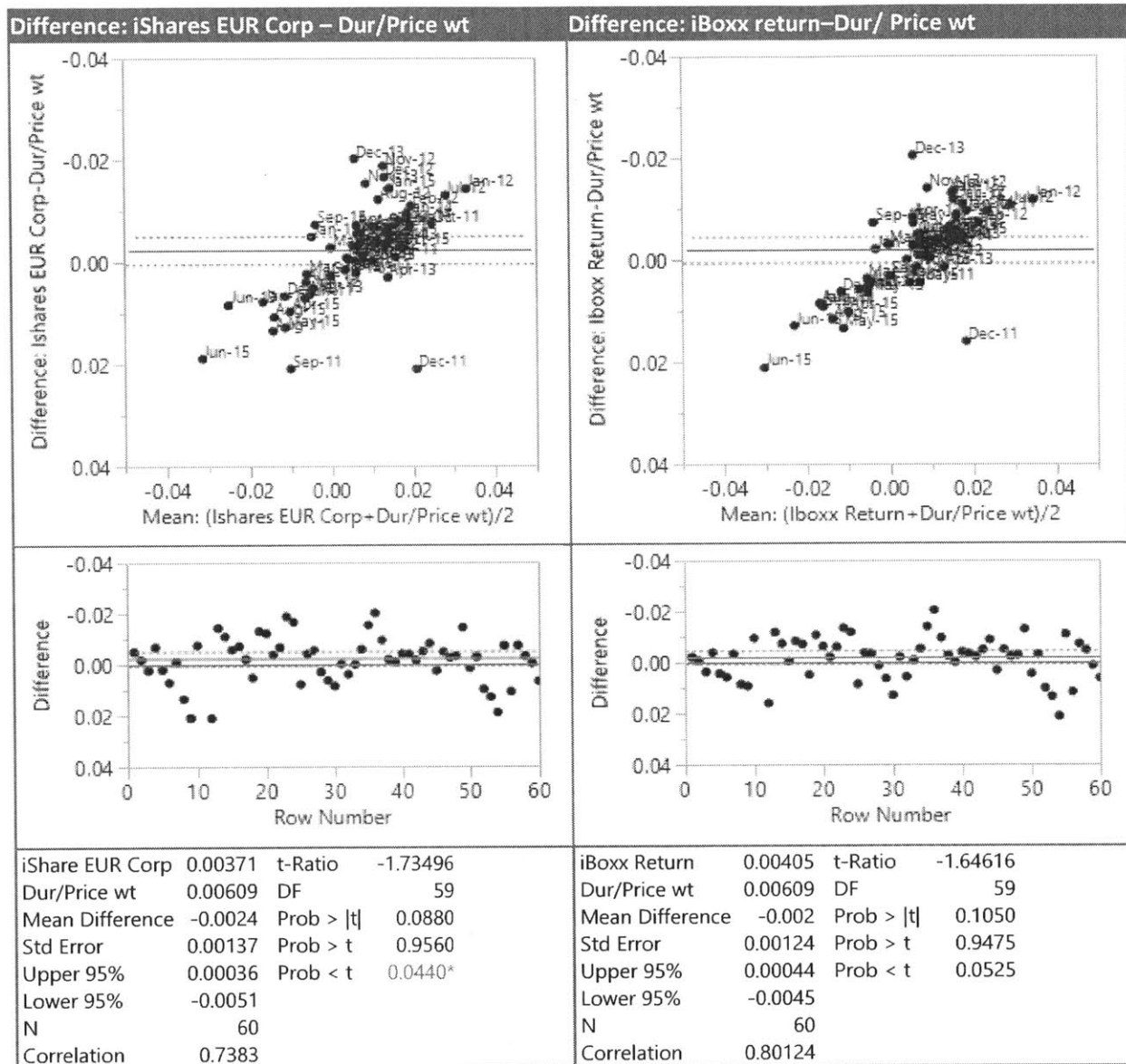


Difference: Std Life EUR Corp – Price wt

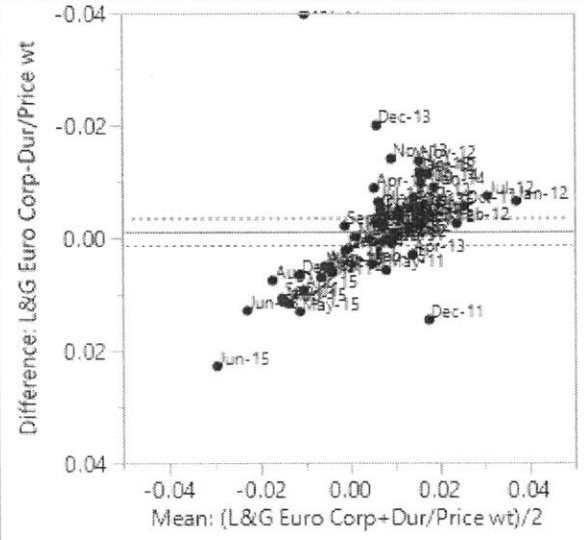


T-Rowe Euro Corp	0.00446	t-Ratio	-1.31093
Price wt	0.00592	DF	59
Mean Difference	-0.0015	Prob > t	0.1950
Std Error	0.00111	Prob > t	0.9025
Upper 95%	0.00077	Prob < t	0.0975
Lower 95%	-0.0037		
N	60		
Correlation	0.80764		

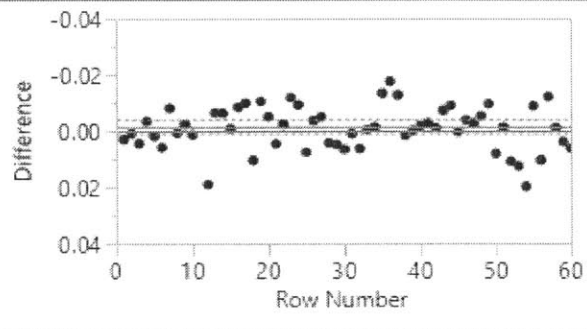
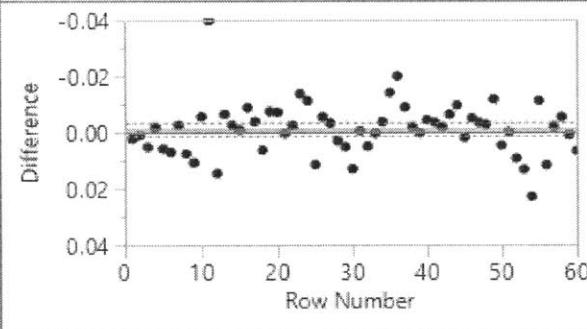
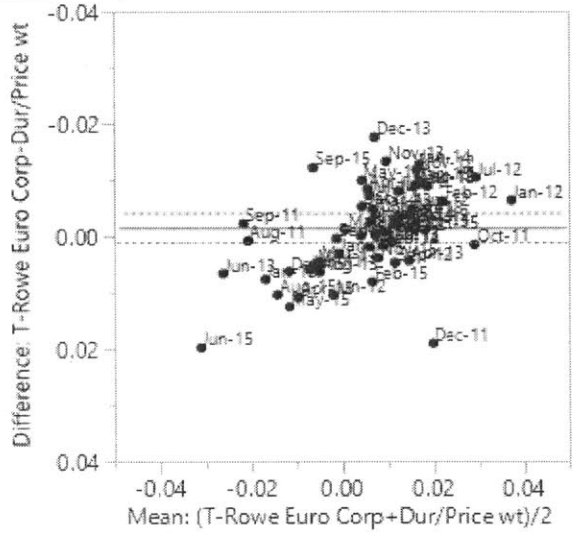
Std Life Euro Corp	0.00425	t-Ratio	-1.45202
Price wt	0.00592	DF	59
Mean Difference	-0.0017	Prob > t	0.1518
Std Error	0.00115	Prob > t	0.9241
Upper 95%	0.00063	Prob < t	0.0759
Lower 95%	-0.004		
N	60		
Correlation	0.7876		



Difference: L&G EUR Corp – Dur/Price wt



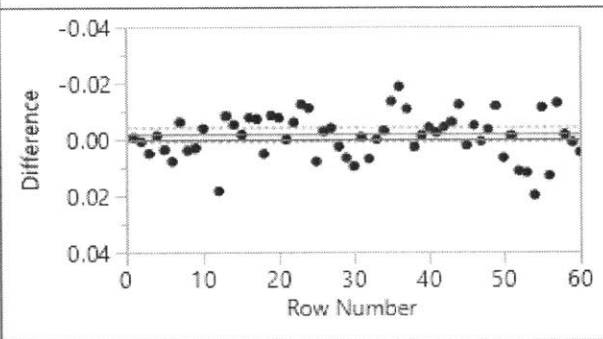
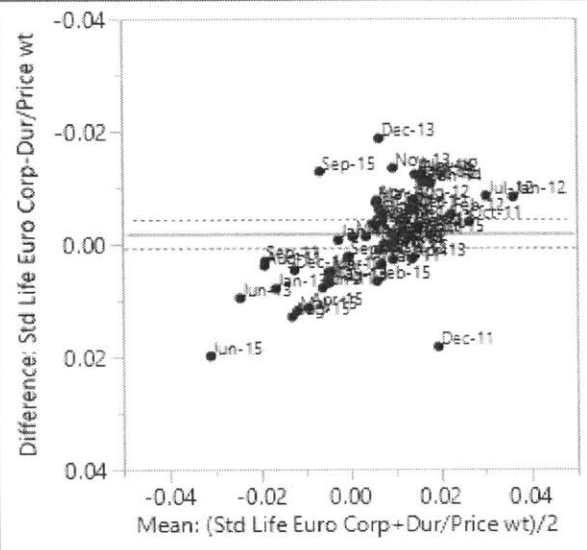
Difference: T-Rowe EUR Corp–Dur/ Price wt



L&G Euro Corp	0.00495	t-Ratio	-0.93586
Dur/Price wt	0.00609	DF	59
Mean Difference	-0.0011	Prob > t	0.3532
Std Error	0.00122	Prob > t	0.8234
Upper 95%	0.0013	Prob < t	0.1766
Lower 95%	-0.0036		
N	60		
Correlation	0.80633		

T-Rowe Euro Corp	0.00446	t-Ratio	-1.2756
Dur/Price wt	0.00609	DF	59
Mean Difference	-0.0016	Prob > t	0.2071
Std Error	0.00127	Prob > t	0.8965
Upper 95%	0.00092	Prob < t	0.1035
Lower 95%	-0.0042		
N	60		
Correlation	0.78167		

Difference: Std Life EUR Corp – Dur/Price wt



Std Life Euro Corp	0.00425	t-Ratio	-1.42733
Dur/Price wt	0.00609	DF	59
Mean Difference	-0.0018	Prob > t	0.1588
Std Error	0.00129	Prob > t	0.9206
Upper 95%	0.00074	Prob < t	0.0794
Lower 95%	-0.0044		
N	60		
Correlation	0.77403		